Indian Transformer Manufacturers Association
2F CS-11, Ansal Plaza, Sector-3, Near Vaishali Metro Station
(Opp. Bhushan Steel), Vaishali, Ghaziabad - 201010 (U.P.)
Phone : 0120-4566119 Fax : 0120-4116651
E-mail : itma_2006@airtelmail.in, itma_2006@itma.org.in
Website: www.itma.org.in

GENTLE REMINDER

ITMA/11 /2019 CIRCULAR NO. 208/2019 18th January 2019

To All Members,

Sub: **Draft guidelines for operation & maintenance of Distribution Transformers**

Dear Member,

This is in continuation to our Circular No.185/2018 dated 27th November 2018 followed with Circular No. 193 dated 10th December 2018 and Circular No. 203/2019 dated 11th January 2019 (copy attached) . We have received inputs from M/s Cargill India Pvt. Ltd only w.r.t maintenance of oil in the transformer whereas there is no response from any member on the document. CEA is pressing hard for the inputs of the association on the various chapters/clauses of the document, as it has been delayed considerably.

You are once again requested to go through the document and offer your critical observations/comments on the document on or before 23rd January 2019 positively failing which we shall be constraint to forward the document to CEA stating that the same is in order and may peruse for further necessary action in the matter.

Thanking You
With best regards

[B.LAL]

DIRECTOR GENERAL
Encl: As Above

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2F CS-11, Ansal Plaza, Sector-3, Near Vaishali Metro Station
(Opp. Bhushan Steel), Vaishali, Ghaziabad - 201010 (U.P.)
Phone : 0120-4566119 Fax : 0120-4116651
E-mail : itma_2006@airtelmail.in, itma_2006@itma.org.in
Website: www.itma.org.in

REMINDER

ITMA/11 /2019 CIRCULAR NO. 203/2019 11th January 2019

To All Members

Sub: Draft guidelines for Operation & Maintenance of Distribution Transformers
Ref: Comments/observations on the Draft guidelines for Operation & Maintenance of Distribution Transformers prepared by CEA.

Dear Members,

This is in reference to our circular No. 185/2018 dated 27th November 2018 followed by reminders dated 10th December 2018 copy attached requesting therein to go through the subject guidelines prepared by CEA and offer your views/observations or comments if any so as to make this document a foolproof to be adopted for Operation & maintenance of Distribution Transformers by all the Discoms/Utilities at National Level in order to contain the failure rate of Distribution Transformers, which generally have been attributed to poor O & M by Discoms/Utilities.
Kindly do the needful at the earliest as it is already delayed.

Thanking You

With best regards

[B.LAL]
DIRECTOR GENERAL

Indian Transformer Manufacturers Association
2F CS-11, Ansal Plaza, Sector-3, Near Vaishali Metro Station
(Opp. Bhushan Steel), Vaishali, Ghaziabad - 201010 (U.P.)
Phone : 0120-4566119 Fax : 0120-4116651
E-mail : itma_2006@airtelmail.in, itma_2006@itma.org.in
Website: www.itma.org.in

ITMA/11 /2018 CIRCULAR
NO. 193/2018 10th December 2018

To All Members

Sub: Draft guidelines for Operation & Maintenance of Distribution Transformers

Dear Members,

This is in reference to our circular No. 185/2018 dated 27th November 2018 copy attached requesting therein to go through the subject guidelines prepared by CEA and offer your views/observations or comments if any so as to make this document a foolproof to be adopted for Operation & maintenance of Distribution Transformers by all the Discoms/Utilities at National Level in order to contain the failure rate of Distribution Transformers.

You are again requested to go through the draft guidelines and suggest the changes if any as per your experience and present practice prevailing in the industry, so that these guidelines could be made more effective after incorporating the inputs/suggestion from members.

Kindly forward your inputs at the earliest.

Thanking You

With best regards

[B.LAL]
DIRECTOR GENERAL
Encl: As Above

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2F CS-11, Ansal Plaza, Sector-3, Near Vaishali Metro Station
(Opp. Bhushan Steel), Vaishali, Ghaziabad - 201010 (U.P.)
Phone : 0120-4566119 Fax : 0120-4116651
E-mail : itma_2006@airtelmail.in, itma_2006@itma.org.in
Website: www.itma.org.in

ITMA/11 /2018 CIRCULAR NO. 185/2018 27th NOVEMBER 2018

To All Members

Sub: Draft guidelines for Operation &Maintenance of distribution transformers

Dear Members,

As you are aware that there was a general observation that the DTs after installation by the utilities/discoms are not being properly maintained and operated as per standard norms resulting in pre-mature failure . The failure is normally attributed to transformer manufacturers and is asked to repair/replace the DT within the warrantee period which is 5 to 6 years which is being misused by the utilities/discoms to cover up their O&M lapses . Accordingly meeting was convened at the instance of ITMA with Member GO&D, CEA who was requested to issue advisory to utilities/discoms to operate & maintain the DTs as per the standard norms. CEA agreed to modify guidelines for operation & maintenance of DTs strictly to be adhered to by utilities/discoms in order to contain the failure rate of DTs in the system.

Accordingly now CEA has prepared the modified draft guidelines for operation & Maintenance of distribution transformers which are attached herewith for your kind perusal. The guide lines are in rudimentary stage and is yet to be finalized.

You are requested to go through the draft guidelines and suggest the changes if any as per your experience and present practice prevailing in the industry, so that these guidelines could be made more effective after incorporating the inputs/suggestion from members.

Kindly forward your inputs at the earliest.

Thanking You

With best regards

[B.LAL]
DIRECTOR GENERAL
Indian Transformer Manufacturers Association [ITMA]
2F CS-11, Ansal Plaza, Sector-3,
Near Vaishali Metro Station
(Opp. Bhushan Steel] Vaishali,
Ghaziabad-201 010. U.P
Phone: 0120-4566119. 4116651 Fax: 0120-4116651
E-mail: itma_2006@itma.org.in/ itma_2006@airtelmail.in/itma2006@gmail.com
Encl: As Above
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Guidelines

for

operation and maintenance

of

Distribution Transformers

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ABBREVIATIONS

BEE	Bureau of Energy Efficiency
CEA	Central Electricity Authority
CRGO	Cold Rolled Grain Oriented
DT	Distribution Transformer
DTM	Distribution Transformer Manufacturers
EMD	Earnest Money Deposit
HV	High Voltage
ICPCI	International Copper Promotion Council India
ITMA	Indian Transformer Manufacturers Association
L1	Lowest
LV	Low Voltage

OLTC	On Load Tap Changer
PBG	Performance Bank Guarantee
R-APDRP	Restructured Accelerated Power Development & Reforms Programme
RF	Radio Frequency
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
T&D	Transmission & Distribution
VA	Volt Ampere

Introduction

Power Sector in India

Growth of Power sector is key to the economic development of the country as it facilitates development across various sectors of the economy, such as manufacturing, agriculture, commercial enterprises and railways. Since Independence the Power Sector in India has grown considerably. However, the enactment of Electricity Act, 2003, has brought in revolutionary changes in almost all the areas of the sector. Through this Act a conducive environment has been created to promote private sector participation and competition in the sector by providing a level playing field. This has led to significant investment in generation, transmission and distribution areas. Regional grids have been integrated into a single national grid with effect from 31.12.2012 thereby providing free flow of power from one corner of the country to another through strong inter regional AC and HVDC links. As a result, the All India peak demand (MW) as well as energy (MU) shortage have registered steady decline.

The Government of India has identified power sector as a key sector of focus so as to promote sustained industrial growth. Many initiatives have been taken by the Government of India to boost the Indian power sector.
The Government of India has released its roadmap to achieve 175 GW capacity in renewable energy by 2022, which includes 100 GW of solar power and 60 GW of wind power. The Union Government of India is preparing a 'rent a roof' policy for supporting its target of generating 40 gigawatts (GW) of power through solar rooftop projects by 2022.
All the states and union territories of India are on board to fulfil the Government of India's vision of ensuring 24x7 affordable and quality power for all by March 2019, as per the Ministry of Power and New & Renewable Energy, Government of India.

Role of Distribution Transformers in power sector in India as well as Rural Electrification / Power for All / Urban Development

Distribution Transformers play a very important and vital role in delivering electricity to the last mile. It can be rightly said that the Distribution industry is bringing light in the life of the people. The thrust by the Indian Government to provide quality power to each village and every household through various schemes of electrification like DDUGJY/ IPDS/ RAPDRP/ Saubhagya has given a huge fillip to the demand of distribution transformers all over India.

The demand of Distribution transformers is catered majorly by the domestic Industry and the import of transformers is very marginal/ project specific. The Industry is dominated by unorganized MSME units which are spread all over India and are mainly supplying to their state utilities. There are large scale units also which apart from having Pan India presence are also engaged in export of transformers.

The transformers produced in India have been brought under mandatory BIS certification, resulting in standardization of the product, which has resulted in improvement of quality and reduction of failure of transformers. The distribution transformers have also been brought under mandatory BEE star labelling scheme which has resulted in the use of modern technology in manufacturing energy efficient transformers.

The demand of distribution transformers will keep on increasing due to increase in generation capacity of both conventional and non-renewable sources due to increase in per capita consumption of electricity and new avenues like electric vehicle charging stations etc. The demand will also increase due to replacement of old transformers with energy efficient transformers.

BACKGROUND

Distribution system in India is facing problem of high network losses and low supply quality. In addition to this, Distribution utilities also facing problem of high failure rate of Distribution Transformer leads to financial loss and reduced system reliability.

Distribution transformer as key elements of the power distribution network, failure of Distribution Transformers leads to failure of Distribution system and subsequent outage of which leads to financial loss in repair & replacement, loss of revenue and reduces quality & reliability of supplied power.

Distribution Transformer failure rate in India is very high in the range of 15% to 20% compared to the failure rate in developed country which is 1% to 2%. This high failure rate also leads to financial loss to the manufacturers if Distribution Transformer fails within warranty period and eventually loss of reputation in the market.

The following are the main reasons for high failure rate of distribution transformer:

- Improper practice to follow IS/IEC
- Lack of Skilled Technician
- Improper Manufacturing Practices
- Malpractices in procurement process
- Improper Operation & Maintenance Practices
- Ageing of assets; and
- Unavailability of funds

Considering this huge financial loss to the manufacturers and utilities, it necessitates the study of all aspects of Distribution Transformers from the purchase of raw material for the manufacturing of transformer at the manufacturer end to the operation and maintenance and repair of transformers at the utility end.

However, this study only includes the study of utility side aspects of distribution transformers which includes study of tendering process, tender selection process, installation process, operation & maintenance, repair process, scrapping process adopted by the utilities. The detail study of these aspects is carried out through site visit and consultation with utility official and technical staff and sector experts. The recommendations are also drawn at the end of the study for the improvement for existing situation of Distribution Transformers. These recommendations will help in reducing failure rate and improvement in performance of DTs and may also improve the financial health of utilities.

The challenges faced by the industry is the lack of mandatory guidelines for installation and maintenance of transformers, bad earthing practices, overloading of transformers, tampering/ bypassing the protection equipment, theft of material/ oil which leads to fire and failure of transformers. The payment position by the utilities, though has improved due to UDAY scheme and MSMED act, needs to be further streamlined.

The main raw material of transformers which accounts for major cost is CRGO/ Amorphous, is not produced in India and is wholly imported. The dearth of the same and its rate fluctuations hampers the timely supply of transformers. The supply of low grade /defective CRGO steel, though banned by the quality control order, entering through various ports is severely affecting the quality and cost of the transformers. The loopholes should be plugged and efforts should be made to start manufacturing of CRGO/ Amorphous core in India under ‘make in India program.

TRANSFORMER - KEY ELEMENT IN THE POWER SYSTEM

Distribution Transformer is an integral part of the Electricity Distribution system. Recent statistics shows that the about 4.24 million Distribution Transformers across 62 utilities are installed in India. The demand for the transformers is expected to grow at 8%. However, there are concerns over the quality of the distribution transformers supplied in the market. Most of the reasons are attributable to the poor raw material used, poor manufacturing, quality /testing practices and poor quality components of the transformers.

This study cuts across not only operation and maintenance practices of utilities but also procurement lifecycle of the transformers followed by the utilities, thus covering the current practices followed by the utilities.

This chapter addresses the technical elements of the transformers and covers various components of the transformers as well as the practices that need to be in place to ensure good quality product.

Basics of Transformer

A transformer is an electrical device that transfers energy from one circuit to another purely by magnetic coupling. Relative motion of the parts of the transformer is not required for transfer of energy. Transformers are often used to convert between high and low voltages, to change impedance, and to provide electrical isolation between circuits.

Transformers are adapted to numerous engineering applications and may be classified in many ways such as:

- By power level (from fraction of a watt to many megawatts),
- By application (power supply, impedance matching, circuit isolation),
- By frequency range (power, audio, RF)
- By voltage class (a few volts to about 750 kilovolts)
- By cooling type (air cooled, oil filled, fan cooled, water cooled, etc.)
- By purpose (rectifier, arc furnace, amplifier output, etc.).

• By ratio of the number of turns in the coils o Step-up: The secondary has more turns than the primary. o

Step-down: The secondary has fewer turns than the primary.

- Isolating: Intended to transform from one voltage to the same voltage. The two coils have approximately equal numbers of turns, although often there is a slight difference in the number of turns, in order to compensate for losses (otherwise the output voltage would be a little less than, rather than the same as, the input voltage).

- Variable: The primary and secondary have an adjustable number of turns which can be selected without reconnecting the transformer.

Distribution transformers are typically in the range of 16 kVA to 1 MVA and have LT voltage which is distribution voltage in the power system. In India, DTs have voltage levels of 11kV/433V, 22kV/433V, and 33kV/433V. These form large share of transformation capacity in the power system and are subject matter of discussion in this report.

Construction of the Transformer

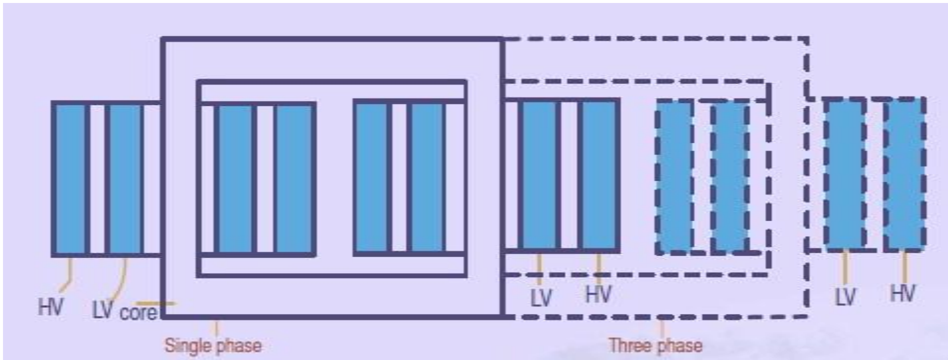
While the principle of operation of the transformers is same, construction of these transformers could be different depending upon the user requirements. Transformers of smaller sizes could be air cooled while the larger ones are usually oil cooled. The transformers are highly material intensive equipments and are designed to match the applications for best operating conditions. Here common construction aspects are discussed.
These can be broadly divided into:

- Core construction
- Winding arrangements
- Insulation
- Cooling aspects

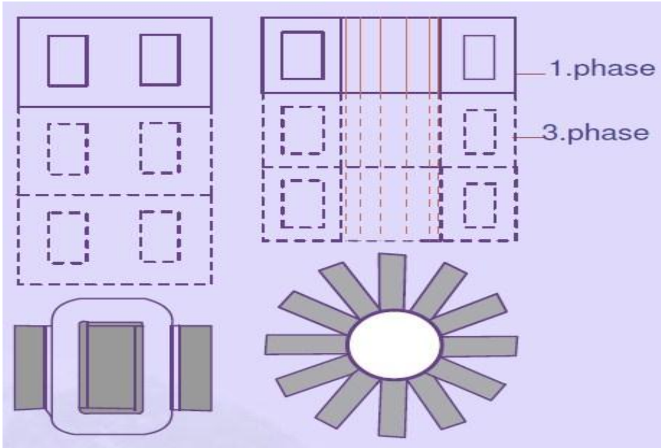
2.2.1 Core Construction

Transformer core for the power frequency application is made of highly permeable material. The high permeability helps in providing a low reluctance for the path of the flux and the flux lines mostly confine themselves to the iron. Relative permeability μr well over 1000 is achieved by the present day materials. Silicon steel in the form of thin laminations is used for the core material. Earlier, better magnetic properties were being obtained by going in for hot rolled non-oriented to hot rolled grain oriented steel. However, now better laminations in the form of Cold Rolled Grain Oriented (CRGO), High B (HiB) grades have become available. The thickness of the laminations has progressively reduced from over 0.5mm to the present 0.23mm or over 0.18mm per lamination. These laminations are coated with a thin layer of insulating varnish, oxide or phosphate. The magnetic material is required to have a high permeability μ and a high saturation flux density, a very low remanence Br and a small area under the B-H loop-to permit high flux density of operation with low magnetizing current and low hysteresis loss. The resistivity of the iron sheet itself is required to be high to reduce the eddy current losses. The eddy current itself is highly reduced by making the laminations very thin. If the lamination is made too thin then the production cost of steel laminations increases. The steel should not have residual mechanical stresses which reduce their magnetic properties and hence must be annealed after slitting and cutting.

Broadly classifying, the core construction can be separated into core type and shell type. In a core type construction the winding surrounds the core. A few examples of single phase and three phase core type constructions are shown in Figure 2.1(a). In a shell type, on the other hand, the iron surrounds the winding as shown in Figure 2.1(b).



(a) *Core type*



(b) *Shell type*

Figure 2.1: Core and Shell Type Construction of Transformer

In the case of very small transformers the conductors are very thin and round. These can be easily wound on a former with rectangular or square cross section. Thus no special care is needed for the construction of the core. The cross section of the core also would be square or rectangular. With the rating of the transformer, the conductor size also increases. Flat conductors are preferred to round ones. To wind such conductor on a rectangular former is not only difficult but introduces stress in the conductor, at the bends. From the point of view of the short circuit force withstand capability this is not desirable. Also, for a given area, the length of the conductor also increases. Hence it results in more load losses. In order to avoid these problems, the coils are made cylindrical and are wound on formers using heavy duty lathes. Thus the core construction is required to be such as to fill the circular space inside the coil with steel laminations. Stepped core construction thus becomes mandatory for the core of large transformers.

2.2.2 Windings

Windings form another important part of transformer. In a two winding transformer, two windings would be present. The one which is connected to the voltage source and creates the flux is called a primary winding. The second winding where the voltage is induced by induction is called a secondary. If the secondary voltage is less than that of the primary, the transformer is called a step down transformer. If the secondary voltage is more, it is a step up transformer. A step down transformer can be made to operate as a step up transformer by making the low voltage winding its primary. Hence it may be more appropriate to designate the windings as High Voltage (HV) and Low Voltage (LV) windings. The winding with more number of turns will be a HV winding. The current on the HV side will be lower as V-I product is a constant and given as the VA rating of the transformer. Also the HV winding needs to be insulated more to withstand the higher voltage across it. HV also needs more clearance to the core, yoke or the body. These aspects influence the type of the winding used for the HV or LV windings.

2.2.3 Insulation

The insulation used in the case of electrical conductors in a transformer is varnish or enamel in a dry type transformer. In larger transformers to improve the heat transfer characteristics the conductors are insulated using un-impregnated paper or cloth and the whole core winding assembly is immersed in a tank containing transformer oil. The transformer oil thus has dual role. It is an insulator and also a coolant. The porous insulation around the conductor helps the oil to reach the conductor surface and extract the heat. The conductor insulation may be called the minor insulation as the voltage required to be withstood is not high. The major insulation is between the windings. Annular Bakelite cylinders serve this purpose. Oil ducts are also used as part of insulation between windings. The oil used in the transformer tank should be free from moisture or other contamination to be of any use as an insulator.

Distribution Transformer

Transformer, which is used for the purpose of distribution of power is called Distribution Transformer. As a result, LT side of the DT has the voltage level at which power is distributed to end consumers. In India, typical voltage level of DT is 11kV/433V. Standard KVA ratings of DT are – 16, 25, 63, 100, 160, 200, 250, 315, 400, 500, 630, 750, 1000, 1250, 1500, 2000, 2500KVA. DTs are typically three phase, however, some distribution systems also use single phase DTs. IS-2026 is a standard used for distribution transformers.

DTs are typically installed on poles or structures along side roads and use natural cooling mechanism i.e. Oil Natural – Air Natural (ONAN). Amongst all types of transformers, Distribution transformer is the most important type of transformer in any power system.

Losses in Transformer

Like all other instruments, transformers aren't perfect devices; they don't convert 100% of the energy input to usable energy output. The difference between the energy input and output is quantified as loss. There are two types of transformer losses: no-load losses and load losses.

2.4.1 No-load losses

The losses incurred in the transformer, even when no energy is being transformed are referred to as No-load losses. These are also referred to as core losses. This loss is calculated based on the amount of power required to magnetize the core of the transformer. Since most distribution transformers are energized 24/7, no-load losses are present at all times, whether a load is connected to the transformer or not. When it is lightly loaded, no-load losses represent the greatest portion of the total losses.

2.4.2 Load losses

Load losses, on the other hand, are the losses incurred while carrying a load. These include winding losses, stray losses due to stray flux in the windings and core clamps, and circulating currents in parallel windings. Because load losses are a function of the square of the load current, they increase quickly as the transformer is loaded. Load losses represent the greatest portion of the total losses when a transformer is heavily loaded. Transformer loss data is readily available from the manufacturers.

Failure of Transformer

Transformers of varied sizes and configurations are at the heart of all power systems. As a critical and an expensive component of the power systems, transformers play an important role in power delivery and the integrity of the power system network as a whole.

Transformers, however, have operating limits beyond which the transformer failure can occur. If subjected to adverse conditions there can be a heavy damage to the transformer, other system equipment, besides intolerable interruption of service to the customers. Since the lead time for repair and replacement of transformers is usually very long, limiting the probability of damage to the transformer is the foremost objective of transformer protection.

Operating conditions like transformer overload, through faults, etc often result in transformer failure, highlighting a need for transformer protection functions, such as over excitation protection and temperature-based protection. Extended functioning of the transformer under abnormal conditions such as faults or overloads can compromise the life of the transformer. Adequate protection should be provided for quicker isolation of the transformer under such conditions. The type of protection used should reduce the disconnection time for faults within the transformer and minimize the risk of catastrophic breakdown to simplify eventual repair.

2.5.1 Transformer Failure

The risk of a transformer failure is two-dimensional: the frequency of failure, and the severity of failure. Most often transformer failures are a result of "insulation failure". This category includes inadequate or defective installation, insulation deterioration, and short circuits, as opposed to exterior surges such as lightning and line faults.

Failures in transformers can be classified as:

- Winding failures resulting from short circuits (turn-turn faults, inter layer faults, phase ground, open winding)
- Core faults (core insulation failure, shorted laminations)
- Terminal failures (open leads, loose connections, short circuits)
- On-load tap changer failures (mechanical, electrical, short circuit, overheating)
- Abnormal operating conditions (overloading, overvoltage)
- External faults
- External conditions (Moisture entry, lightning, loose conservator cap, pilferage of oil)

Reason for failure of distribution transformers can categorise into two headings as Manufacturing Side Defect and Utility Side Defect.

2.5.2 Manufacturing Side Defects

The manufacturing side defect includes Design/Manufacturing Errors/conditions such as loose or unsupported leads, loose blocking, poor brazing, inadequate core insulation, inferior short circuit strength, and foreign objects left in the tank. These causes of transformer failure of transformer could be further categorised into four types as follows:

1. Failure caused by raw material,
2. Failure caused by assembly process,
3. Failure caused by cleaning process and
4. Unspecified causes.

In following section leaks in the manufacturing process which further results in these failure are elaborated

1. Failure caused by Raw Material

Following are reasons of failure of raw material which results in the failure of transformer

- **Moisture in insulated paper -** The process to release moisture in paper is not good enough. Short turns of winding will be found in transformer.
- **Contamination in winding insulation -** The small contamination is found during the raw material manufacturing process. It results the short turn in winding.
- **Bubble in insulated paper -** The process to release bubble in paper is not good enough. After transformer is energized, the dielectric withstand at that point is not enough and it leads to short turn in winding.
- **Sharp edge of low voltage winding -** Short turn happens on low voltage foil type winding because sharp edge of winding deteriorates paper during winding process.
- **Change supplier of raw material -** Because old supplier cannot supply raw material and quality of raw material from new supplier is not good enough.

2. Failure caused by Assembly Process

Following are the leaks in the assembly process which may results in the failure of transformer

- **Assembly of gasket and quality of tank welding -** Moisture can go into the tank or transformer oil can leak out. Dielectric strength will be reduced and breakdown will occur in the tank.
- **Assembly of winding to silicon steel core -** It causes deterioration of insulated paper between winding and steel core in case of careless workmanship. Short circuit from winding to steel core will be found in transformer.
- **Assembly of tap changer -** Contact of tap changer is not tight, heat is generated at that points.
- **Assembly of low voltage busbar and bushing -** Bolt of busbar and bushing can be loose. It causes abnormal voltage and the customer equipment at load side will damage.

- **Winding connection -** It is from poorly soldered joints between winding and heat is generated at that joints.

3. Failure caused by Cleaning Process

Following are the leaks in the cleaning process which may results in the failure of transformer

- **Small copper from wiring process in transformer -** During wiring process in transformer tank, cutting copper drops in the tank and cleaning is not good enough.

- **Small particle from welding busbar and winding -** Careless workmanship results in solder splashes on the coil.

- **Small particle from busbar -** The selected busbar has sharp edges, small particle is found in the process to reduce sharp edges and cleaning is not good enough.

4. Unspecified Causes

Unspecified causes mean they can be either from assembly process or design process.

- **Small clearance or long bolt -** Short circuit between bolt and low voltage busbar is found in transformer tank because design clearance is not sufficient or bolt is too long.

- **Small wiring clearance or wiring process -** Short circuit between tank and copper wiring is found in transformer tank because design clearance between wiring and tank is not sufficient or skill of worker is not sufficient.

- **Thickness of transformer tank or lifting measure -** Because price of transformer tank steel rapidly increases, transformer manufacturer tries to reduce the cost by reducing thickness of transformer as low as possible. In case lifting angle is less than the design when lifting transformer, tank can be deformed at the welding point between lifting lug and tank.

2.5.3 Utility Side Defect

The Utility Side Defect includes leaks in the Operation & Maintenance process and External factor which result into the failure of Distribution Transformer.

In following section leaks in the Operation & Maintenance process and External factor which further results in these failure are elaborated

- **Overloading -** Transformer that experiences sustained loading that exceeds the name plate capacity often faces failure due to overloading.
- **Line Surge** - Failure caused by switching surges, voltage spikes, line faults/flashovers, and other T&D abnormalities suggests that more attention should be given to surge protection, or the adequacy of coil clamping and short circuit strength.
- **Loose Connections -** Loose connections, improper mating of dissimilar metals, improper torquing of bolted connections etc can also lead to failure of the transformer.
- **Oil Contamination -** Oil contamination resulting in slugging, carbon tracking and humidity in the oil can often result in transformer failure.
- **Improper/inadequate Maintenance -** Inadequate or improper maintenance and operation is a major cause of transformer failures. It includes disconnected or improperly set controls, loss of coolant, accumulation of dirt & oil, and corrosion.
- **External Factors -** Several external factors like floods, fire explosions, lightening and moisture could also cause the failure of the distribution transformer.

As can be seen from the above list both manufacturing and operation & maintenance related factors cause failure of DTs. It is essential to improve the processes at both ends.

ASSESMENT OF DT OPERATIONAL PRACTICES IN UTILITIES

The different asset management practices followed by the utilities for management of distribution transformers. The different processes involved in asset management are grouped under Governing Processes, Vendor Interfacing Processes, and Operations Processes. Further observations and implications are framed in tabular form for each group and processes therein. Further issues utilities facing during these processes were addressed.

Process Involved in DT Asset Management by Utility

The transformer - particularly the distribution transformer - is the most important piece of electrical equipment installed in an electrical distribution network. It also has a large impact on a network's overall cost, efficiency and reliability. Selection and procurement of quality distribution transformers involves various processes and sub processes which are grouped in the figure below

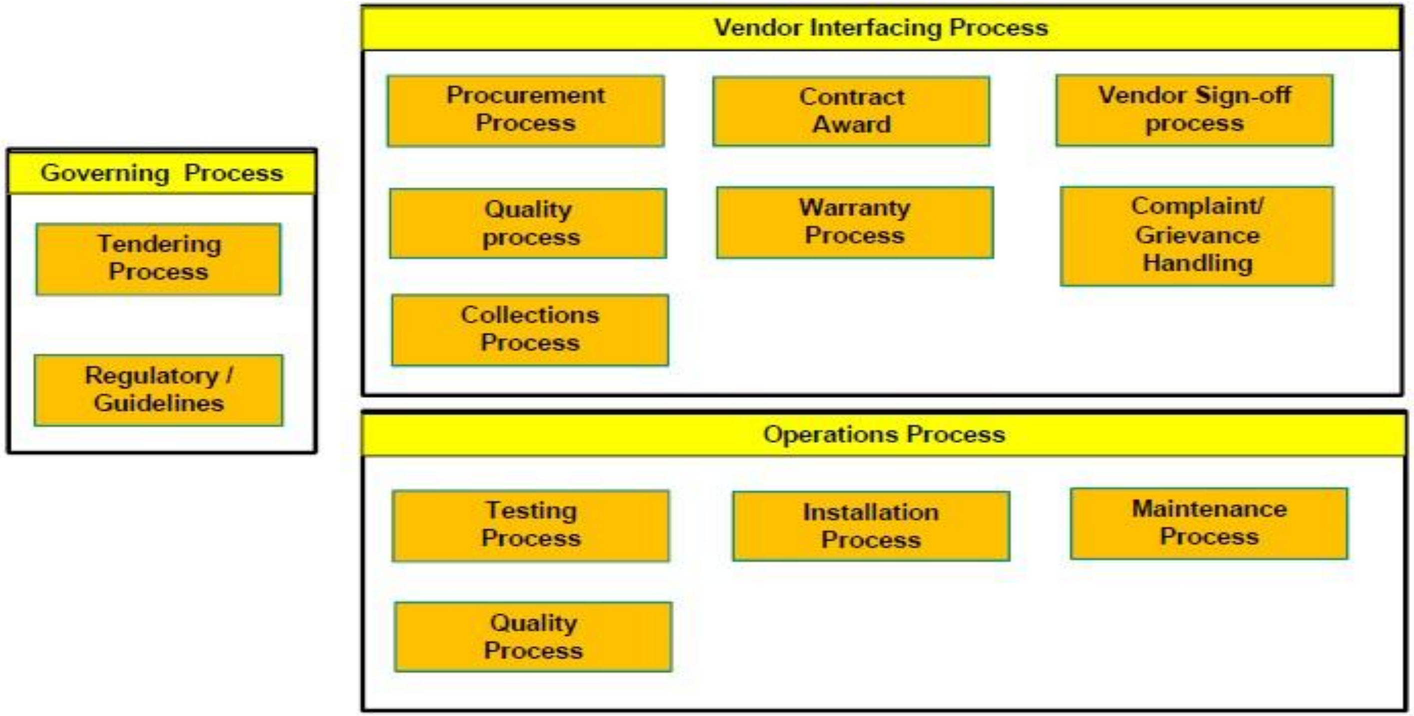


Figure 3.1: Process Involved in DT Asset Management at Utility End

3.1.1 Governing Processes

The Governing process from the point of view of utility is the pre-order placement communication with all DT manufacturers through the Tender Document. The utilities specify their technical & commercial terms and condition of supply of material in the tender document. Some utility call for the pre bid meeting to discuss their requirement with the DTM.

Regulation/Guidelines involve the IS standards, CEA standards, BEE specification for the Star rated transformer and CVC guidelines to be followed during the procurement process of DT.

3.1.2 Vendor Interface Processes

The vendor interface process involves the interactions between the utilities and the transformer manufacturer during the procurement process of transformer. The vender interaction is further divided into following processes

- Proposal Management
- Contact Award
- Vendor Sign-off Process
- Quality Process
- Warranty Process
- Complaint/Grievance Process
- Collection Process

3.1.3 Operations Processes

The transformer is the important part of the distribution system, the life of the quality transformer mainly depends upon operational practices at the utility end. The operational processes involve following sub processes.

- Testing Process
- Installation Process
- Maintenance Process

- Quality Process

In the following table processes involved in the DT asset management and Observations & implications observed during consultation with the utilities are tabulated.

Process	Observations & Implications
Governing Processes	
Tendering Process	• Open Tender is floated on the Utility website; no pre-selection process for quality assurance is undertaken.
Regulatory/ Guidelines	• Contracts are awarded exclusively on the basis of the L1 criteria as per CVC guidelines.
	• Cost of raw material is not covered by the amount offered under L1.
	• Cost of the star rated DT is much higher than the non-star rated DT. Higher the rating of the transformer, higher will be the cost.
	• Many Utilities have not started using star rated transformers
Vendor Interfacing Processes	
Proposal Management	• Tendered quantity should be offered only to the L1 bidder as per CVC guideline. • Incapability of the utility staff for factory inspection and capability judgment of the manufacturer for the supply of tender quantity. • Lack of the knowledge for the factory/infrastructure inspection of the transformer manufacturer.

Contract Award	• Contract is awarded on the basis of the L1 criteria as per CVC guideline. • Previous history of the manufacturer is not considered. • Quality of the supply of the material is not considered
Quality Process	• Utility demand for the test certificate of the raw material and the Type test certificate for the DT
	• Inspection of the raw material and during the mfg process is arranged but on many occasions it is only on paper
Warranty Process	• DT failed during warranty period is repaired by the manufacturer at his own cost
	• Collection of failed DT from the site and delivery back to the site is the manufacturer's responsibility.
Transportation of failed DT	• Manufacture has to collect the failed DT within the warranty period from site, which could be located far away and send back to site.
Operations Process	
Testing Process	• Routine tests are carried out by many utilities on the sample from a lot of the DT received from the mfg in their stores
	• As per the utility, it is not possible to test all DTs at the store.

Installation Process	• Installation of a DT is carried out by the contractor engaged by the utility
	• Relevant IS is not followed by the contractor, workers due to absence of the knowledge.
	• Adequate protection for the DT is not provided or not maintained.
Maintenance Process	• Lack of knowledge of the preventive maintenance practices
	• Negligence towards the maintenance.
	• Maintenance activity is outsourced to the contractor.

Issues Utility Facing During the Asset Management Process of Distribution Transformers

As the transformer is the important part of the distribution system which plays the vital role in the system, utility need to be very keen during the asset management of the DT, especially during procurement process of the DT.

Following figure shows the issues the utilities facing during the asset management of the DT:

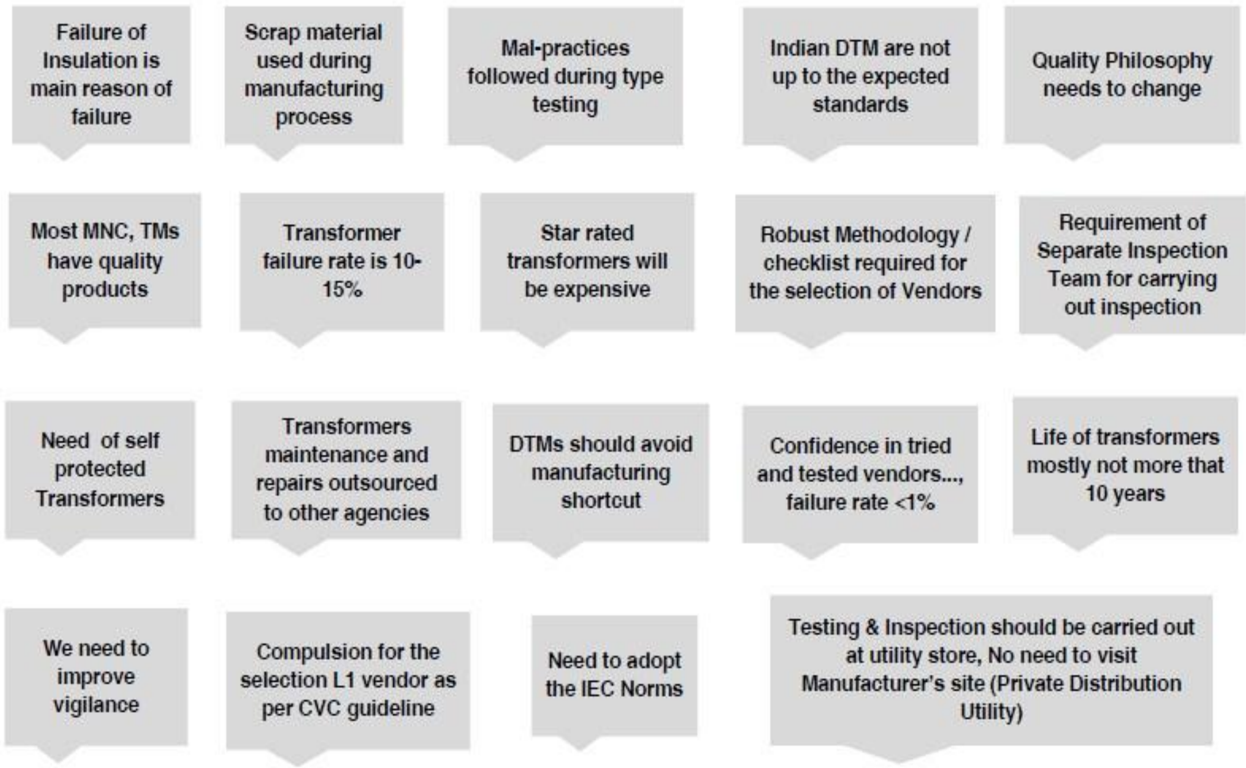


Figure 3.2: Issues Utility Facing during the Procurement of DT

The issues mentioned above are more concerned to the quality of the raw material used for manufacturing the transformer and quality of the final product i.e. transformer.

STANDARDIZATION OF OPERATIONAL PRACTICES OF UTILITIES

There is a lot of variation in the operational practices of the private and government utilities; this drastically affects the performance of the system and DT failure rate. It is observed that the failure rate of distribution transformers in the private utilities is less than 5% as compared to the 15-20% in government utilities. Further it is observed that this failure rate is only 1-2% in the developed countries compared to the 15-20% in India.

As high failure rates of system equipment leads to the financial burden on the utilities in terms of repair & replacement cost and indirect revenue loss due to the non-availability of the system. It is need of the developing country like India to have the lower failure rate and for the growth in the power sector. As it is observed that the private utilities have adopted the good operational practices compared to the government utilities, but the operational practices are not upto the mark as failure rate is still higher than the developed country utilities. Further modifications were required in the operational practices of the private as well as government utilities.

In the following table current operational practices are tabulated, further proposed practices and key benefits of adopting proposed practices are added in the subsequent columns followed by the initiative taking authority for the proposed practices.

Sub Process	*Current Practices*	*Best Practices*	*Key Benefits*	*Initiatives*
Governing Process				
Tendering Process	Open tender is floated on the Utility website.	Vendor registration system may be implemented.	Vendors not capable of supplying the material are eliminated.	Utility may take the initiative for the raw material supplier and vendor registration.

Sub Process	*Current Practices*	*Best Practices*	*Key Benefits*	*Initiatives*
	Tender has open invitation to all interested vendors.	The vendor registration should be based on the past history of the supply of material, different order completion with the utility.		
	EMD and Bank guaranty is take for each tender.	The utility should take certain amount as security deposit on permanent basis.	The process of depositing the EMD and BG is avoided.	
		Trial order is given to the new vendors; third party inspection of factory may be arranged by the utility.		
		The regular supplier may also be inspected during the manufacturing process by the third party.		
		Vendor registration for the raw material also be carried out to	As raw material suppliers are pre defined in the tender so	

Sub Process	*Current Practices*	*Best Practices*	*Key Benefits*	*Initiatives*
		insure good quality of the raw material should be used by the manufacturer.	quality of the raw material is maintained.	
	The Clause of challenge testing is used by some utilities.	The clause of challenge testing should be incorporated in tender document of all the utilities.	Through the challenge testing other manufacturers can keep watch on the quality of DT supplied by their competitors to the utilities.	
	In some of the private sector utilities tender evaluation is based on the TOC analysis.	Capitalization must be incorporated in every tender and thus the supplier must be judged on the concept of TOC.	This will ensure strict compliance to the guaranteed losses by the manufacturers.	
	E bidding process is followed by some utilities only.	It should be made mandatory to follow E procurement process by all the utilities.		
	There is neither in-built qualification criterion in the tender nor any process to	Detailed pre qualification Criteria should be defined in the tender, should be followed		

Sub Process	*Current Practices*	*Best Practices*	*Key Benefits*	*Initiatives*
	qualify manufacturers to participate in the tender.	by all the utilities.		
Regulation/ Guideline	Many Utilities have not started using star rated DT.	As the efficiency of the star rated DT is more than the nonstar rated DT, Utility may use the Total owning cost (TOC) method for the analysis of the cost of the DT and take the decision on which DT is used.	TOC analysis may be useful analysis when selection is between the star and non star rated DT, if the TOC cost of the star rated DT is less, utility should go for the use of the star rated DT.	BEE may take the initiative and make the compulsion for the use of star rated DT, as this will lead to the reduction in energy loss in DT and help in Nation building.
Customer Interface Process				
Proposal Management	Tendered quantity is offered only to the L1 bidder.	Quantity may be divided in the group of L1, L2…..	As the quantity is divide into the L1, L2…… if any vendor fails to supply the DT at offered price or may be due to some other reason, continuity of the supply of the DT is will not disturbed.	

Sub Process	Current Practices	Best Practices	Key Benefits	Initiatives
Contract award	Contract is awarded on the basis of the L1 criteria.	Tender evaluation using Weighted Average Criteria.	Low quality material supplier vendor may get eliminated	
		Tender evaluation should be done based on the both technical and commercial terms.	Equal emphasis is give to the quality and cost.	
		History of the manufacturer should be considered.		
		History of supply may include order completion period, delay in the schedule etc.		
Quality Process	Utility demand for the test certificate of the raw material and the Type test certificate for the DT.	If the clause of the use of the raw material from the registered supplier is mentioned in the tender then the quality of the raw material may be maintained.		
	Inspection for the raw	Fixing the responsibility of the	Officer came for the inspection	Utility

Sub Process	Current Practices	Best Practices	Key Benefits	Initiatives
	material check and during the mfg process of DT is arranged. However, many times the inspection is only on paper.	officer coming for the inspection may be more effective.	may get aware of their responsibility.	
Warranty Process	Warranty terms and condition are not defined.	Fault covered under the warranty condition should be defined.	Negligence towards the operation, loading, maintenance of the DT is avoided.	
			DT failure rate during the warranty condition may reduce.	
		Warranty is given for the manufacturing defect only.	The National loss due to negligence may be avoided.	
		DT failure analysis may be arranged out by the joint inspection with the DTM.	Guilty person will be punished.	
		Fixing the responsibility of the	Utility practices of O&M will	

Sub Process	*Current Practices*	*Best Practices*	*Key Benefits*	*Initiatives*
		failure should be carried out.	improve.	
Collection Process	Manufacturer supply DT to the location specified by the utility in the order.	Central Store should be formed by utility. DT will be transferred to the required place from central store by utility.	The revenue loss due to off supply of the Utilities and customers will reduce. If DT were collected at the central store, utility can have all facility to test the DT at central store.	
Operations Process				
Testing Process	The routine test is carried by the many utility on the sample taken from the lot of the DT came from the manufacturer to store room.	The each and every DT came from factory should be visually inspected at the store for any physical damage.	If Utility goes for the 100% DT testing, then inspection during the manufacturing process may be avoided.	Utility
		Utility may go for the CUT- OPEN testing of DT at their	Malpractices during the inspection of the	

Sub Process	*Current Practices*	*Best Practices*	*Key Benefits*	*Initiatives*

		store, rather than visiting the manufacturer factory.	manufacturing process may be avoided.	
		Utility should go for losses testing at store for the some percentage of the random sample selected from the lot size.		
		Each and every DT should be going through the following test at Utility store. 1. Insulation resistance test. 2. Losses test.	As each and every DT is tested, DT failure rate may reduce and loss due to transportation, installation of DT may be saved.	

Sub Process	*Current Practices*	*Best Practices*	*Key Benefits*	*Initiatives*
	Now many utilities like WBSEDCL has started using poly numbered seal & putting one property plate duly engraved the details of mfg. months, Sr. no. etc. which to be welded in one side of tank and sr. no. to be engraved/punched in inside on top core mounting channel. This is incorporated for receiving tested transformers.	This practice is included as standard practice should be followed by all the utilities.		
Installation Process	Installation of DT is carried by the contractor employed by the utility.	Utility authority should keep keen watch on the work carried by the contractor.		

		Fixing up the responsibility for the installation of DT may be carried out.		

Sub Process	*Current Practices*	*Best Practices*	*Key Benefits*	*Initiatives*
	The relevant IS standard is not followed by the contractor, worker due to absence of the knowledge.	Utility offices should take care that the IS std must be followed and proper protection devices should be installed.	DT failure rate may reduce.	
	Adequate protection for the DT is not provided nor maintained.	DT manufacturer may give checklist for the Do's and Don'ts.	DT failure rate will reduce.	
Maintenance Process	Maintenance carried by contractor/utility staff.	• Proper training of the maintenance should be given to the utility staff. • Log book should be maintained by the utility. • Maintenance activity should be assessed by the higher authority of the utility.	DT failure rate will reduce.	Utility

KEY RECOMMENDATIONS

Vendor Management System

The raw material is purchased from the independent vendors by the transformer manufacturer. As a result, quality of the raw material would affect the quality of quality of distribution transformer. The Utilities are not taking the part in the raw material procurement/nor define the raw material suppliers.

For maintaining the raw material quality used by the manufacturers, the utility should have vendor approval system. In the vendor approval system, raw material suppliers have to approach the utility and register themselves as approved vendors. The Utility has to test the sample raw material submitted by the vendor at their premises/through the third party testing. If the raw material quality fulfils the required IS standard, the Utility may register to the vendor as approved one. Also utility has to list their registered vendor names in the tender document and make the compulsion of the use of the raw material through these registered vendors. This process will have following benefits:

- Quality of the raw material is maintained
- Quality of the transformer would improve
- Utility need not inspect / test the raw material
- Raw material prices will be known to the utilities which would help in deciding the basic price of the final product
- Malpractices in the use of the raw material by the DTM would reduce
- Tendency among the utilities to offer prices lower than the manufacturing cost will be minimised.

The CRGO material, Insulating material and Transformer oil are crucial important raw material, low quality of these raw materials drastically affect the performance and life of the transformer. The utility may go for the procurement of the CRGO material, insulating material and transformer oil through the vendor management system.

CRGO Laminations

Choice of metal is critical for transformer core. It is important that good quality magnetic steel is used for fabrication of core. There are many grades of steel that can be used in a transformer core. Choice of core is dependent on how evaluation of non-load losses and total owning costs is carried out by the utility.

Almost all transformer manufacturers today use steel in their cores that provide low losses due to the effects of magnetic hysteresis and eddy currents. To achieve these objectives, high permeability, cold-rolled, grain-oriented, silicon steel is almost always used. Construction of the core utilizes step lap mitred joints and the laminations are carefully stacked.

Further, in order to cut costs, some manufacturers use second hand/scrapped CRGO material for core in their transformers. Some manufacturers accepted that such practices are followed by some manufacturers to reduce the cost and bag the order which is placed on the basis of 'Lowest initial cost', popularly known as 'L1' basis. This second hand/scrapped CRGO is usually extracted from the transformer sold by the utilities as scrapped transformers to the dealers. This scrap is supplied to the manufacturer.
It is also observed that the large amount of the second grade CRGO is imported from other countries and the same is used/ recycled during the manufacturing of DT in India. Recently the use of the Second grade/scrapped CRGO has been banned by the Government of India. It is essential that utilities strictly follow this practice to ensure elimination of this practice.

SMART Substation

The Smart Substation is an advanced version of the self protected transformer wherein addition to the internal protection devices, indicators and monitoring devices are also installed for the monitoring the internal condition/unmanned operation of the distribution transformer/ substation. While Smart Substation is a concept, which has larger application to increase reliability of supply and reduce losses in the system, from the point of view of our discussion, following are the important features.

1. Sensors installed to monitor the temperature of the internal parts, temperature of oil in the transformer,

2. Various indicators installed to monitor Voltage, Current, Load condition, Oil temperature of the transformer, temperature of the internal part, oil level indicator, and operational condition of the protection devices.

3. Remote monitoring and operation is through the GPRS/GPS based system.

4. Protection devices to protect the transformer from abnormal conditions like overload, over voltage, short circuit, internal short circuit, etc.

5. Energy metering system for Energy audit and automatic theft detection system.

Smart Meter for Performance Monitoring

Transformers are the vital element of the electric power distribution infrastructure. It should be monitored regularly to prevent any potential faults. Failure of the distribution transformers easily costs several crores rupees for repair or replacement, and causes loss of service to customers and revenue until the system is restored.

Given that several thousand transformers are operational in the area of any distribution utility, it is not possible to physically monitor these transformers. It is necessary to develop systems for remote monitoring of these transformers. For this purpose, GPRS/GPS based metering system may be installed on the transformer. The meter should measure, monitor and record the different system parameters including those mentioned in earlier section. The meter can continuously monitor the performance of the transformer and give signal to the control centre through communication channel in case of abnormal behavior.

Further, as the meter keeps the record of the different system parameters, the transformer failure analysis would be possible; the cause of the transformer failure can be easily identified and analyzed before taking decision on repairs/ replacement.

Analysis of Cause of Failure of Distributor Transformer

Distribution transformer may fail due to various reasons. The root cause of failure may be lacunae in manufacturing practices or inappropriate operation & maintenance practices. Analysis of causes of failure would help in taking corrective measures and thereby reducing costs associated with repairs/ replacement. For the purpose of analysis, it is necessary to identify nature of failure and entity primarily responsible for defect. In the following table different types of failures, primary defects that caused failure have been indicated.

Type of Failure	*Operational Defects*	*Manufacturing Defect*
Winding failures		
a) Turn-turn faults, phase-phase faults, phase-ground,	1. Overheating of the transformer. 2. Overload.	Use of improper insulation material for the winding/use of low quality material, bad insulation covering.
b) Open winding	Short circuit at transformer **1**	
c) Opening at core joints	1. Short Circuit 2. Improper transportation	1. Design short comings 2. Poor clamping of

Type of Failure	*Operational Defects*	*Manufacturing Defect*
		laminations at yoke area
Core faults		These are mostly manufacturing defects.
a) Core insulation failure	Continuous overloading and overheating of the transformer	Improper varnishing of the stamping, improper formation of core.
b) Shorted laminations	Short terminal circuit at the trans	Use of improper insulation, improper formation of core, burr to the lamination blades, improper core bolt insulation.
Terminal failures		
a) Open leads		Bad insulation covering, improper brazing of joints.
b) loose connections		Improper joining terminals
c) Short circuits		Loose connection, improper use of the insulating material, bad insulation covering.
Off-load tap changer failures		
a) Mechanical	Improper handling of tap changer switch	
b) Electrical	Failure of insulating oil	
c) Short circuit	Sparking at the contacts	

Type of Failure	Operational Defects	Manufacturing Defect
d) Overheating	Frequent operation	
Abnormal operating conditions	These are purely utility side defects.	
a) Overfluxing	Overvoltage in system	
b) Overvoltage		
c) Overheating	Failure of the cooling, improper maintenance/checking of oil level in conservator/transformer and not topping up oil to required level, unbalanced load conditions.	Insufficient cooling ducts in the winding.
d) Overloading	Continuous over loading of transformer beyond rated capacity. Improper contact of fuses/over capacity fuses.	
External faults	These are usually utility side defects.	

Above list of failures and associated reasons of failures or defects could be used to prepare check-list for assessment of reasons for failure of distribution transformers. However, it should be noted that such check-list will not serve purpose unless process is developed for analysis of failures and incorporation of corrective measures in maintenance and/or manufacturing processes.
For this purpose, following process is suggested.

1. Development of check-list for analysis of failure of distribution transformers
2. Preparation of check-list for each failed DT
3. Collation of data division, zone, HQ level

4. Analysis of reasons attributed to operations/ maintenance practices
5. Incorporation of corrective measures in operating procedures
6. Sharing of data related manufacturing issues with Utilities

The process may be refined depending upon discussions with utilities. It is believed that development and implementation is critical for improvement in quality of distribution transformers in India.

Manufacturer to be Made Responsible for Maintenance

It was mentioned that though rate of failure of distribution transformers has decreased in the last few years, it is still very high. This high rate of failure may be due to either poor quality of product or poor operational practices adopted by the distribution utilities. While poor quality of DT could be result of poor quality processes followed during the manufacturing process, poor operational practices could be result of various reasons.

One of the most important reasons for poor operational practices is poor culture of asset maintenance, as some entities don’t undertake any preventive maintenance. As a result, maintenance occurs only after failure of equipment. It has been noticed that culture of maintenance of the assets is better among private utilities than in public sector utilities.

Second reason for poor maintenance is non-availability of money for maintenance. Several utilities in the country are facing acute cash flow problems. This results in avoidance of preventive maintenance costs. However, due to various reasons, purchase of distribution transformers is undertaken.

Finally, the failure rate is generally higher during the warranty period of the transformer as compared to the transformers already in operation. While utilities accuse manufacturers for poor quality of material, manufacturers accuse that utility staff ignore maintenance of the transformer under warranty period. Further, without ascertaining reason for failure and thereby responsibility of failure, manufacturer is forced to undertake repairs of the transformer. As a result, manufacturer is forced to suffer losses.

In order to address these issues, it is suggested that the manufacturer may be asked to provide maintenance services for warranty period. This will ensure single point responsibility for manufacturing and maintenance issues. The costs associated with annual maintenance contract may be included in the initial cost of the transformer. Following would be the key features of the proposed arrangement.

- Responsibility of maintenance for a period of warranty should be included in the tender for purchase of distribution transformer

- Cost associated with maintenance should be included in the cost of transformer
- Payment schedule should reflect the fact that part of the contract will be completed in the form of maintenance
- Utilities to develop protocol to enable manufacturer to undertake preventive maintenance at regular interval as defined in the maintenance contract
- Utilities to specify the events of failures for which manufacturer will not be responsible for repair of the transformer, this would be like negative list of services under service tax.
- Apart from reduction in failure rate, the utility would also benefit due to regular preventive maintenance practices followed by the manufacturer. Utility staff would get trained as a part of maintenance work.

Operation and Maintenance Practices for Utilities

Transformer is the heart of any power system. Hence preventive maintenance is always cost effective and time saving. Any failure of the transformer affects the functioning of the power system and reliability of supply. Following are the some operational and maintenance practices that must be included in the maintenance schedule for better performance of the distribution transformer. It may be noted that the list given below is not exhaustive. Further, some/all of the practices mentioned below may already be part of the maintenance manual of the distribution utilities. Comprehensive list of activities may be drawn by utilities in consultation with transformer manufacturers. Such list should be made available at every distribution substation. Following list has been drawn on the basis of components of the distribution transformer.

- Oil:
  - Oil level checking. Leakages to be attended.
  - Oil BDV & acidity checking at regular intervals. If acidity is between 0.5 to 1mg KOH, oil should be kept under observation.
  - BDV, Color and smell of oil are indicative.
  - Sludge, dust, dirt, moisture can be removed by filtration.
- Insulation Resistance:
  - Insulation resistance of the transformer should be checked once in 6 months.

- Megger values along with oil values indicate the condition of transformer.

- Bushings:

  - Bushings should be cleaned and inspected for any cracks.
  - Dust & dirt deposition, Salt or chemical deposition, cement or acid fumes depositions should be carefully noted and rectified.
- Periodic checking of any loose connections of the terminations of HV & LV side.
- Breather examination. Dehydration of Silica gel if necessary.
- Explosion-vent diaphragm examination.
- Conservator to be cleaned from inside after every three years.
- Regular inspection of oil & winding temperature meter readings.
- Cleanliness in the Substation yard with all nets, vines, shrubs removed.
- Each and every transformer operating in the system must be reconditioned after some useful life, may be after 15 to 20 years.

Records should be kept of the transformer, giving details of all inspections and tests made, and of unusual occurrences if any.

The detailed maintenance schedule distribution transformer w.r.t. capacity is give below:

Maintenance Schedule for Transformer of Capacity less than 1000 KVA:

Inspection Frequency	***Items to be inspected***	***Inspection Note***	***Action required if Inspection shows unsatisfactory conditions***
Hourly	1. Load (Amp.) 2. Temperature 3. Voltage	Checks against rated figures. Oil/ambient temperature. Check against rated figures.	Nil Nil Nil
Daily	Dehydrating breather	Check the air passage and colour of silicagel	If Silicagel is pink, change by spare charge. The pink gel may be re-activated for reuse.
Monthly	1. Oil 2. Connection Bushing	Check oil level. Check tightness.	If low, tap up with dry oil and examine for cause of leak. If loose, tighten.

Quarterly	Bushing	Examine for physical cracks and dirt deposits.	Clear or replace.
Inspection Frequency	***Items to be inspected***	***Inspection Note***	***Action required if Inspection shows unsatisfactory conditions***
Half Yearly	1. Non conservator transformer 2. Cable box, gasketed joints. 3. Guages, Painting.	Check for moisture under cover. Inspect. Inspect.	Improve ventilation, check oil. Attend to remove defects. Attend to remove defects.
Yearly	1. Oil in transformer 2. Earth resistance 3. Relays, alarm and their circuits etc.	Check for dielectric strength, water content, acidity and sludge. Examine the relays and alarm contacts, their operations and fuses etc. Check relay accuracy.	Take suitable action to restore quantity & quality of oil. Take suitable action if earth resistance is high. Clear the components and replace contacts and fuses, if necessary, Change the setting, if necessary.
2 Yearly	Non-Conservator transformer	Internal inspection above core.	Filter the oil regardless of condition.
5 Yearly		Overall inspection and lifting of core-coil unit.	Wash by hosing down with clean dry oil.

Source: ITMA Directory-2010

Maintenance Schedule for Transformer of Capacity 1000KVA and above:

Inspection Frequency	***Items to be inspected***	***Inspection Note***	***Action required if Inspection shows unsatisfactory conditions***
Hourly	1. Ambient Temperature 2. Winding and oil temperature 3. Load (ampere) & voltage.	 Check the temperature rise whether reasonable. Check against rated figures.	Nil Shut down the transformer and investigate if either is persistently higher than normal. Nil
Daily	1. Oil level		If low, top up with dry oil, examine the transformer for leaks.
Inspection Frequency	***Items to be inspected***	***Inspection Note***	***Action required if Inspection shows unsatisfactory conditions***
	2. Oil level in bushing 3. Relief diaphragm 4. Silica gel breather	Check against transformer oil level. -- Check the air passage for free, check colour of the active agent.	Nil Replace if found cracked on broken. If Silica gel is pink, change by spare charge. The pink gel may be re-activated for reuse.
Quarterly	1. Bushing 2. Oil in transformer 3. OLTC 4. Indoor transformer	Examine for physical cracks and dirt deposits. Check for dielectric strength and water content. Check oil in OLTC and driving mechanism. Check ventilation.	Clear or replace. Take suitable action to restore quantity of oil. Replace burst or worn parts or other defective parts. Nil
Half Yearly	Oil Cooler	Test for pressure.	Nil

Yearly	1. Oil in transformer 2. Oil filled bushing 3. Cable boxes 4. Gasket joint 5. Surge deviator 6. Relays, alarm and their circuits etc. 7. Earth resistance	Check for dielectric strength, water content, acidity and sludge. Test oil. Inspect. Examine for cracks and dirt deposits. Examine relays and alarm contacts, their operations, fuses etc.	Take suitable action to restore quality of oil. Filter or replace. Nil Tighten the bolts evenly to avoid uneven pressure. Clean or replace. Clear the components and replace contacts and fuses, if necessary. Take suitable action if earth resistance is high.
5 Yearly	1000 KVA to 3000 KVA	Overall inspection including lifting of corecoil unit.	Wash by housing down with clean oil.
7 to 10 Yearly	Above 3000 KVA	Overall inspection including lifting of corecoil unit.	Wash by housing down with clean oil.

Source: ITMA Directory-2010

Annexure 1

MAINTENANCE POLICIES OF UTILITY OF DT'S:

1. **Maintenance of DT include**

- o Routine maintenance
- o Preventive maintenance
- o Breakdown maintenance
- o Any other

____

____

2. **Maintenance activity of DT's carried by:**

- o Utility staff
- o Contractor
- o Manufacturs

3. **Operational practices for overloading and tap changing:**

- o Regular load forecasting
- o Connected load criteria
- o Considering future load demand
- o Peak demand criteria
- o Any other:

____

____

4. **Whether load shedding done out by utilities:**

____

____

Methods adopted for load shedding: ______________________________

____

____

UTILITY NETWORK INFORMATION:

1. Fault level (KVA/MVA) at the size of transformer?

Size of DT	Fault level in KVA/MVA
1. ____________	____________
2. ____________	____________
3. ____________	____________
4. ____________	____________
5. ____________	____________
6. ____________	____________
7. ____________	____________
8. ____________	____________
9. ____________	____________
10. ____________	____________
11. ____________	____________
12. ____________	____________
13. ____________	____________
14. ____________	____________
15. ____________	____________

2. Protection provided to DT's:

o Internal protection:

____

____

____

o L.V. side:

____

____

____

o External LV side:

____

____

____

o H.V. side:

____

____

____

o Additional protection provided as requirement of geographical area:

____

____

3. Additional protection provided to DT in rural area.

____

____

4. Whether load monitoring of DT is carried out:

____ **if**

yes, specifies method of load management/information system adopted: _____________

____

____

____

____

ABNORMAL ACTION/FAILURE ANNALYSIS OF DT's:

1. **What are the Reasons of failure of DT's?**
   - o Ageing
   - o Manufacturing defects
   - o Utility side defects
   - o Natural calamities

Most frequent reason: ____

2. **Analysis of reasons for failure of DT's from utility side:**
   - o Over loading o LT line loose span
   - o Usage of improper size of fuse wire
   - o Tree branches touching LT lines
   - o Improper maintenance of Breathers
   - o Oil leakage:

- Non topping of oil o Improper earthing
- Not connecting the Lightning Arresters
- Using Two Phase supply in Rural areas
- Un-standard methods adopted
- Any other

____

____

3. **What are the types of Transformer Fault occurs?**
    - Winding failures due to short circuits (turn-turn faults, phase-phase faults, phase ground, open winding)
    - Core faults (core insulation failure, shorted laminations)
    - Terminal failures (open leads, loose connections, short circuits)
    - On-load tap changer failures (mechanical, electrical, short circuit, overheating)
    - Abnormal operating conditions (over fluxing, overloading, overvoltage)
    - External faults

Most frequent fault occur: ____

4. **DT Failure description:**

% of DT's failure in each year: ____

% of DT's failed during guarantee period each year: ______________________________

% of DT's scraped each year: ____

% of DT's repaired each year: ____

5. **Average loading and peak loading on DT's (%):**

____

____

COST AND EXPENCES FOR DT FAILURE:

1. **Expenditure on repair of DT w.r.t. size:**

Nature of Failure.	**Expenditure in Rs.**
a) Open winding	______________________
b) Al Winding replacement LV	______________________

c) Al Winding replacement HV ____________________________
d) Cu Winding replacement LV ____________________________
e) Cu Winding replacement HV ____________________________
f) Terminal failures ____________________________
g) Core failure ____________________________
h) On-load tap changer failures ____________________________

Any other failure:

____ ____________________________

____ ____________________________

____ ____________________________

2. Repair Process of DT's:

Average Life of DT's: ____

____

Expected Life of DT's: ____

____

Expected Life of DT's after major repair/replacement of major part like winding: ___________

____

____

Nos. of times DT's repaired in there useful life: ____

____ If DT's repaired more than one time in their useful life, average age of DT's in years at the time of major failure:

First major failure: ____

Second major failure: ____

Third major failure: ____

Repairing of DT's carried out by:

○ Utility itself

○ Tendering process

○ Manufacturer of DT's ○ Local repairer unit

Repairing conditions: ____

____

____

If tendering process,

Specify Tender process: ____

____

____

____

Tender condition: ____

____

____

____

____

____

____ %

Tolerance in losses specified for DT after repair.

____

Age of DT at the time of repair (in years):

Minimum: ______________ Maximum: ________________

Preferred IS standard during repair: ____

____

____

____

3. **Average age of DT at the time of scrapping?**

____

4. **Process of Scraping and valve recovered during scrapping:**

____

____

____

5. What kind of care taken for scraped DT/part of DT will not be recycled / reused?

6. Reconditioning of DT is carried out?

If yes, specify reconditioning process, activities in the same.

UTILITY COMFORTABLILITY:

1. **Major DT supplier to utility:**

2. **Quality DT suppliers:**

3. **Quality service provider in case of repair of DT within warranty period:**

YOU'RE SUGGESTION FOR US IN THIS ASSESSMENT:

SUGGESTION FOR DT MANUFACTURERS:

Annexure 2

Format for Transformer Failure Analysis

Transformer Failure Report						
Utility Area(Zone/Division/Sub division):						
Substation Area:						
Transformer Make:						
Transformer Sr. No.:				Year of Mfg.:		
Voltage Rating DT: Type & Capacity of DT:						
Peak Load on DT:	L.V.		Amps.	H.V.		Amps.
Date of Installation: Date of Testing: Date of Failure:						
Inspected by: Tested by:						

Inspection Report:

Sr. No.	***Item to be check***		***Remark***
1	Indication of bachholz relay if any:		
2	Indication of Temp. controller if any:		
3	Distributer fault frequency		
4	Last date of transformer oil filtration:		
5	Oil leakage noticed if any:		
6	Oil level status:		
7	Status of Explosion Vent Diaphragm:		
8	Size of Fuses	H.V. Side (Amps.)	

Sr. No.	Item to be check		Remark
	provided.	L.V. Side (Amps.)	
9	Did protection operate?	H.V. Side	
		L.V. Side	
10	Whether lightening arrestors is provided?	H.V. Side	
		L.V. Side	
11	Condition of lightening arrestors at the time of failure.	H.V. Side	
		L.V. Side	
12	No. of earth pits provided for the transformer & size of earth wire used.		
12	Peak load reached so far or prior to failure.		
13	Total connected load on the equipment.		
14	Period from which it is in service at present situation.		
15	Whether the equipment was sick previously if so nature of failure.		
16	Apparent causes of failure.		
17	Was there any climatic condition i.e. any thunder storm activity, in the vicinity of transformer?		
18	If it is due to manufacturing defects.		
19	Has the transformer failed within the guarantee period & if So has it been taken with the supplier.		
20	Whether experienced any faults simultaneously with failure of T/F either on HT / LT side, if yes please state the exact details.		
21	Particulars of the last maintenance		
	a. Oil test results & Date		
	b. Insulation test results & Date		

Sr. No.	Item to be check	Remark
22	Details of other maintenance	

23	Past History of failure of transformer
24	Any comments

Site Testing Report:

Test Report						
1. Insulation Resistance Values (Megger Test):						
R-e	Y-e	B-e	r-e	y-e	b-e	P-S

2. Winding Continuity Test:					
RY	YB	BR	Ry	yb	Br
3. Pressure Test:					

Detail Lab Test Report:

Test Report
4. BDV test:
5. Insulation Resistance Values (Megger Test):

R-e	Y-e	B-e	r-e	y-e	b-e	P-S

6. Winding Continuity Test:

RY	YB	BR	Ry	yb	Br

7. Ration Test:

Primary Voltage			Secondary Voltage					
RY	YB	BR	Ry	yb	Br	rn	yn	bn

8. L V Magnetic Balance Test:

	ry	yb	br	rn	yn	Bn	lr	ly	lb
a. Fuse inserted in R ph									
b. Fuse inserted in R ph									
c. Fuse inserted in R ph									

9. Remarks & Comments:
