DMRC ELECTRICAL STANDARDS & DESIGN WING (DESDW)

SPECIFICATION NO.
DMES-T/0002/DMRC-E-PS-TRANSF-02

SPECIFICATIONS FOR
TRACTION TRANSFORMER

Issued on:

<table>
<thead>
<tr>
<th>Date</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>17th May 2017</td>
<td>Draft-1.</td>
</tr>
</tbody>
</table>

DELHI METRO RAIL CORPORATION LTD.
7th Floor, B-Wing, Metro Bhawan, Fire Brigade Lane,
Barakhamba Road, New Delhi –110 001
### Previous Record of specification

<table>
<thead>
<tr>
<th>Stage</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft -1.</td>
<td>17-May-17</td>
</tr>
<tr>
<td>Draft -2</td>
<td>31-Aug-17</td>
</tr>
<tr>
<td>Draft -3</td>
<td>20-Sep-17</td>
</tr>
<tr>
<td>Draft -4</td>
<td>30-Oct-17</td>
</tr>
</tbody>
</table>


SPECIFICATIONS FOR TRACTION TRANSFORMER

Contents

Traction Transformer....................................................................................................................................... 4

1.1 Standards .................................................................................................................................................. 4
1.2 Abbreviations ............................................................................................................................................ 5

2.1 Characteristics:- ....................................................................................................................................... 5
2.2 Rated power .............................................................................................................................................. 5
2.3 Service condition ....................................................................................................................................... 6
2.4 Overload capacity ..................................................................................................................................... 6
2.5 Rated voltages ......................................................................................................................................... 6
2.6 On-load tap changer .............................................................................................................................. 7
2.7 Cooling system ......................................................................................................................................... 8
2.8 Short-circuit withstand capability ........................................................................................................ 8
2.9 Iron core .................................................................................................................................................. 9
2.10 Transformer losses ............................................................................................................................... 9
2.11 Windings ............................................................................................................................................... 10
2.12 Terminals and connections .................................................................................................................. 10
2.13 Tank and radiators ............................................................................................................................. 11
2.14 Oil expansion vessel ........................................................................................................................... 12
2.15 Control and protection ......................................................................................................................... 12
2.16 Control and monitoring cabinets ....................................................................................................... 13
2.17 Metal work and Paint-work ............................................................................................................. 14
2.18 Particular dispositions, Installation .................................................................................................... 15

3.1 Fire Protection & Suppression system:.................................................................................................... 16
3.2 Fiber Optic Winding Hot Spot Temperature Monitor: ......................................................................... 19
3.3 Ester oil filled transformers: .................................................................................................................. 21

TEST SHEET and GTP SHEETS .................................................................................................................. 21

5.1 Type tests: ............................................................................................................................................... 21
5.2 Routine tests.......................................................................................................................................... 22
5.3 BOM of sample ..................................................................................................................................... 24
TRACTION TRANSFORMER

SCOPE

These specifications are applicable to Traction Transformer of 2-phase 220 kV / 132 kV / 110 kV / 66 kV (for line 2A) primary voltage and 1-phase, 27.5KV secondary voltage. Traction Transformer shall be designed for outdoor installation and for operation at frequencies of 50 Hz.

The Traction Transformer shall be complete with all Parts, Fittings, and oil for the first filling, and accessories necessary for its efficient operation, including mounting frame work of steel. All such Parts, Fittings and Accessories shall be deemed to be within the scope of this Specification, whether specifically mentioned or not. The Traction Transformer shall be of proven design.

1. Governing Specifications

The Traction Transformers shall comply with the standards of the International Electro Technical Commission (IEC60076) or equivalent Indian standards

1.1 Standards

The Traction Transformer shall satisfy the requirements given below and shall also comply with standards in force when they are manufactured, particularly which are in the following table. (unless otherwise stipulated in the specifications, the latest version of the following standards shall be applicable): -

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Specification No.</th>
<th>Title of Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>IEC:60076-1,2,3,4,5 &amp;7</td>
<td>Power Transformer</td>
</tr>
<tr>
<td>2.</td>
<td>IEC : 60214</td>
<td>Tap changer for power transformer</td>
</tr>
<tr>
<td>3.</td>
<td>IEC 60296</td>
<td>Insulating oil for Transformer</td>
</tr>
<tr>
<td>3A</td>
<td>IS 12463:1988 along with additional requirements of RDSO</td>
<td>Insulating oil for Transformer (revise for Ester Oil)</td>
</tr>
<tr>
<td>3B</td>
<td>IEC 61099</td>
<td>Synthetic Ester Oil (SEO) for power transformers</td>
</tr>
<tr>
<td>3C</td>
<td>IS16081</td>
<td>Synthetic Ester Oil (SEO) for power transformers</td>
</tr>
<tr>
<td>4.</td>
<td>IS335</td>
<td>Insulating oil for Transformer</td>
</tr>
<tr>
<td>5.</td>
<td>IEC 60028</td>
<td>Conductor for Insulated cable</td>
</tr>
<tr>
<td>6.</td>
<td>IEC 60137</td>
<td>Insulating Bushing for rated Voltage above 1KV</td>
</tr>
<tr>
<td>7.</td>
<td>IEC 617-2</td>
<td>Earthing terminal</td>
</tr>
<tr>
<td>8.</td>
<td>IEC 60 721-2-5</td>
<td>Specification for painting:- Environmental condition</td>
</tr>
<tr>
<td>9.</td>
<td>ISO12944-5</td>
<td>Protective Paint system</td>
</tr>
</tbody>
</table>
1.2 Abbreviations

- TT - Traction Transformer
- IEC - International Electro-technical Commission
- IS - Indian Standard
- OLTC - On Load Tab Changer
- ONAN - Oil Natural Air Natural
- ONAF - Oil Natural Air Force
- NIFPS - Nitrogen Injection Fire Protection System

2. Technical Requirement

2.1 Characteristics:

The Traction Transformers at TSS shall meet the following characteristics:

- 2-phase Primary winding of 220kV/132kV/110kV/66kV (for line 2A)
- 1-phase secondary winding of 27.5kV
- Entirely submerged in mineral oil tank
- Outdoor type, suitable for tropical conditions, satisfying the climatic conditions of Mumbai.
- On load tap changer on primary windings
- Possibility of various overload conditions
- Separated oil conservator with aircell.
- Cooling by natural oil circulation and banks of radiators mounted on the tank
- Both transformers shall be identical
- Transformer noise level should not exceed 75dB measured at a distance of 1.5 m
- The Vector group shall be I. i.
- Should have symphonic filter.
- The two transformers at any Traction Substation are not meant to work in parallel

2.2 Rated power

The 220kV or 132kV or 110 or 66kV/27.5kV (for line 2A) transformers shall be manufactured and guaranteed so as to perform satisfactorily with a power rating, measured across the secondary winding, of the following value under load with cooling system in operation (ONAN/ONAF mode).

<table>
<thead>
<tr>
<th>Cooling System</th>
<th>Rating (MVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONAN/ONAF</td>
<td>As specified in the Particular Specification</td>
</tr>
</tbody>
</table>
2.3 **Service condition**

The normal service conditions for the transformer are as follows:

- Altitude: A height above sea-level not exceeding 1 000 m (3 300 ft).
- Temperature of ambient air and cooling medium
  A temperature of ambient air not below –5 °C and not above +55 °C.
- Wave shape of supply voltage
  A supply voltage of which the wave shape is approximately sinusoidal. The deformation shall neither exceed 5 % total harmonic content nor 1 % even harmonic content.
- Installation environment very heavy as per
  An environment with a pollution severity level as very heavy as per IEC 60815.

2.4 **Overload capacity**

After constant operation at continuous full load, the transformer shall have a guaranteed minimum overload capacity of:
- 50% for a duration of 15 minutes,
- 100% for a duration of 5 minutes

After overload the temperature rise shall not be more than:

- 65°C above ambient temperature for oil.
- 75°C above ambient temperature for windings

2.5 **Rated voltages**

The primary winding voltage shall be 220kV or 132kV or 110kV or 66kV as applicable at a power frequency of 50 Hz, on the main tapping.

Operating voltage may increase to + 10% or drop to -15% for the traction transformers. The primary winding shall be fitted with on-load tap changer offering 16 steps ensuring the primary voltage compensation from -15% to +10% of primary voltage. The secondary winding voltage shall be 27.5 kV at a power frequency of 50 Hz, one end being connected to the rails and the earth.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>220 kV</th>
<th>132 kV</th>
<th>110 kV</th>
<th>66 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primary winding rated insulation voltage</td>
<td>245 kV</td>
<td>145 kV rms</td>
<td>123 kV</td>
<td>72.5 kV</td>
</tr>
<tr>
<td>2</td>
<td>Impulse withstand voltage for primary</td>
<td>950 kVP</td>
<td>650 kVP</td>
<td>550 kVP</td>
<td>325 kVP</td>
</tr>
<tr>
<td>3</td>
<td>Power frequency withstand</td>
<td>395 kV rms</td>
<td>275 kV rms</td>
<td>230 kV rms</td>
<td>140 kV rms</td>
</tr>
</tbody>
</table>
2.6 **On-load tap changer**

Voltage shall be substantially constant at the untapped windings (secondary windings) and variable at the tapped winding (primary winding). The category of regulation applied shall be constant-flux variable voltage type (CFVV).

The on-load tap changer shall be single-phase enclosure type, installed in a separate oil tank, offering 16 steps (+6step, normal and -9step), each representing 1.667% of the nominal voltage.

The tap changer shall have the following characteristics:

- 50 000 operations without any attention
- Motor and hand-driven possibility
- Tap position indicators
- Commutation current compatible with the short duration transformer over-current.
- Diverter switches shall be designed for high speed operation and shall be interlocked to ensure that there is no possibility of an operation stopping in mid-position. Arcing contacts shall be of tungsten alloy material.
- Devices for ease of extraction for maintenance purpose
- Manual/Automatic, Local/Remote, Control & Monitor of OLTC from RSS control room and OCC.

The oil volume of the on-load tap changer unit must be separated from the tank for core and winding oil.

The power circuit of the on-load tap changers shall be connected to the primary windings and shall enable the required voltage variations as mentioned in the annexed technical sheet.

The full technical description shall be given as regards power and auxiliary circuits; periodicity for checking and over-hauling the power circuit shall be indicated in the transformer maintenance Manual. The servomechanism settings shall be designed and executed to avoid too many actuations.

The manufacturer shall provide mechanical and electrical diagrams. A suitable protection relay shall be connected on the oil pipe between the on-load tap changer and the expansion
vessel. The voltage ratio shall be checked according to the guaranteed figures and the tolerances stipulated in the standards.

2.7 Cooling system

The Traction Transformer shall be designed to operate in ONAN/ONAF mode (mineral oil natural / air natural/air forced). The oil along with inhibitor to be used for the transformer must be in conformity with the IEC 296 standard, or IS 335 (with latest amendments) and of the highest inflammability degree.

Spare oil for at least 10% of each transformer shall be provided.

The maximum temperature allowable at nominal rating shall never exceed:
- 50°C above ambient temperature for mineral oil
- 55°C above ambient temperature for the copper winding and the iron core.

Dielectric strength of the oil during test should be more than 55 kV /2.5 mm; the contractor shall mention the method and the referenced standard employed.

The transformer shall be rejected in case the temperature rise exceeds the guaranteed values by more than five degrees centigrade’s.

The contractor shall give full description of the design, operation and maintenance of the proposed air cooling system for ONAN/ONAF and indicate the air flows needed for ventilating the cubicle and the air cooling units.

In case of fire detection into the transformer cubicle, the air cooling system shall be immediately and automatically switched off.

2.8 Short-circuit withstand capability

2.8.1 Short-circuit on H.V. side

The transformer shall be designed and constructed so as to withstand without damage, or impairment in its performances, any external short-circuit.

The primary winding of the transformer shall be designed for carrying the full symmetrical short circuit current, for 3 sec. The full symmetrical short circuit current shall be calculated in accordance with IEC after taking into account the system impedance on the primary voltage of the transformer.

The design of the primary side bushings of the Transformers shall withstand the symmetrical current for three seconds during short-circuit on primary voltage (40 kA/1 s for 220 kV, 31.5 kA/1s for 132 kV, 110 kV and 66 kV) as specified in IEC 60076-5.

To limit the short-circuit symmetrical current to an allowable value; the impedance voltage shall never be less than twelve percent (12%). At rated power and frequency on the main tapping, the impedance voltage shall be equal to about twelve point five percent (12.5%).
**Short-circuit on L.V. side**

The maximum short circuit current at the output of feeder station has to be limited at 16 kA to comply with the rolling stock on board circuit breakers breaking capacity, (compared to distribution network) only limited by the internal transformer leakage impedance.

Consequently transformers must be designed taking into account this current short circuit limit, as well as electrodynamics and thermal constraints.

The contractor shall specify a guaranteed value and tolerances according to the standards and requirements

2.9 **Iron core**

The magnetic core, frame assembly, clamping and general structure of the transformer shall be mechanically sturdy so as to be capable of withstanding shocks which may happen during transport or during short-circuits and over-voltages.

Cores and magnetic circuit shall consist of cold-rolled grain-oriented silicon steel sheets of the best quality, offering every guarantee of durability, heat and oil resistance

The core tightening bolts shall be suitably insulated and the grounding of the magnetic circuit shall employ generously sized copper connections and links.

The keying and compression of the laminations, together with the induction value, shall be designed so as to keep vibrations to a minimum and to reduce, in particular, the third and fifth harmonics influences. Calculation sheets to establish maximum flux density (i.e. 1.55 Tesla) shall also be submitted with Design to employer. The contractor shall submit complete technical data of the system to the employer

2.10 **Transformer losses**

The transformers shall be designed for minimum losses.

When comparing between different tenders the present value of the capitalized cost of losses in the transformers shall be added to their financial bid by the following formula

\[
PW = K*365*24* C (Wir + b^2 Wcu)/1000
\]

Where

- \(PW\) is the present worth (in IR) of annual capitalized cost of losses at 10% rate of interest over 25 years
- \(K\) is the present worth factor (10% interest, 25 years) = \({((1+0.1)^{25} - 1)}/(0.1*(1+0.1)^{25})\} = 9.077
- \(C\) is the cost of the kWh (in Indian Rupees) = Rs.8
- \(Wir\) is the iron losses in Watts at normal voltage and main tapping
- \(Wcu\) is the full load copper losses in Watts at normal voltage and main tapping at 95°C
- \(b\) is the load factor of transformer = 50%
Thus

\[ PW = 9.077 \times 365 \times 24 \times 8 \times (W_{ir} + b^2 \times W_{cu})/1000 \]

\[ PW = 636.12 \times (W_{ir} + 0.25 \times W_{cu}) \]

In case the transformer losses during tests are found greater than the values guaranteed in the offer, a consolidated penalty shall be paid by the contractor, according to the following formula (for the tolerance permissible according to IEC standard):

\[ 636.12 \times (d \times W_{ir} + 0.25 \times d \times W_{cu}) \]

Where:
- \( d \times W_{ir} \) and \( d \times W_{cu} \) are the differences between the test values of iron losses at full voltage and copper loses at full load on one transformer at main tapping and the values guaranteed in the offer.

2.11 Windings

The winding conductors shall be made of best quality high conductivity electrolytic copper, in compliance with the standard (IEC 60028) requirements.

Both windings, primary and secondary, shall be designed to withstand over-voltages and over-currents in case of direct short-circuit across the medium voltage terminals with the primary winding line for three seconds.

Construction shall take into account electrodynamics and thermal constraints specific to railway traction duty.

The adjustments windings shall be designed specifically to withstand direct short-circuit of all part of the adjustment turns that may occur at the contact plates of the on-load tap changer. The windings, connections and terminal links shall be properly brazed so as to withstand the shocks and vibrations that may occur during transport or short-circuit.

Tests on samples shall be carried out and results submitted for approval before starting assembly of the transformer windings. Current density for each winding shall be not more than 2.5 A/mm². The insulation material used for the transformer windings and connections shall be at least of class A.

2.12 Terminals and connections

The primary and secondary connections shall be realized through porcelain/polymeric bushings insulators as applicable. The porcelain shall be brown glazed. It shall be unaffected by atmospheric conditions like fumes, ozone acids, alkaline, dust, sand storms or rapid change in temperature between 0°C and 75°C under working conditions and the prevailing environmental conditions.

In order to avoid damages to tank in case of disruptive discharge, bushing base should be connected to the earth. Creepage distance for one bushing should be 3.1 cm/kV. Bushings
shall be realized in conformity with the IEC 60137 standard. Special care shall be taken against transmission of vibrations by employing a damping system and suitable fittings.

The design shall take into account the ease of overhaul. It should be possible to withdraw and to remove the transformer at ease. Interchangeability between transformers shall be achieved through the use of identical elements.

The link between secondary terminals of the transformer and the 25 kV switchgear shall be made by cables connected directly at the outside of the secondary bushing. Bushings shall be realized in conformity with the IEC 60137 standard.

**NOTE:** Employer may go for primary and secondary connections through Dry plug type termination on the transformer as applicable. The vendor may quote the price separately in the addition/deletion items given in the BOQ for the change in the transformer tank design suitable for this type arrangement and cost of dry plug type termination in place of porcelain bushing.

### 2.13 Tank and radiators

The transformer tank shall be made of high quality boiler plate steel with stiffening frame and girders. The thickness of sections shall be suitably sized so that it is possible to dismantle by grinding and re-do welding at least three times, before it becomes necessary to condemn the sections and refabricate.

The thickness of the tank should not be less than 10 mm, with reinforcement in order to withstand full vacuum, and mineral oil pressure. Tank shall only be connected to the earth through current transformer. In case of separated radiators, they shall be earthed separately and consequently pipes network shall be mounted with insulating joints.

The tank itself, the pipe work, valves, joints and gaskets shall be airtight, watertight and oil-tight. The junction shall be capable of withstanding the temperature of a fire without causing any leak as per IEC 60076 standards. The tank shall be fitted with hooking points to enable it being lifted in balance by means of an overhead travelling crane, either as the main package or in form of the complete unit, fully equipped and filled with mineral oil. The frame shall enable the transformer being laid normally on a slab or foundation block, without rollers. Each dismountable tank and radiators element shall be equipped with the following auxiliary devices:

- flanged oil drainage valves,
- oil sampling cocks at top and bottom of the tank with suitable oil flanges,
- flanged valves suitable to connect the oil filtering unit,
- hooking points

and overall shall be equipped with:

- special pockets for checking by thermometers,
- earthing terminals according to IEC 617-2 standard
- Frame to ease the transportation
- swivelling removable rollers with locking devices.
- overpressure relief device provided with electrical contacts
- manholes on the tank cover so as to obtain access to the core winding assembly, tap changer mechanism, terminal, the lower ends of all bushings etc. for purpose of repair without lifting the core winding assembly

Each transformer shall be equipped with the suitable lockable ladder to reach top of tank for inspection & Maintenance.

Name plate to be provided with all technical particulars

2.14 **Oil expansion vessel**

The transformer shall be equipped with an oil expansion vessel placed above the transformer on a specific support.

It shall be partitioned so as to avoid mixing between the on-load tap changer oil and the core and winding oil.

Each partition shall:
- be connected to the transformer through all the necessary pipe-works, fitted with flexible metal joints and gaskets; the connecting pipe shall over-extend vertically inside the vessel (at least 8 cm)
- be provided with, easy to reach, drainage valves, oil sampling devices and relief valve.
- be equipped with a dehydrating breather made of transparent glass material shall contain Silica gel or equivalent fitting and checking glass shall be accessible easily to change the dehydrating product during operation of the transformer.
- be provided with an oil level indicator having auxiliary contacts and easily observable from ground level.

The oil volume should be above the minimum level, when the ambient temperature is 0°C or below. Similarly the oil volume should be below the maximum level when the ambient temperature is 55°C or above.

2.15 **Control and protection**

The transformer shall be delivered with "buchholz", thermal and earth fault protections, all connected to the control and monitoring cabinet "Buchholz"

The term "buchholz" protection denotes the gas-sampling device and relay for gas fault detection and storage for analysis

The relay shall comprise of two thresholds as follow:
- alarm in case of minor fault such as local overheating of windings or core (small gas discharge),
- tripping-out in case of major fault (violent gas discharge) and excessive oil leakage.

Both transformer and load-tap changer oil circuits shall be equipped with "buchholz" protection. They shall be connected to the oil pipe between the tank and the expansion vessel, without any flat part and any less than 50mm bend.

It shall be free for access and maintenance; a by-pass system shall be provided to enable oil flow without interrupting operation during maintenance checks. In order to ease gases chemical analysis, the gas-sampling device shall be accessible during transformer operation, at man’s working level.

**Thermostat**

The thermostat itself shall be installed in the monitoring box, while the indicator on it facade and the thermal probe shall be installed into the tank with appropriate pocket.

**Earth fault**

The insulated tank shall only be connected to the earth through a resin cast core/ring type current transformer as per GTP, which shall be linked to the control system via monitoring cabinet terminal block.

### 2.16 Control and monitoring cabinets

Made of stainless steel-sheets, grade-304 totally enclosed dust-proof and watertight type (IP55) suitable for outdoor applications it shall be equipped with:

**a) For transformer**
- Access doors with padlocks
- 415 /230 V protection and power circuits.
- 110 V dc control and monitoring relays
- Internal lighting monitored by the door position.
- Heating thermostat with indicators and contacts
- Information terminal block
- Remote control and monitoring multi-pin connector

**b) For On-load tap changer**
- Access doors with padlocks
- 415 /230 V protection and power circuits.
- 110 V DC or 415 V AC (3 ph) or 220 V AC (1ph) motor, control and monitoring relays
- Internal lighting monitored by the door position.
- On-load tap changer operating equipment and control
- Counter
- Information terminal block
- Remote control and monitoring multi-pin connector

OLTC tap position should operate based on voltage level of primary side voltage of Transformer. This provision shall be provided with PLC based logic and PLC should be installed in the RTCC indoor Panel and should have adjustable time & voltage settings for OLTC tap operation feature. Operation of OLTC shall be possible from OCC.

Control of Auto / Manual and Local/Remote selector switch shall also be possible from OCC /Local SCADA.

All control and monitoring cabinets used in indoor shall conform to the following minimum specifications

<table>
<thead>
<tr>
<th>Material</th>
<th>Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum thickness of Steel sheets</td>
<td>3 mm for front cover &amp; base frame</td>
</tr>
<tr>
<td></td>
<td>2 mm for rear door</td>
</tr>
<tr>
<td></td>
<td>1.6 mm for roof plate, bottom plate &amp; side covers</td>
</tr>
<tr>
<td>Powder Coating :</td>
<td>RAL 7032, Texture finish</td>
</tr>
<tr>
<td>Exterior</td>
<td>Black</td>
</tr>
<tr>
<td>Interior</td>
<td>Min. 80 microns of Power coating</td>
</tr>
<tr>
<td>Base frame</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td></td>
</tr>
</tbody>
</table>

The Contractor shall submit to the Employer, the complete details of the Control & Monitoring Cabinets, including details of the structure, process of finish and painting, wiring, terminal blocks, cubicle illumination heating etc, for Employer’s approval.

The details adopted for Control and Relay panels, Bay Control and Protection units, Transformer and On-load tap changer cubicles and all other Control and Monitoring Cabinets, located inside the RSS Control Room shall be identical to project an aesthetically good appearance

2.17 **Metal work and Paint-work**

Painting should be suitable for salty seaside atmosphere and has to comply with IEC 60 721-2-5 standard. The entire surface (Internal as well as External) to be painted shall be prepared by Shot blasting to cleanliness level, SA21/2 as per ISO 8501/SIS 055900. Ensure that the cleaned surface is free of oil or grease, scales rust and other residue. Surface profile of the blasted surface should be approximately 40-60 microns.
All the external surface of the transformer shall be given first coat of Epoxy zinc rich (having minimum 83% metallic zinc) primer (Min.50 microns thickness), first intermediate coat of epoxy zinc phosphate paint (Min.60 microns thickness), intermediate coat of Epoxy high build MIO (Min.80 microns thickness), and final coat of glossy Aliphatic Acrylic polyurethane (Min.50 microns thickness). The total dry film thickness (DFT) of the paints shall be minimum 240 microns and should withstand 120°C. The shade of paint shall be gray shade 631 as per IS: 5.

All steel surfaces which are in contact with insulating oil shall be painted with heat resistant oil-insoluble insulating varnish.

After baring, all metal surfaces shall receive anti-corrosion process:
- natural stainless for Bolts & screws
- hot dip galvanization for radiators
- rust-proofing and anti-corrosion paint for tank, oil expansion vessel and other metal surfaces.

The transformer and its accessories shall be completely painted in plant. The necessary touch-ups shall be executed on-site after erection. This protection shall be fully guaranteed for five years starting from provisional taking over. Should any noticeable deterioration by rust or corrosion appear before this time elapses, the contractor shall be responsible for repainting at his own expense and for renewing his guarantee for the work performed.

The painting and preserving of panels for transformer protection should be similar match with that of other control and relay panels provided in the control room.

2.18  Particular dispositions, Installation

Transport

For transport either by road, ship or rail, the transformer shall be filled with oil up to windings top and then with Nitrogen at recommended pressure up to the tank top or alternatively the transformer may be filled with Nitrogen, in full, during transportation.

The bushing, breather, wheels and all other external parts shall be removed on condition that they can be mounted at site.

Installation

The Transformers are to be installed in Substation on two running rails, and consequently must be delivered with a set of swiveling rollers. These rollers shall be mounted, electrically insulated from tank and with locking devices.

Material layout and volume shall be such that it shall be possible to remove parts without dismounting other parts. The contractor shall indicate the method

3.  Additional Requirement
3.1 Fire Protection & Suppression system:-

In terms of CEA (safety regulations), 2010 “transformers of 10 MVA and above rating or in case of oil filled transformers with oil-capacity of more than 2000 litters are provided with fire fighting system as per IS - 3034: 1993 or with Nitrogen Injection Fire Protection system”;

In view of above, transformer shall be provided with “Nitrogen Injection Fire Protection System”. The specifications of “Nitrogen Fire Protection System” are detailed as below:-

Nitrogen injection fire protection system designed for oil filled transformers shall prevent tank explosion and the fire during internal faults resulting in an arc, where tank explosion will normally take few seconds after arc generation and also extinguish the external oil fires on transformer top cover due to tank explosion and/or external failures like, bushing fires, OLTC fires and fire from surrounding equipments.

The system shall work on the principle of DRAIN AND STIR and on activation: it shall drain a pre-determined quantity of oil from the tank top through outlet valve to reduce the tank pressure and inject nitrogen gas at high pressure from the lower side of the tank through inlet valves to create stirring action and reduce the temperature of top oil surface below flash point to extinguish the fire. Conservator tank oil shall be isolated during bushing bursting, tank explosion and oil fire to prevent aggravation of fire. Transformer isolation shall be an essential pre-condition for activating the system. The system shall be designed to operate automatically. However it shall be designed for manual operation, in case of failure of power supply.

The system shall consist of following equipments:
1. Fire extinguishing cubicle placed on a plinth at about 5-10 meter away from the transformer.
2. Control box placed in the control room.
3. Pre-stressed non return valve in the conservator pipe.
4. Required number of fire detectors on the tank top cover.
5. Signal box fitted on the tank top or tank side wall

SCOPE

Notwithstanding the technical specifications and requirements mentioned herewith any modification can be incorporated for correct operation of nitrogen injection fire protection system without extra cost. The full details of the same are required to be submitted to DMRC for approval.

OPERATIONAL CONTROLS

The system shall be provided with automatic control for fire prevention and fire extinction. Besides automatic control remote electrical push button control on control box and local manual control in the fire extinguishing cubicle shall be provided. Spare interlocks are to be provided for ensuring that it should not be possible to close HV or LV circuit breakers to energize the transformer after the activation of the fire prevention and, fire extinction
system.

**SYSTEM ACTIVATING SIGNALS**
Transformer isolation shall be an essential pre-condition for activating the system. Transformer isolation through Master trip relay or circuit breaker (HV and LV side in series) has to be incorporated. Besides, two electrical signals to be provided in series, for activating the system as under:

**For Prevention:**
- Differential relay,
- Buchholz relay paralleled with pressure relief valve

**For Extinction:**
- Fire detector.
- Buchholz relay paralleled with pressure relief valve

**SYSTEM EQUIPMENTS**

A. Fire Extinguishing Cubicles (FEC), placed on plinth at about minimum 5 meter away from the transformer shall consist of:

1. Nitrogen Gas cylinder with regulator and failing pressure electrical contact manometer.
2. Oil drain pipe with mechanical quick drain valve.
3. Electro mechanical control equipments for oil drain and pre determined regulated nitrogen release.
4. Pressure monitoring switch for backup protection for nitrogen release.
5. Limit switches for monitoring of the system.
6. Flanges on top panel for connecting oil drain and nitrogen injection pipes for transformer.
7. Panel lighting
8. Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

B. Control box with activating, monitoring devices and line faults indicators. (To be placed in control room). It should have audio visual alarm indication and push button switches.

C. Pre-stressed non return valve (PNRV) to be fitted in the conservator pipe line, between conservator and bucholz relay operating mechanically on transformer oil flow rate with electrical signals for monitoring.

D. Fire detectors to be fixed on transformer tank up cover and On Load tap Changer for sensing fire.

E. Signal box to be fixed on transformer side wall for terminating cable connections from fire detectors and PNRV

F. All other consumables necessary for complete system.
OTHER REQUIREMENTS FOR SYSTEM INSTALLATIONS

A. Oil drain and Nitrogen openings with gate valves on transformer tank at suitable locations.
B. Flanges with dummy pipes in conservator pipe between Buccholz relay and conservator tank for fixing PNRV.
C. Fire detector brackets on transformer top cover.
D. Spare potential free contacts for system activating signals i.e. differential relay, buchholz relay, pressure relief valve, transformer isolation (master trip relay).
E. Status of Fire Protection System Operated, NIFPS out of service, PNRV/TCIV valve close, Fire detector initiation alarm/trip, Nitrogen cylinder pressure low, Visual/Audio Alarm for NIFPS system and Visual/Audio Alarm of NIFPS for DC supply fail shall be available on the Local/OCC SCADA.
F. Pipe connections between transformer to fire extinguishing cubicles and fire extinguishing cubicle to oil pit.
G. Cabling on transformer top cover all fire detector to be connected in parallel and inter cabling between signal box to control box and control box to fire extinguishing cubicle.
H. Plinth for fire extinguishing cubicle. Oil pit with suitable capacity.

TECHNICAL DETAILS

Fire extinction period
- On commencement of Nitrogen injection : Maximum 30 seconds
- On system activation up-to post cooling : Maximum 3 minutes
- Fire detectors heat sensing temperature : 141 degcelcius
- Heat sensing areas : 800 mm radius
- Pre-stressed non-return valve setting for operation : Minimum 60 ltr per minute
- Power Source :
  - Control Box : 110 V DC
  - Fire fighting cubicles for lighting : 240 V AC

CABLING:

Fire survival cables, able to withstand 750 degcelcius, of appropriate size & core for connection of fire detector in parallel shall be used. The test certificates for the cables shall be submitted.

Fire retardant low smoke AC/DC cable as applicable (FRLS) cable of appropriate Sizes & core for connection between transformer signal box/marshalling kiosks box to control box and further from control box to fire extinguishing connection shall be used.

PREVIOUS EXPERIENCE FOR QUALIFYING SUPPLIER:

The supplier shall have a minimum experience of two years in the design, manufacturing, erection, testing and commissioning of nitrogen injection fire protection system on power transformers of similar or higher rating. At least 2 sets of the system shall be in successful operation for a minimum period of the 2 years. The supplier shall furnish the details of nitrogen injection fire protection system supplied by them so far, giving order reference,
name and address of the customer, indicating the dates of commissioning as well as performance certificate of successful and satisfactory operation for minimum two years from the customers.

**TESTS**

**TYPE TEST**
Type Test reports including that for detectors along with declared response time shall be submitted within the tender. The system shall be tested by reputed international testing body or a national testing body (BIS) recognized laboratory. TAC approval, if any, shall be submitted with the tender.

**FACTORY TEST**
Tests will be carried out on individual equipment of the system and the total system in the supplier’s workshop in presence of purchaser’s representatives.

**PERFORMANCE TEST**
Performance test of the complete system shall be carried out after complete erection at site by the supplier’s representatives. These tests shall include simulation and verification of the response of the complete system without actual draining of the oil and injection of the nitrogen gas. In addition to above, additional tests as required necessary shall be conducted.

**DRAWINGS AND MANUALS**
Detailed layout drawings along with the equipment drawing to be given in the proposal along with the complete bill of materials. After awarding of contract, detailed dimensional drawing of the system complete bill of materials including location and size of plinth for cubicles and recommended capacity of oil soak-pit shall be submitted for purchaser’s approval. After approval 10 (ten) sets of all above drawings and 5 (five) sets of operation and maintenance instruction manual (bound) shall be submitted for purchaser’s use.

**SPARES**
One full set of spares nitrogen gas filled cylinder, 50 % of the installed no. of fire detectors (heat sensing element) shall be provided in addition to additional other recommended spares. The list of recommended spares is to be submitted along with the proposal of vendor approval.

### 3.2 Fiber Optic Winding Hot Spot Temperature Monitor:
Fiber optical winding hot spot temperature monitor to be provided with transformer windings connected in parallel of the winding temperature indicator to measure transformer-winding hot spots in real time and activate control of the cooling system. The Fiber to be given high strength casing through rugged jacketing and fiber to be securely routed till the tank wall plate. Temperature readings shall be available on SCADA and FO sensor shall have IEC 61850 compliant port to communicate with SCADA.
Specification for Fiber Optic Temperature Measurement System:

Fiber optic based temperature measurement of Oil and windings shall be done using Fiber Optic sensors meeting following criteria:

1. System shall be of proven technology. The temperature sensing tip of the fiber optic shall be ruggedized. The probes shall be directly installed in each winding of power transformer to measure the winding hot spot and at the top oil temperature. There shall be at least 4 probes inside the transformer.

2. Out of the 4 probes one probe shall be used for top oil temperature measurement and the balance will be placed in the LV, HV and Tap Changer winding (One probe per winding).

3. Probes shall be able to be completely immersed in hot transformer oil they shall withstand exposure to hot vapour during the transformer insulation drying process, as part of Vacuum Phase Drying (VPD). The probes shall meet the requirement to eliminate the possibility of partial discharge in high electric stress areas in the transformer. Probes shall have certified Weidman testing for electrical parameters as per ASTM D3426 and ASTM D149 that is current (not more than 15 year old). Test results and studies to be submitted by the transformer manufacturer along with the first unit of a certain type of traction transformer.

4. Temperature range of the system should be up to +200°C without any need of recalibration. Probes must connect to the tank wall plate with threaded connectors containing a Viton o-ring to prevent against oil leakage.

5. Probes shall be of material inert to mineral and ester oils, multiple jacketed (Kevlar preferred), perforated outer jacket to allow complete oil filling and mechanical strength.

6. System should include analog outputs for each measurement channel. Temperature resolution of the analog outputs shall be ±0.1°C and precision of +/−1°C and the system shall offer user programmable temperature alarm outputs with 8 relays (along with 1 Form C system status relay). The cooling system (Fans &Pumps) should be operated through these relays. The temperature settings for the relays shall be made as per the end user request.

7. All inputs and outputs of the system shall meet the Requirements of surge test of IEEE C37.90.12002 in which a 4000 V surge is applied to all the inputs and outputs without permanent damage to the instrument. The system should electronically store testing records of components and allow for on board diagnostics and instructions, including a signal strength reading to verify integrity of fiber optic connections. System should contain a battery for date/time stamp of data readings. The system should contain IEC61850 protocol, along with DNP3.0, Modbus, TCP/IP and ASCII.

8. The transformer manufacturer should submit data showing that the probes are located in the hottest point of the winding, while submitting drawings for approval.
9. The controller shall be housed in cooler cubicle or in a separate enclosure having ingress protection IP 55.

10. Temperature Rise Test Measurements shall be made with the Fiber Optic Thermometers. The equipment shall be operational during temperature tests and be demonstrated during these tests. During probe verification, the hottest probes for each phase shall be identified, and temperature data for all probes recorded and reported in the test report.

11. All temperatures probes should be compatible with SCADA communicability.

3.3 Ester oil filled transformers:

If the employer requires ester oil filled transformer, the contractor shall submit detailed design of the transformer along with relevant extracts of applicable International/Indian standards. Any savings in size due to ester oil shall be clearly specified. The contractor shall submit the credentials to assist proven-ness of the design. Transformer shall be designed with thermally upgraded papers and OLTC other accessories shall be designed with high temperature rises, so as to minimize the size of the transformers. The adjustment price of transformer with synthetic ester oil is to be quoted in pricing/BOQ document (this includes the supply of spare ester oil drums in place of mineral oil, if ester oil filled transformers are chosen).

4. Maintenance & Life

The Traction Transformer should be designed for trouble free service of minimum 30 years for all types of installation methods & environmental conditions prescribed.

5. TESTING

TEST SHEET and GTP SHEETS

All type tests and routine tests of Transformer, ON load tap Changer and Bushings as per relevant IEC standards specified in technical specifications shall be carried out. Short circuit withstand test shall be conducted on one each type and rating of transformer to validate the design and quality unless such test has been conducted within last five years on the transformer of same design. In case there is change in design before five years, the new transformer design shall be validated by carrying out short circuit withstand test. All the type test report shall be valid at the time of vendor approval. The BOM of the transformer which is type tested earlier and the report of which is submitted shall meets the present specifications, else the earlier report of type test conducted within 5 years will not be acceptable.

5.1 Type tests:

The list of Type tests is as follows:

<table>
<thead>
<tr>
<th>S.no</th>
<th>Name of Type test</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperature rise test</td>
<td></td>
</tr>
</tbody>
</table>

Page 21 of 24
# SPECIFICATIONS FOR TRACTION TRANSFORMER

<table>
<thead>
<tr>
<th>S.no</th>
<th>Name of Type test</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Measurement of Harmonics of No-Load as per IS 2026-1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Determination of sound level for each method of cooling.</td>
<td>Please refer GTP</td>
</tr>
<tr>
<td>4</td>
<td>Measurement of power taken by Fans</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Short-circuit withstand test</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Line terminal AC withstand voltage test (LTAC)</td>
<td>For 220kV only</td>
</tr>
<tr>
<td>7</td>
<td>Vacuum deflection test on liquid immersed transformers</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Pressure deflection test on liquid immersed transformers</td>
<td></td>
</tr>
</tbody>
</table>

## Bushings

<table>
<thead>
<tr>
<th>S.no</th>
<th>Name of Routine test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC Long Duration Test</td>
</tr>
<tr>
<td>2</td>
<td>Dry lightning impulse voltage withstand test</td>
</tr>
<tr>
<td>3</td>
<td>Temperature Rise test</td>
</tr>
<tr>
<td>4</td>
<td>Thermal Short-Time current withstand</td>
</tr>
<tr>
<td>5</td>
<td>Cantilever Load Withstand Test</td>
</tr>
<tr>
<td>6</td>
<td>Tightness test on liquid-filled</td>
</tr>
<tr>
<td>7</td>
<td>Dimensions Verifications</td>
</tr>
</tbody>
</table>

## OLTTC

<table>
<thead>
<tr>
<th>S.no</th>
<th>Name of Routine test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperature rise of contacts</td>
</tr>
<tr>
<td>2</td>
<td>Service duty test</td>
</tr>
<tr>
<td>3</td>
<td>Breaking capacity test</td>
</tr>
<tr>
<td>4</td>
<td>Short-circuit current test</td>
</tr>
<tr>
<td>5</td>
<td>Mechanical endurance test</td>
</tr>
<tr>
<td>6</td>
<td>Millivolt test</td>
</tr>
</tbody>
</table>

## 5.2 Routine tests

The list of Routine tests is as follows

<table>
<thead>
<tr>
<th>S.no</th>
<th>Name of Routine test</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Measurement of winding resistance</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Measurement of voltage ratio and check of phase displacement</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Measurement of short-circuit impedance and load loss</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Measurement of no-load loss and current</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Full wave lightning impulse test for the line terminals (LI)</td>
<td>Not for 220 kV Transformer</td>
</tr>
<tr>
<td>6</td>
<td>Chopped wave lightning impulsetest for the line terminals (LIC)</td>
<td>Applicable for 220kV Transformer only</td>
</tr>
<tr>
<td>7</td>
<td>Switching impulse test for the line terminal (SI)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Applied voltage test (AV)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Induced voltage test with PD measurement (IVPD)</td>
<td></td>
</tr>
</tbody>
</table>
### SPECIFICATIONS FOR TRACTION TRANSFORMER

<table>
<thead>
<tr>
<th>S.no</th>
<th>Name of Routine test</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Line terminal AC withstand voltage test (LTAC)</td>
<td>Not applicable for 220kV Transformer</td>
</tr>
<tr>
<td>11</td>
<td>Auxiliary wiring insulation test</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Tests on on-load tap-changers operation test</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Leak testing with pressure for liquid-immersed transformers (Tightness test)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Check of core and frame insulation for liquid immersed transformers with core or frame insulation</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Check the insulation between the Transformer body &amp; Earth and provision of the insulation Pad</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Determination of capacitances windings-to-earth and between windings</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Measurement of D.C insulation resistance between each winding to earth and between windings</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Measurement of dissipation factor (tan δ) of the insulation system capacitances</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Measurement of no-load loss and current at 90 % and 110 % of rated voltage</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Measurement of zero-sequence impedance(s) on three-phase transformers</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Measurement of frequency response (Frequency Response Analysis or FRA).</td>
<td>This test is also to be repeated at site to correlate any transportation damage.</td>
</tr>
</tbody>
</table>

**Bushings**

1. Measurement of tan δ and capacitance.
2. Dry lightning impulse voltage withstand test
3. Dry power-frequency voltage withstand test
4. Measurement of Partial Discharge Quantity
5. Tests of Tap Insulation
6. Tightness test on bushings
7. Tightness test at the flange or other fixing device
8. Visual inspection and dimensional check

**OLTC**

1. Mechanical tests
2. Sequence tests
3. Auxiliary circuits insulation test
4. Overrun test

The contractor shall submit fully filled technical data sheet given in chapter 8B of PS along with other relevant data during technical approval
5.3 **BOM of sample**

The manufacturer shall not change the Bill of Material used in the manufacturing of samples used for routine testing and Type testing as repeated above and that it intends to supply against the contract.