Hello Friends,

Good to be in touch at the end of 2019. This issue was delayed due to some professional commitments outside India. You all will agree that 2019 was an year of mixed fortunes for Indian politics. In India as well as in most parts of the world industrial scene is almost tied with political scene. So in India even Industries had a mixed fortune. Some sectors are still reasonably comfortable while some have faced heat of SLOW DOWN. However, India is a big country and world says that our “Population” is our strength. So we will come out of this soon and there will be business for everyone. I think all of you will agree on one noticeable change that clients are getting more and more exposure and started demanding great services at most competitive prices. So all of us will have to be continuously on our tows as never before to keep pace with new technologies and new avenues.

CEEAMA GC is working hard on organizing CEEAMATECH 2020 scheduled on 8th Feb 2020. Let us get ready to know more exciting things about Industry 4.0 and it’s relevance to us. We are glad to inform you that M/S ABB has accepted to cohost our event and their CTO is going to deliver key note address. On international scene ABB is on forefront in implementing Industry 4.0 and has launched many products and services related to it. We are on the verge of finalizing few other eminent authorities on the subject who will address us in other sessions. I appeal you all to please register your participation as early as possible so that you do not miss the opportunity. As you all know one day CEEAMATECH event also gives all of us a very good opportunity to interact among ourselves and helps in networking.

Kindly find MSEDCL circular CE/Testing/N.Ester-C.C.FPI/33471 dated 4th Dec 2019 which now allows use of Natural Ester oil in transformers installed in basements and covered areas. This was a long pending issue bothering to Electrical safety Activists. However, the question “When MSEDCL/electrical inspectorate will implement this in all OLD transformers and will force users of all existing transformers to do so” is yet unanswered.

We are opening 2020 with third round table meet scheduled on 3rd Jan 2020 at Pune. We will discuss a relatively new and uncommon standard IS/IEC 62305 about lightening protection. It is seen in the market that lightening protection is taken lightly in most of the projects and actual compliance to standard is very rare. I will share the outcome of this in next issue.

CEEAMA GC wishes a very happy, prosperous and SAFE new year 2020 to all members and associates. As usual requesting more and more participation by all members. For any new ideas which can help CEEAMA grow, please contact me directly any time on +919822528734.

Goodbye for now.

Narendra Duvedi
Hon Secretary CEEAMA

Article: Uncommon tests on Transformers which help in life prediction.
Uncommon tests on Transformers which help in life prediction.

By: Narendra Duvedi

Considerable portion of Electrical infrastructure Investment is always in Power transformers. Power transformers are installed mostly at the entrance of electrical energy intake point of any establishment. Any abnormalities in grid power first hit the power transformer. Unless the application justifies commercially transformers are never used with redundancy. So transformer failure although it is not very common, can trigger grinding halt for a working establishment. Most of the time establishments have Diesel Generator set backups, but cost of energy generated is almost two times the utility cost and standby generators may not be rated for continuous duty.

A well – designed transformer should handle the load, while maintaining its load side power quality and voltage regulation within acceptable limits. Temperature rise also should be within limit.

A well-designed and systematically Type tested transformer having gone through Routine tests after manufacturing and also Pre commissioning tests after installation gives multiple decades of trouble-free service provided Preventive maintenance and some special diagnostic tests are carried out periodically during it’s working life and required maintenance is done intime.

It is observed that transformers installed in medium and large substations of utility companies are usually installed to cater expected loads for next 10 to 15 years – so most of the time they are capable of handling current loads without any problem. The maintenance during working life of these transformers usually depends upon culture of the organization.

The utility transformers catering to last mile residential and commercial loads in urban and semi urban area usually are neglected and suffer maximum due to overloading, poor / no maintenance etc.

Similarly, large corporate sector Industries usually have underloaded transformers. Many places HOT Standby transformers are also seen, which are kept charged from primary but are not loaded. Recently while auditing a chemical plant with 45MW running load, we came across almost 60MVA redundant capacity, causing more than 300KW no load loss, costing the company around Rs.3 Crores a year.

Above discussion suggests that a periodic check on transformer loading, justification for input supply redundancy and reshuffling of transformer loads and shutting down transformer which are not required for longer time, helps in reduction in wastage of electricity. Another main concern is to get 30 years plus working life from the transformer and predicting it’s deterioration to help allowing retrofitting and maintenance expenses.

The main issue about oil filled power transformers is, they can not be opened frequently for assessing health of windings and health of insulation. There are specific tests like Magnetic balance test, magnetizing current test, Dissolved Gas Analysis test, Furan test– which are not commonly done but are very useful if done with defined periodicity and results are monitored closely on “year on year” basis. Here is an attempt made to discuss some details about how these tests are carried out and how the results are interpreted to know physical condition of transformer windings and insulation.

1 Magnetic Balance Test of Transformer

Magnetic balance test of transformer is conducted only on three-phase transformers to check the magnetic circuit imbalance.

How is this test performed?

Three limbs of magnetic material are placed side by side in a transformer. One phase winding is wound on each limb. The voltage induced in different phases depends upon the respective position of the limb in the core. The voltage induced in different phases of a transformer in respect to neutral terminals given in the table below.

1. Keep the tap changer in normal position and disconnect neutral from ground
2. Apply single phase 230 V AC supply across one winding terminal and neutral.
3. Measure the voltage in two other terminals with respect to neutral.
4. Repeat the test for each of the three phases.
Interpretation of test results.

This indicates that the transformer is magnetically balanced. If there is any inter-turn short circuit that may result in the sum of the two voltages not being equal to the applied voltage.

2 Magnetizing Current Test of Transformer

Magnetizing current test of transformer is performed to locate defects in the magnetic core structure, shift of winding position, failure in between turn insulation or problem in tap changers. This may happen just after transportation from factory – loading / unloading etc. This can also happen due to low impedance short circuit – very near to transformer. These conditions may change magnetic circuit reluctance, and affect the current required to establish flux.

1. Keep the tap changer in the lowest position. Apply 415 V supply on the three-line terminals
2. Measure the supply voltage and current in each phase
3. Repeat the test with keeping tap changer in normal position
4. Repeat the test while keeping the tap at highest position
5. Compare the current with measured exciting current during factory testing or during previous testing.
6. If the test current is found within 25% of previous readings, usually the test is considered as satisfactory.
7. If the current measured is much more than the previous readings, there are chances that there is fault in the windings and needs further investigation for confirmation.

3 Furan Analysis Test

Mechanical properties like tensile strength of insulating paper are used to evaluate reliable life of paper insulation. Measurement of Degree of Polymerization (DP) of paper insulation is used for this prediction. Whenever the transformer is opened and detanked, such physical paper sample can be taken but for in service transformers it is required to draw inferences from transformer oil testing.

DP values of 150-250 are considered as end-of-life criteria for paper insulation; for values below 150, the paper is without mechanical strength. The results of this test will be a deciding factor in rebuilding or scrapping a transformer. When a cellulose molecule de-polymerizes (breaks into smaller lengths or ring structures), a chemical compound known as a furan is formed and it suspends in transformer oil. Measurement of quantity and types of furans present in transformer oil sample, the DP of paper insulation can be inferred. This also indicate abnormal stress in a transformer. It may be intense, short duration overheating or prolonged, moderate overheating. Furan analysis can be used to confirm Dissolved Gas Analysis where carbon monoxide present indicates problems with solid insulation. It has been shown that the amount of 2-furaldehyde in oil (usually the most prominent component of paper decomposition) is directly related to the DP of the paper inside the transformer. Paper in a transformer does not age uniformly and variations are expected with temperature, moisture distribution, oxygen levels and other operating conditions. The levels of 2-furaldehyde in oil relate to the average deterioration of the insulating paper. Consequently, the extent of paper deterioration resulting from a “hot spot” will be greater than indicated by levels of 2-furaldehyde in the oil. New Kraft paper has a DP in excess of 1200, and paper with a DP of 200 or less is considered to be unfit.

Other Diagnostic Compounds The presence of phenols and cresols in concentrations greater than 1 ppm indicate that solid components containing phenolic resin (laminates, spacers, etc.) are involved in overheating. The values can be optimistic if the oil has been regenerated within the last two years. This data should be evaluated in conjunction with routine chemical analysis and transformer history.

4 Dissolved gas analysis (DGA)

This test is the study of dissolved gases in transformer oil. Whenever a transformer undergoes abnormal thermal and electrical stresses, certain gases are produced due to the decomposition of the transformer oil. When the fault is major,
the production of decomposed gases are significant and are collected in Buchholz relay. But when abnormal thermal
and electrical stresses are not significantly high the gasses due to decomposition of transformer insulating oil will get
enough time to dissolve in the oil.

Hence by only monitoring the Buchholz relay it is not possible to predict the condition of the total internal
healthiness of electrical power transformer. That is why it becomes necessary to analyze the number of different
gasses dissolved in transformer oil in service. In a DGA test, the gases in oil are extracted and analyzed to determine
the quantity of gasses in a specific volume of oil. By observing the percentages of different gasses present in the oil,
you can predict the internal condition of the transformer.

Generally, the gasses found in the oil in service are hydrogen (H2), methane (CH4), Ethane (C2H6), ethylene (C2H4),
acetylene (C2H3), carbon monoxide (CO), carbon dioxide (CO2), nitrogen (N2) and oxygen(O2). This test uses
Vacuum Gas Extraction Apparatus and Gas Chronographs. Using this apparatus, gasses are extracted from oil by
stirring it under vacuum. These extracted gasses are then introduced in gas Chronographs for measurement of each
component.

The experience shows that hydrogen and methane are produced in large quantity if the internal temperature of
power transformer rises up to 10DegC to 300DegC due to abnormal thermal stresses. If the temperature goes above
300oC, ethylene (C2H4) is produced in large quantity. If temperatures are higher than 700DegC a large amount of
hydrogen(H2) and ethylene(C2H4) are produced. If during DGA test of transformer oil, CO and CO2 are found in large
quantity it is predicted that there is decomposition of proper insulation.

Below is a table derived from ANSI/IEEE. The suggested action levels for key gas concentrations are also provided:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Normal limits &lt;</th>
<th>Action Limits &gt;</th>
<th>Fault prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen H2</td>
<td>150</td>
<td>1000</td>
<td>Corona Arcing</td>
</tr>
<tr>
<td>Methane CH4</td>
<td>25</td>
<td>80</td>
<td>Sparking</td>
</tr>
<tr>
<td>Acetylene C2H2</td>
<td>15</td>
<td>70</td>
<td>Arcing</td>
</tr>
<tr>
<td>Ethylene C2H4</td>
<td>20</td>
<td>150</td>
<td>Severe Overheating</td>
</tr>
<tr>
<td>Ethane C2H6</td>
<td>10</td>
<td>35</td>
<td>Local overheating</td>
</tr>
<tr>
<td>Carbon Monoxide CO</td>
<td>500</td>
<td>1000</td>
<td>Severe Overheating</td>
</tr>
<tr>
<td>Carbon Dioxide CO2</td>
<td>10000</td>
<td>15000</td>
<td>Severe Overheating</td>
</tr>
<tr>
<td>Total combustibles</td>
<td>720</td>
<td>4630</td>
<td></td>
</tr>
</tbody>
</table>

It is recommended that these tests should be carried out every year or every two years and the record of parameters
should be maintained for comparative study. A careful analysis of this comparison helps in deciding preventive
maintenance schedules and arranging shutdown etc. It is also observed that expenses of these tests are not
prohibitive compared to there usefulness.
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CE/Testing/N.Ester-C.C.-FPI/ No 3 3 4 7 i Date: 4 DEC 2019

CIRCULAR

Sub: Approval for use of latest technology material in MSEDCL i.e. Natural Ester, HT Covered conductor and Fault Passage Indicator.

A proposal to use new technologies in MSEDCL distribution network system was submitted to the Board. The Board vide BR No 1941 dated 07/11/2019 has given approval to use following technologies in network at specific locations-

1. Natural Ester Oil filled Transformers, 
2. Insulated conductors for HT overhead lines (Covered Conductors) and 
3. Overhead Line Fault Passage Indicators (FPI).

1. **Natural Ester Oil Filled Transformers:**
   - Existing mineral oil used in transformers is not bio-degradable and has low flash point (140°C and fire point 150°C). Further, the mineral oil requires periodical maintenance (filtration). There are many incidences of fatal and non-fatal accidents due to transformer oil flashover.
   - Natural Ester Oil is bio-degradable and has much superior properties in terms of flash point (minimum 250°C as compared to 140°C of mineral oil). Fire point (minimum 300°C as compared to 150°C of mineral oil). Hence, the incidences of catching fire by oil can be reduced, if natural ester oil is used in such cases. Natural Ester Oil does not require periodical maintenance and has greater moisture tolerance. The Chief Electrical Inspector, PWD, GoM, has allowed to use Natural Ester Oil for sealed transformers to be used in the basement area of high-rise buildings also.

2. **Covered Conductor:**
   1. It is observed that there are many fatal or non-fatal electrical accidents and power interruptions occurring due to touching of tree branches to the live conductors and less clearance of overhead lines which have bare conductors strung on the poles.
   - It is also observed that at some places where there is crossing of gaathann feeder and agriculture feeder, illegal hooking from gaathann feeder to agriculture feeder is done for illegally using electricity for agriculture more than stipulated period.
   - The cost of covered conductors and associated accessories is much less than the underground cable, which becomes very costly affair, if RI charges are required to be paid.
   - The advantages of using covered conductors has been already observed at Thane and Washim circle.
3. **Fault Passage Indicators**:

At present, whenever fault occurs on HT line, patrolling has to be done physically for detecting any fault on the line and line can be charged only after physically isolation of faulty section. It takes long time for carrying out this activity, due to which interruption period increases and large number of consumers are affected. The problem is more severe for long HT line catering power supply to Industries and Towns. The above problem of delay in restoration of power supply can be addressed to large extent if Fault Passage Indicators (communicable or non-communicable) are used at long 'T' point of lengthy feeders.

- The indication (communicable / non-communicable) of the fault passage indicator will enable to the lineman to know the location of faulty section of the line immediately and after isolating that faulty section, the power supply can be restored immediately, thus reducing the interruption period and consumers unrest thereof.

- The fault passage indicators for underground cable are already being used by MSEDCL at RMU locations and its usefulness has been also observed.

In view of above, it is to inform that the Board of Directors vide Board Resolution no.1941 dated 07/11/2019 has accorded approval for adopting these technologies in MSEDCL as under:

a. To use of Natural Ester Oil filled sealed distribution transformers and power transformers at crowded locations of towns and tourist places and basement of high-rise buildings.

b. To use insulated/covered conductors to replace the existing overhead HT lines passing through crowded places, narrow lanes having less clearances from buildings. HT lines passing through trees of forest or elsewhere and at crossing of gatcchan and AG feeder.

c. To use communicable fault passage indicators on Industrial feeders and high revenue feeders and to use non communicable fault passage indicators on long HT feeders having long tap lines.

This is for your information and immediate necessary action for implementation please.

(\textsuperscript{Dr. Manish Kath})  
Chief Engineer (Testing)

\textbf{Copy s.w.r.to:-}

1) The Director (Operations)/(Projects)/(Commercial), Corporate Office, MSEDCL.

2) The Executive Director (O&M),MSEDCL, Corporate Office, Mumbai.

\textbf{Copy to:-}

All field offices, MSEDCL (as per mailing list)
Intractive Session - ABB India Ltd. Mumbai on 16 November 2019
on Journey to Industry 4.0: IOT Based ABB Ability EDCS & Futuristic EMAX 2