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Case Study on Averting Distribution Transformer Failure

Classification of Failure

Major	Minor
1. Insulation Failure	1. Oil Sample not Satisfactory
2. Damage to HT Coil	2. Lead connections cut of
3. Damage to LT Coil	3. Worn-out Bushing rods
4. Damage to Core & Laminations	4. Broken Bushings
5. Failure of Tap Switch & Tap arrangement	5. Gasket Leakage
	6. Welding Leakage
	7. Leakage thro' Valves
	8. Broken guage glass
	9. Broken vent diaphragm
	10. Worn-out Breather

Care to be Exercised to Avoid Failure

In Manufacturing Stage	During Transport	In Working Conditions
1. Proper insulation arrangement. 2. Mechanical rigidity to withstand heavy forces. 3. Adequate cooling arrangement. 4. Adequate quantity of oil for insulation & cooling. 5. Maintaining atmospheric pressure inside with pure air.	1. Safe handling during transport and erection. 2. Adoption of standards for erection of transformer structure.	1. Maintenance of oil level. 2. Maintenance of Breather with silicagel & oil seal. 3. Periodical testing of IR Values. 4. Periodical tests in transformer. 5. Earth resistance values and Earth maintenance.

In Manufacturing Stage	During Transport	In Working Conditions
6. Rigid fixing of core coil unit inside main tank. 7. Pucca earthing of core & other metallic parts.	3. Utilizing standard methods of lifting of Transformers i.e crains, chain pulley instead of handling by pulling through bushings.	6. Keeping standard voltage & current at load terminals. 7. Maintaining LAS to prevent damage due to surges. 8. Maintaining LT System 9. Keeping the loading within the limits. 10. Standard Construction of LT lines.

Examination of failed Distribution Transformers

External Check up	Internal Physical Verification	Healthiness Test
1. Oil level and Quantity available. 2. Places of oil leakage 3. Condition of Breather & silicagel. 4. Condition of Bushing & Bushing rods. 5. Condition of Vent Diaphragm.	1. Conditions of HT coils in all the three phases. 2. Checkup of lead connection from coil (Delta & Star points) 3. Condition of core. 4. Condition of Tap switch and connections.	1. By injecting 15V on LV side & measuring stack voltage of HT coil.

External Check up	Internal Physical Verification	Healthiness Test
6. Condition of Valves. 7. IR Value & continuity. 8. BDV Test on oil.	5. Condition of Core earthing. 6. Presence of sludge & moisture in oil & physical condition of oil.	2. Short circuit test by injecting 400V on HV side & short circuiting the LV side.

Case Studies on Averting Distribution Transformer Failure

Details of Defects Noticed at Field	Observation at Lab	Probable Cause for the Defects	Rectification done and suggestions to avoid recurrence in future
Case 1: All 3 HT Fuses blows out slowly after 1 Hour (Examined at Field)	**Case 1:** HT Leads insulation near top of bushing found charred	**Case 1:** Conservator oil level below bushing rod. Absence of oil around caused heating of leads.	**Case 1:** Insulation Sleeves changed. Higher oil level was asked to be maintained.
Case 2: Oil spurt out (Similar happening on previous transformers also)	**Case 2:** B Phase end windings (Top and Bottom found shattered)	**Case 2:** Lightning surges entered and caused shattering. (Area prone to lightning)	**Case 2:** Coil rewound and sent. The previous failure was also in same “B” Phase. Asked to examine HT LAS of “B” Phase. All three LAS Changed and no such failure thereafter.
Case 3: Undue heating in LT Rod. “R” Ph. Rod worn out and insulation tape charred.	**Case 3:** “R” Phase rod inside connection loosened.	**Case 3:** Connection loosened due to improper handling of bushing during jumper connections.	**Case 3:** Connections tightened and sent for use. Advised to use checknuts and proper handling.

Details of Defects Noticed at Field	Observation at Lab	Probable Cause for the Defects	Rectification done and suggestions to avoid recurrence in future
Case 4: L.T. Voltage Measured- OK. But found drop in voltage when load is connected.	**Case 4:** Neutral Bushing Connection loosened inside.	**Case 4:** Improper handling of neutral bushing during meggering.	**Case 4:** Neutral connection set right and sent for use. Advised to handle bushing connections properly.
Case 5: LT Voltage- OK. But load in "R" Phase could not be loaded.	**Case 5:** LT & HT connection found alright. No visual defect SC test revealed no current in R Phase, full current in neutral.	**Case 5:** Examined the soldered connections in "R" Phase and found "R" Phase bottom delta connection improper. (not completely cut)	**Case 5:** Defective Connections resoldered and found OK. Improper soldering gave way during use.
Case 6: HT Fuse in all 3 Phases blown out.	**Case 6:** Inter turn short in R Phase- 3rd Stack Y Phase – 4th Stack B Phase- 2nd & 3rd Stack	**Case 6:** Suspected heavy absorption of moisture. Oil sample not satisfactory. Crackle test proved positive.	**Case 6:** All good stacks removed. Core with LT coil placed in Hot Air Chamber and dried. Failed coils replaced. Put into use after circulation and test.

Details of Defects Noticed at Field	Observation at Lab	Probable Cause for the Defects	Rectification done and suggestions to avoid recurrence in future
Case 7: HT Fuse frequently blows out in "B" Phase.	**Case 7:** Insulation of lead inside "B" Phase bushing found charred. All coils in Good condition.	**Case 7:** Insulation of lead inside "B" Phase Bushing found charred. All coils in Good condition.	**Case 7:** Advised the field to release Air monthly. Charred insulation replaced and sent for use.
Case 8: Informed that (a) No oil could be taken from sampling valve- oil not flowing out. **(b)** Oil level in conservator is full (attended at field).	**Case 8:** Examined at spot and observed that the "Field Report is correct."	**Case 8:** Examined at spot and observed that the "Field Report is Correct."	**Case 8:** Air trapped under the bottom portion and pushed the oil up. Advised to release air frequently through air plug and also through top lid
Case 9: HT in "R" Phase blown out. (Similar failure in 5 months)	**Case 9:** "R" Phase HT Coils failed with symmetry giving way. LT "R" Phase also failed.	**Case 9:** Due to Heavy Short Circuit forces because of intermittent feeding of fault current.	**Case 9:** LT "R" Phase conductor frequently touched nearby neutral. Fuse not blown. Earth value high- 30 Ohms. Asked to rectify earthing system and adopt proper LT fuse.

Details of Defects Noticed at Field	Observation at Lab	Probable Cause for the Defects	Rectification done and suggestions to avoid recurrence in future
Case 10: HT fuse blowing out on load. (attended at site)	**Case 10:** Oil level found upto core level only. Gauge glass showing OK level. HT Lead insulation charred due to heat. Coil alright.	**Case 10:** Gauge Glass indication misleading. Actually oil level is low.	**Case 10:** Gauge Glass cleaned. Block in air hole removed. Insulation of leads strengthened. Transformer put back in service OK.
Case 11: HT Fuse blown out LT IR Value Zero.	**Case 11:** All LT leads removed. Now LT Megger value is 30 M Ohms.	**Case 11:** “Zero” I.R. value is on LT leads & not in transformer.	**Case 11:** The LT lines and cables was asked to be inspected and defects rectified.
Case 12: HT Fuse is blown out.	**Case 12:** Core & channel short circuited with “C” Phase coil top stack and leads. Earthing of core not found..	**Case 12:** Core not kept earthed (not provided after repairs). Stray Voltage caused short circuit.	**Case 12:** Advised the field to revamp earthing system. Transformer condemned since laminations got charred.

Details of Defects Noticed at Field	Observation at Lab	Probable Cause for the Defects	Rectification done and suggestions to avoid recurrence in future
Case 13: Transformer changed for two times due to unequal voltage.	**Case 13:** No fault in the two transformers brought to Lab.	**Case 13:** Advised to inspect the line for any jumper cut.	**Case 13:** Reported that one phase line cut on load side with incoming three phase intact in pin insulator (Location in the midst of a lake full of water.)
Case 14: Removed as unequal voltage. IR value and continuity OK.	**Case 14:** Delta connection cut in bottom of “B” Phase.	**Case 14:** May be due to ageing and wear & tear.	**Case 14:** Continuity test is OK since it is connected in Delta. Soldered and sent for use.
Case 15: HT Fuse blown out. IR value and continuity OK.	**Case 15:** “B” Phase coil inter-turn short in 2^{nd} stack. No shattering of coils/ contacting with Earth.	**Case 15:** Insulation failure due to ageing. Since no earth contact of winding, IR values are OK.	**Case 15:** Failed stack replaced and sent for use. Flexibility of connection increased and soldered with rod.

Details of Defects Noticed at Field	Observation at Lab	Probable Cause for the Defects	Rectification done and suggestions to avoid recurrence in future
Case 16: Unequal voltage. Continuity not found with the “B” Phase HT.	**Case 16:** HT lead in “B” bushing rod, come out.	**Case 16:** The lead was tight. Hence came out from Rod.	**Case 16:** Flexibility of connection increased and soldered with Rod.
Case 17: Oil Sample not satisfactory for 3 consecutive tests.	**Case 17:** Found heavy sludges & moisture absorption IR value low. Found vent pipe diaphragm broken. Gauge glass broken. Breather all right.	**Case 17:** Sludging due to ageing, water entry through vent pipe & gauge glass.	**Case 17:** Oil completely discharged. Core and coil cleaned. Dried in chamber. Put hot oil circulation with new oil and tested OK.
Case 18: Frequent failure of certain make transformer.	**Case 18:** Causal examination revealed low quantity of oil than that at name plate- 260 Ltrs. Available 30 Ltrs.	**Case 18:** Non availability of sufficient oil-very small spacing between tank & core and top cover, leads to failure.	**Case 18:** Taken up with company by Purchase wing. (Ineffective cooling system)

Problems and their Possible Solutions Related to the Distribution Transformers

Distribution Transformer-

Distribution transformers of different ratings are being used in the cities and they are being loaded indiscriminately. Absence of Proper and adequate protection on the HT and LT sides of these transformers, improper cable connections on the LT side and improper earthing are the main sources of the trouble.

It is suggested that:-

1. Two or three standard sizes of transformers should be selected and used, e.g.400, 250, and 100 KVA in general. Individual connections of Jal Nigam and others may, however, require use of smaller capacities.

2. Normal loading on these transformers should not be allowed to exceed 60% of their rating and fresh transformers should be added expeditiously when the loading exceeds the above limit.

3. The protection to be provided on the transformers should be standardized.

4. The size of the LT cables and number of cables to be used should be standardized. It is suggested that 400 mm2 single core should be used for the incoming cables and 240 mm2 LT cables should be used for the outgoing connections. Two cables should be used for the 400 KVA transformers and one cable for the 250 KVA transformers in each phase. The LT studs of transformers of 400 KVA ratings should, therefore, have studs of bigger length to accommodate two cables.

5. It will be advisable to provide a set of false LT bushings and studs for the connections of cables so that the main studs/bushings are not subjected to frequent stresses due to damages of LT cables/lugs. Protection may be provided between these two sets of bushings.

6. The earthing connection of the transformers should be checked atleast once a year and corrected, if necessary.

7. The oil level, its dielectric strength and loading of the transformer should be checked atleast twice a year and while replacing a transformer it should invariably be checked by Engineer.

LT Distribution System-

The LT distribution system is the most important one from the point of view of consumers and the Losses. But the tragedy is that this is most neglected one. The network grows haphazardly and with out taking into account the future growth. It is suggested that:-

1. The size of conductors should be prescribed for the LT mains. For this purpose ACSR Dog may be prescribed for the mains, Raccoon for the branches and Rabbit for the minor branches.

2. Properly graded fuses should be provided on the tee-off points.

3. The LT circuits should be taken out through properly rated fuse units connected to the busbars on the LT side of the transformers/LT ACBs as the case may be.

4. Each circuit should be loaded to a limit of 50% under normal operation conditions and if the loading exceeds 60% the mains should be strengthened before the loading reaches 75%.
5. The mains in the lanes, where the horizontal clearance is the main problem, which are overloaded or have decayed over the years of use should be renovated by using insulated conductors of capacity which is double of the present loading.
6. A number of LT faults are created due to trees branches touching the conductor. Regular lopping and chopping of tree branches shall definitely avoid LT faults and thereby reducing heavy currents in LT circuit.

Service Connections-

The cable size for the connections have already been prescribed for light & fan and small & medium power connections and these are to be followed. In case of large and heavy power connections, however, the cable sizes have to be properly selected taking into account the various derating factors. Use of lugs/clamps and sealing the connections at the tapping points will help in reducing the jumper faults and oxidation. Aerial fuses have gradually vanished from the scene and they are to be revived.

The general tendency while selecting the size of the cables is to take into account only the normal loading conditions. The fault current rating or the Short-time rating should also be taken into account, specially in case of the HT connections.

Storage & Handling of insulating oils-

Generally oil is received in 210 Ltrs. Capacity M.S. Steel barrels.

Following care should be exercised in storage and handling of barrels-

1. Rough handling of drums should be avoided.
2. Drums should not be kept in open but should be stored under cover.
3. Drums should not be kept in vertical position with its plug on the top.
4. It should be placed in horizontal position in such a way that there is a head of oil on the stopper or plug to prevent the entry of water or moisture.
5. Oil from drums should always be treated before use.
6. Vessel or drum for handling of oil should always be clean, free from dust, dirt contaminants or moisture. Flexible pipe and hand pumps used for taking out and filling oil should also be clean, their end be covered properly so as to avoid being contaminated.

Appearance (Few Thumb Rules to be applied to know the health of T/f oil)-

1. Colour:- The colour of oil darkens with the age. Very dark colour may suggest excessive oxidation.

2. Clarity:- Cloudiness if it appears while cooling of oil sample, is indication of presence of moisture which can be confirmed by crackle test. If cloudiness is present when oil sample is warm and oil does not become clear even after heating, it is an indication of contamination. A greenish tinge will indicate presence of copper slats which usually occurs during advance stage of deterioration of oil.

3. Smell- (1) Gassy smell suggests the crecking of oil.
   (2) A Strong acid smell suggests the presence of excessive amount of volatile acids due to deterioration of oil.
   (3) A pungent acetylene like smell which is common in oil samples drawn from switchgear, if present in oil sample drawn from a transformer indicates gas formation due to arcing or hot spots etc.

Final conclusions have to be drawn only after the others tests are made and not merely on the basis of above observations.

Electric Strength (Breakdown Voltage) Test:-

When a new oil is filled the minimum breakdown voltage should be 40 KV for one minute with2.5 mm gap. This value falls during service when the oil is contaminated due to dust, water, other extraneous matters or dissolved gases etc. During service the breakdown voltage should not fall below 30 KV for one minute for 2.5mm gap of electrodes. If the values goes down, oil should be filtered to removed the contaminants.

For power transformers the minimum breakdown voltage during service may be kept above 40 KV.

HOW TO MINIMIZE THE DAMAGED RATE OF TRANSFORMER

A lot of things are thought to be done but the outcome is not as desired by you because of-

1- Lack of Knowledge

2- Lack of Will

3- Lack of time

4- Lack of Money

First two components i.e. lack of knowledge and lack of will are in our hands and can be improved. The remaining two things are directly proportional i.e. time is money. You have lot of time to do work, you have a lot of money to earn.

Spend some time to save a transformer and thus save time to replace a transformer. Utilize the time saved for revenue realization and increase the revenue. Plan properly. Invest in system improvement.

Repeat the cycle and you will be successful.