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Practical Approach for Detection Of Failure Of Distribution Transformers And Their Remidies.

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I. INTRODUCTION

Power is generated at lower voltage like 11KV and 13.8 KV in generating stations which are far away from the load centre. The power is transmitted to the load centers at extra high voltages like 132KV, 220KV and 400KV to reduce the losses and to improve the system efficiency. The power of these higher voltages is stepped down at various E.H.T., 33/11KV and 11KV/400V Sub-stations to attain the requirements of the consumers of different categories.

As the demand for electrical power is increasing day by day, the distribution system plays an important role in catering the needs of consumers. For reliability in maintaining un-interrupted power supply one must have an efficient distribution system. The major components in the distribution system are 11KV feeders, Distribution transformers and LT 3 phase 4 wire line.

One of the most vital component of the above, the heart of the system is distribution transformer. Hence the failure of a distribution transformer leads to break down in power supply to all the LT consumers. Therefore the reliability in power supply mainly depends on the reliable functioning of distribution transformer.

At present about 28204 distribution transformers of various capacities rating from 10 KVA to 500KVA are installed in Medak district. The failure rate is about 14.5% of total installed transformers which accounts for higher side.

In the present project work it is proposed to investigate the practical and technical causes for failure of distribution transformers and suggested suitable remedial measures to minimize the failure and to study the testing procedures which are being adopted in APCPDCL. For this purpose the No. of distribution transformers existing in Sangareddy, Jogipet, Medak, Toopran, Siddipet have been considered for cause study.

1.2 ORGANISATION OF PROJECT WORK

The project report is organized in 6 (six) chapters excluding the introductory chapter it has 5 chapters. The Chapter-II deals with the failure of the distribution transformers, the general causes for failure and maintenance schedule recommended/adopted by APCPDCL

1.3 STATEMENT OF THE PROBLEM:

An attempt has been made to analyze the practical causes contributing to the failure of distribution transformers.

2.DISTRIBUTION TRANSFORMER GENERAL CAUSES FOR FAILURES AND MAINTENANCE SCHEDULE

2.1 INTRODUCTION

In this chapter an attempt is made to explain the essential features involved in construction, operation, maintenance and the reasons for failure of transformers. Specific emphasis is made on what is likely to happen if a particular item of maintenance is not done in-time.

The power that is generated at various power stations is stepped up and transmitted at extra high voltages viz., 132 KV, 220 KV and 400 KV for reducing the transmission line losses. The voltage stepped down to service voltages at various receiving stations depending upon the requirement of the prospective consumers. The higher voltage is stepped down to 11KV/400V and is made available at L.T. consumers installations. It is roughly estimated that the power that is generated is transformed 3 or 4 times before it reaches the consumers installations. Thus the distribution transformer is an essential device in the distribution network which step down the voltage

2.2. THE DISTRIBUTION TRANSFORMER COMPRISES OF THE FOLLOWING FEATURES.

1. Magnetic Circuits : Comprising of limbs, yoke and clamp Structures.
2. Electric Circuits :The primary and secondary windings, insulation and bracing devices.
3. Terminals: Tappings, tap switch, insulators i.e. bushings and leads.
4. Others: Tank, Oils, Radiators, conservator,Breather and auxiliary apparatus.

2.3 FUNCTIONS OF A DISTRIBUTION TRANSFORMER:

The Distribution Transformer is static equipment and is used to either step down or step up the voltage as the case may be. The capacity of the transformers is the extent of power in KVA that can be handled by the transformer while it does the voltage transformation at the pre-determined ratio. The number of turns in H.V. and L.V. windings determine the voltage ratio.

Suppose the primary winding has N.P. number of turns and secondary winding has N.S. number of turns and the primary and secondary voltages are VP and VS respectively, the voltage ratio of the Distribution Transformer will be equivalent to

$$VP/VS = NP/NS$$

Therefore the number of turns on HV and LV Windings also decide the voltage ratio and the size of the winding wire decide the capacity of the transformer.

2.4 CAUSES OF FAILURE OF DISTRIBUTION TRANSFORMERS:

From a study on the various causes of failure of a transformer it is easy to know what is to be done to prevent them. The various causes for failure of distribution transformers are listed below.

2.4.1 FAILURES DUE TO MECHANICAL DAMAGES

These are generally (1) oil leakages (2) flash over of bushings.

1. The welding of the main tank may be defective and also the fillings are not leak proof. This causes oil to leak reducing the oil level in the transformer causing heating of winding and leading to a certain break-down of the equipment. Rough handling during transport may also contribute to leak.
2. The LT terminals connected through cables to LT take off lines. If these cables are not properly wired through wooden cleats they cause some loading on LT Bush rods and finally results to burnt out.
3. Deposits of coal dust, saline or chemicals on the bushing may cause a flash over, as the bushings will loose their insulating properties.
4. Sufficient place around a transformer to dissipate heat must be provided. If two transformers are kept close the surfaces may get clogged and oil temperature increases endangering to coil insulation.
5. Vapours at the top of an oil cooled transformers, may be explosive. Bringing naked lamps at the places may cause damage.

2.4.2 FAILURE IN DI-ELECTRIC CIRCUITS:

1. Moisture entering the tank by breathing action of transformer reduces the di-electric strength of oil .The results in break down from coils or terminal leads to tank or core structures. The greatest damages is however the inter turns short in the coils.
2. Deterioration of oil may occur due to prolonged over loading of the transformer. This action is aggravated by the presence of copper and lead. When oil temperature increases formation of sludge, water and acids are accelerated.
3. Certain amount of oil is lost due to evaporation and oxidation while the transformer is in service. Periodical topping up of oil level with fresh tested oil is necessary, leads to unit gets over heated.
4. Narrow oil ducts and improper ventilation reduce the useful life of a transformer. Oil insulation turns brittle and may get punctured on account of this.
5. Some times the clearance, provided between phases is insufficient. Also insertion of press board barriers may aggravate as they may up set the di-electric stress to throw too much stress across the coil spaces and across the barriers.
6. Wooden ducts provided for taking the terminal leads over them should be properly dried. These may cause short circuit between tapping leads.
7. Presence of foreign particles in oil reduces the di-electric strength of the insulating oil and may cause a flash over resulting in serious break down of the transformer.
8. When the acidity value of the oil increases, it will promote oxidation of the metal parts and results in a break-down.

SAFE VALUES FOR OIL

Di-electric strength: 30 KV for 1 minute between gap of 2.5mm 40 KV instant.
Acidity: Upto 0.7m.grs/KCH per gram of oil satisfactory.

2.4.3. FAILURE IN ELECTRIC CIRCUITS:

1. When moisture manages to ingress through the fabric insulation of the coils it causes short circuit between turns sooner or later. Impregnation of coils by applying varnish so that it penetrates deep enough to the inner layers of the coils is to be ensured. Failures from this cause are most common.

2. Presence of sharp edges on the copper conductors may cause a short circuit between adjacent turns when the transformer vibrates on load or when the windings are subjected to repeated electromagnets stresses cause adjacent turns coming into contact.
3. One or more turns in a coil may get dis-lodged and a short circuit between them may result, when heavy external short circuit occurs and if the same is not cleared by fuses intime. Break down may not immediately occur but when the transformer vibrates on load dislodged coils may take place causing a break down.
4. Improper drying out and applying full voltage with poor I.R.values will result in failure of insulation between adjacent layers. The I.R. values for a 11kv/440v distribution transformers are given below:
The I.R. values in mega ohms are to be taken with a 1000v megger.

Temperature	11kv/440v distribution Transformer		
	HT to LT	HT to E	LT to E
60 C	65	50	25
50C	130	100	50
40C	260	200	100
30C	above 250	above 200	above 100

Whenever readings are taken at ambient temperature, the temperature also is to be noted.
5. Sudden changes in load cause sudden expansion and contraction of copper and is likely to damage the insulation fabric.
6. Where individual H.V. coils are designed to have too great a radial depth, compared to its height, hot spots may develop in the interior of the coils due to in adequate oil passage allowed. The insulation becomes brittle and short circuit between turns may result.
7. Over heat on load occurs badly soldered joints and oil gets carbonized locally. The heat at the joints will be conducted to a certain length in the copper coil and the insulation may get carbonized to a little extent resulting in a short circuit between turns.
8. When external short circuit occurs, the coils get displaced violently as a result of the internal imbalance in electromagnetic conditions.
9. Sustained heavy over loads produce high temperature throughout the transformer. The coil insulation becomes brittle and in the course of time flakes off the conductors at places resulting in short circuit between turns. Transformers with a high ratio of copper losses to iron losses are less able to withstand over load and are therefore more liable to fail on account of sustained over loading.
10. The tap adjusting leads should be carefully handled to ensure that wrong leads are not joined otherwise part of winding may get short circuited and heavy currents circulate in the short circuited windings which would produce a fault between turns.
11. It is to be ensured that bolted joints and all connection are tightly screwed and locked lest they may become loose in service due to vibrations produced and such joints get heated up rapidly.
12. When a transformer is switched off the magnetizing current and thus the magnetic flux tends to collapse instantaneously. Due to various reasons this some time does at a much more rapid date than corresponding normal cyclic rate of change and as a result high voltage rises may occur.
13. Short circuit between turns, break-down of windings to earth and puncture of insulation may take place due to following phenomenon:-
(a) Lightening surges reaching the transformer, usually for the damage in the surge impedance and coils get damaged as they take the burnt of the shock.
(b) Excessive voltage set-up by surges may be accent rated at open ended tappings, at any point of change of surge impedance like at termination of conductor reinforcement where employed, spare between series coils, at the neutral or midpoint. Extra insulation is to be provided at these points.

2.4.4. FAILURES IN MAGNETIC CIRCUITS

1. The laminations are clamped together by inserting bolts through core and yoke. The bolts are provided with insulation around them which may give way. This total amount to a short in lamination causing local eddy currents. When this trouble occurs, in due two bolts simultaneously they form a short circuit turn through which magnetic flux passes. If one of the bolts situated at the ends of the limb fail simultaneously they form a short circuit turn through which magnetic flux passes. If one of the bolts situated at the ends of the limb fail simultaneously with an adjacent bolt-in-the yokes. The patch between the two bolts is threaded by almost the entire value of the magnetic flux when passing from the core to the yoke. The heat generated is so severe to

cause a distortion of the whole core also causing charring of the insulation and a resultant short circuit between turns of adjacent windings.
2. Failure may occur of insulation between lamination and insulation between yoke clamping bolts fails. This registers an increase in the iron losses of the transformer.
3. Core clamping bolts should be securely tightened and locked lest vibration will set up causing damage of core insulation and produce failures.
4. Care should be taken to ensure that the edges of the core and yoke lamination do not develop burns which produce local short circuit in the lamination.
5. No metallic fillings should be allowed to be present in between lamination in finished transformers which causes short circuit.

2.5. GENERAL REMARKS:
1. Almost all the parts in a transformer liable to failure on opening a failed transformer it is often very difficult to say definitely the reason for the failure as all evidence is eliminated by the very nature of the break down. Consequently the cause of failure is only a matter of guess.
At best: A close idea of the real cause may be obtained by a careful study of the transformer and the operating conditions obtaining at the time of failure of transformers and also the weather conditions.
2. Careful design and construction on the part of the manufacturer, without sub-ordinating quality to competition in market is necessary, on the part of purchasers also the economic behind the purchase should not be arrive at by cost alone but by performance guarantee.
3. Timely preventive maintenance is the back bone for safe and efficient operation of any electrical equipment the maintenance scheduled as well as the construction standards drown up by the APCPDCL are exhaustive enough to detect and prevent a possible failure ahead. If these are adhering it may be possible to reduce the failures to a large extent.

2.6 PRE –COMMISSIONING TESTS
The following tests are to be done before commissioning a distribution transformer. These are termed as pre-commissioning tests.
1. Megger Test: **-** This test is to be done with a 1000v megger. At normal ambient temperature the I.R.Values should not be less than the following.

H.T. to Body	-	150 MegaOhms
L.T. to Body	-	100 Mega Ohms
H.T. to L.T.	-	150 Mega Ohms

b) Whenever possible and alternate L.T. Supply is available L.T. Supply may be given to the H.V. Terminals and the voltages on L.V. side measured between phase and phase and phase and neutral. This not only confirms the correctness of tap operation and healthiness of transformers but also gives scope to identify the neutral bushing.

2.7. TESTS BEFORE DECLARING THE TRANSFORMER SICK
Instances are not remote when section officers have handed over healthy transformer as a sick-unit. They appear to have been mislead by repeated blowing off the H.G. Fuses presembly due to placing lower gauge fuses or due to reasons other than faults in the transformers. Replacing of H.G. Fuses is to be properly done. Usage of under size fuses result in frequent blowing off H.G. fuses and switching surges decreases the useful life of a transformer.
They are advised to do the following tests at site of L.T. Supply is available or at their section office before declaring it sick.
(a) Megger test H.V. to body and L.V. to body and see if satisfactory I.R. values or obtained. If not it can be declared sick straight away.
(b)If I.R. values are o.k., conduct ratio test, if unequal voltages are obtained the transformer is sick.