DMRC ELECTRICAL STANDARDS & DESIGN WING (DESDW)

SPECIFICATION NO.
DMES- 0003/DMRC-E-TR-TRANSF-03

SPECIFICATIONS FOR TWO PHASE 220/27.5 KV, 40/50 MVA TRACTION TRANSFORMER FOR RECEIVING SUBSTATIONS

Issued on:

<table>
<thead>
<tr>
<th>Date</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>28th Jan 2014</td>
<td>Draft</td>
</tr>
</tbody>
</table>
Table of Contents

1. 220 kV / 27.5 kV Traction Transformers .......................................................... 3
   1.1 Governing specification ............................................................................... 3
   1.2 Characteristics ............................................................................................... 3
   1.3 Rated power ................................................................................................. 3
   1.4 Overload capacity ......................................................................................... 3
   1.5 Rated voltages .............................................................................................. 3
   1.6 On-load tap changer .................................................................................... 4
   1.7 Cooling system ............................................................................................. 5
   1.8 Short-circuit withstand capability ................................................................. 6
      1.8.1 Short-circuit on H.V. side ...................................................................... 6
      1.8.2 Short-circuit on L.V. side ...................................................................... 6
   1.9 Iron core ....................................................................................................... 6
   1.10 Transformer losses ...................................................................................... 6
   1.11 Windings ..................................................................................................... 7
   1.12 Terminals and connections ......................................................................... 8
   1.13 Tank and radiators ..................................................................................... 8
   1.14 Oil expansion vessel ................................................................................... 9
   1.15 Control and protection .............................................................................. 9
      1.15.1 “buchholz” ............................................................................................ 10
      1.15.2 Thermostat ............................................................................................ 10
      1.15.3 Earth fault ............................................................................................ 10
      1.15.4 Control and monitoring cabinets ......................................................... 10
   1.16 Metal work and Paint-work ........................................................................ 11
   1.17 Particular dispositions, Installation ............................................................ 12
   1.18 Fire Protection & Suppression system: ....................................................... 12
      1.19 Fiber Optic Winding Hot Spot Temperature Monitor: .......................... 12
2. DATA SHEET ........................................................................................................ 13
   2.1 220 / 27.5 kV TRACTION Transformer 40 / 50 MVA .................................. 13
   2.2 On Load Tap Changer for 220 / 27.5 kV Transformer .................................. 15
3. TEST SHEET ........................................................................................................ 16
   3.1 TRACTION TRANSFORMERS .................................................................. 16
   3.2 ON LOAD TAP CHANGER ........................................................................ 17
1. **220 KV / 27.5 KV TRACTION TRANSFORMERS**

1.1 **GOVERNING SPECIFICATION**

The traction power transformers shall comply with the standards of the International Electrotechnical Commission (IEC 60076).

1.2 **CHARACTERISTICS**

The traction power transformers shall meet the following characteristics:
- 2-phases 220 / 27.5 kV
- Entirely submerged in mineral oil tank
- Outdoor type, suitable for tropical conditions, satisfying the climatic conditions of Delhi
- On load tap changer on primary windings
- possibility of various overload conditions
- separate oil conservator
- 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: l. i.
- Should have syphonic filter.

The two transformers are not meant to work in parallel.

1.3 **RATED POWER**

The transformer shall be manufactured and guaranteed so as to perform satisfactorily a power rating, measured across the secondary winding of the following value under load without any forced cooling system in operation (ONAN mode).

<table>
<thead>
<tr>
<th>Cooling System</th>
<th>Rating (MVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONAN / ONAF</td>
<td>40 / 50</td>
</tr>
</tbody>
</table>

1.4 **OVERLOAD CAPACITY**

After constant operating at continuous full load, the transformer shall have a guaranteed minimum overload capacity of:
- 50% for a duration of 15 minutes, i.e. 60 MVA
- 100% for a duration of 5 minutes, i.e. 80 MVA

After overload the temperature rise shall not be more than:
65°C above ambient temperature for oil.
75°C above ambient temperature for windings

1.5 **RATED VOLTAGES**

The primary winding voltage shall be 220 kV rms. at a power frequency of 50 Hz on the main tapping.
Operating voltage may increase to 220 kV + 10% (242 kV) and drop to 220 kV -15% (187 kV).

The primary winding shall be fitted with on-load tap changer offering the 16 steps ensuring the primary voltage compensation from 187 kV to 242 kV.

The secondary winding voltage shall be 27.5 kV at a power frequency of 50 Hz, one phase being connected to the rails and the earth. Calculation sheets to establish maximum flux density shall also be submitted with Design to employer. The contractor shall submit complete technical data of the system to the employer.

1.6 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 separated oil tank, offering 16 steps, each representing 1.6667% of the nominal voltage as follows:
- $+ 6 \times 3667 \text{ V}$
- $- 9 \times 3667\text{V}$

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 monitoring of OLTC from RSS control room and OCC

The automatic operation of OLTC through Remote Tap Changer Cubicle (RTCC) in auto mode should be blocked in case of back feed to traction transformer from 25 kV OHE i.e reverse current flow in traction power supply from OHE towards transformer.

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 servo-mechanism settings shall be designed and executed to avoid too many actuation.

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.

1.7 COOLING SYSTEM

The power 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 60296 standard, or IS 335 (with latest amendments) and of the highest inflammability degree.

The maximum temperature allowable at nominal rating 40 MVA shall never exceed:
- 50°C above ambient temperature for mineral oil
- 55°C above ambient temperature for the copper winding and the iron core.

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

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.

The contractor shall give full description of the design, operation and maintenance of the proposed air cooling system and indicate the air flows needed for ventilating the cubicle and the air cooling units:
- For natural ventilation
- For low speed assisted ventilation
- For high speed assisted ventilation.

In case of fire detection into the transformer cubicle, the air cooling system shall be immediately and automatically switched off.
1.8 SHORT-CIRCUIT WITHSTAND CAPABILITY

1.8.1 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 design of the transformers 40 MVA shall withstand 40 kA symmetrical for three seconds during short-circuit on 220 kV network.

1.8.2 Short-circuit on L.V. side

The maximum short circuit current at the output of feeder station has to be limited at 14 kA only to comply with the rolling stock on board circuit breakers breaking capacity, (compared to distribution network) 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.

1.9 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.

During testing, noise shall be measured according to the standard and the guaranteed minimum noise level shall be as low as possible for transformer of this power.

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.

1.10 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

\[
P_W = K \times 365 \times 24 \times \frac{C (W_{ir} + b^2 W_{cu})}{1000}
\]

Where
- \( PW \) is the present worth (in IR) of annual capitalized cost of losses at
  8% rate of interest over 25 years
- \( K \) is the present worth factor (8% interest, 25 years) = \( \frac{(1 + 0.08)^{25} - 1}{0.08 \times (1 + 0.08)^{25}} \) = 10.675
- \( C \) is the cost of the kWh (in Indian Rupees) = Rs. 5.25
- \( W_{ir} \) is the iron losses in Watts at normal voltage and main tapping
- \( W_{cu} \) 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

\[
P_W = 10.675 \times 365 \times 24 \times 5.25 \times (W_{ir} + 0.25 W_{cu}) / 1000
\]

\[
P_W = 490.94 (W_{ir} + 0.25 W_{cu})
\]

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):

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

Where,
- \( d W_{ir} \) and \( d W_{cu} \) 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.

1.11 WINDINGS

The winding conductors shall be made of best quality high conductivity
electrolytic copper, in compliance with the standard 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 adjustment 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 which 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 of class A.

1.12 TERMINALS AND CONNECTIONS
The 220 kV connections shall be realized through porcelain bushings.

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 secondary winding connections shall be realized through plain porcelain bushing insulators.

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. 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 cm/kV.

Bushings shall be realized in conformity with the IEC 60137 standard.

1.13 TANK AND RADIATORS
The transformer tank shall be made of high quality boilerplate steel with stiffening frame and girders. The width of the welding sections shall be sized so as to permit three dismantling operations by grinding before having to completely reform them.

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.
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.

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,
- flanged valves suitable to connect the oil filtering unit,
- hooking points

and the overall shall be equipped with:
- special pockets for checking by thermometers,
- earthing terminals according to IEC 60617-2 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

Name plate to be provided with all technical particulars.

1.14 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 filled with “Silicagel” or equivalent, permitting easy maintenance during transformer normal operation.
- be provided with an oil level indicator having auxiliary contacts and easily observable from ground level.

The oil volume should not reach:
- the minimum level by 0°C (Ambient temp)
- the maximum level by 55°C (Ambient temp)

1.15 CONTROL AND PROTECTION
The transformer shall be delivered with "buchholz", thermal and earth fault protections, all connected to the control and monitoring cabinet
1.15.1 "buchholz"

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

The relay shall comprise 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.

1.15.2 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.

1.15.3 Earth fault

The insulated tank shall only be connected to the earth through a current transformer, which shall be linked to the control system via monitoring cabinet terminal block.

1.15.4 Control and monitoring cabinets

For transformer

Made of stainless steel-sheets, 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(3ph) 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
- RTCC indoor Panel with AVR relay and remote indication. AVR relay to have adjustable time voltage settings for OLTC tap operation, feature for auto and only manual operation of OLTC. AVR should operate based on voltage level of primary side of transformers.

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>3mm 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></td>
</tr>
<tr>
<td>Exterior</td>
<td>RAL 7032, Texture finish</td>
</tr>
<tr>
<td>Interior</td>
<td>RAL 7032, Texture finish</td>
</tr>
<tr>
<td>Base frame</td>
<td>Black</td>
</tr>
<tr>
<td>Thickness</td>
<td>Min. 80 microns of Power coating</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

1.16 METAL WORK AND PAINT-WORK

Painting should be suitable for salty seaside atmosphere and has to comply with IEC 60 721-2-5 standard

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
Then all metal surfaces shall be painted in accordance with the rules of art with three coats of non-metallic paint of the same quality as that used for outdoor transformers, total thickness should not be less than 120µm and should withstand 120°C

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.

1.17 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 1bar pressure up to the tank top.

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

Installation
The 220/27.5 kV transformers are to be installed 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.

1.18 FIRE PROTECTION & SUPPRESSION SYSTEM:-
Please refer clause 1.19 of specifications for 220/33 kV Auxiliary main transformer Specifications no. DMRC-E-TR-TRANSF-01.

1.19 FIBER OPTIC WINDING HOT SPOT TEMPERATURE MONITOR:-
Please refer clause 1.20 of specifications for 220/33 kV Auxiliary main transformer Specifications no. DMRC-E-TR-TRANSF-01.
2. **DATA SHEET**

2.1 **220 / 27.5 KV TRACTION TRANSFORMER 40 / 50 MVA**

<table>
<thead>
<tr>
<th>INDICATIONS</th>
<th>U</th>
<th>VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td></td>
<td>Required</td>
</tr>
<tr>
<td>Place of manufacture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port of embarkation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer drawing reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standards</td>
<td></td>
<td>IEC 60076, 60137, 60296</td>
</tr>
</tbody>
</table>

**1) ELECTRICAL CHARACTERISTICS**

| Type                                              | Outdoor |
| Coupling                                         | l.i.     |
| Rated frequency                                  | Hz 50    |
| Rated secondary power                            | MVA 40 / 50 |
| Cooling mode                                     | ONAN/ONAF |
| Primary rated insulation voltage                 | kV 245   |
| Primary operating voltage                        | kV 220   |
| Rated Power frequency withstand voltage-one minute | kV 395 r.m.s. |
| Rated Impulse withstand (1.2/50 micro second)     | kV peak 950 |
| Primary line ends                                |         |
| Secondary maximum non permanent voltage           | kV 29    |
| Secondary rated voltage Without load             | kV 27.5  |
| Rated power frequency withstand voltage for one minute secondary winding | kV 95 r.m.s. |
| Rated impulse withstand (1.2/50 micro second) voltage for secondary winding | kV peak 250 |
| Short-circuit voltage                            | %        |
| - On load tap changer on tap 1                   | %        |
| - On load tap changer on median tap              | %        |
| - On load tap changer on tap 16                  | %        |
| Voltage drop at secondary winding                | V        |
| - 4/4 of secondary load                          |         |
| Short circuit voltage                            | % 13.8   |
| Magnetic loading                                 | Tesla < 1.55 |
| Permissible overload duration at                 | mn 15    |
| - 50%                                            |         |
| - 100%                                           | mn 5     |
| Iron losses                                      | kW       |
| Copper losses                                    | kW       |
| - 4/4 of secondary load                          |         |
### INDICATIONS U VALUES

<table>
<thead>
<tr>
<th>Indications</th>
<th>U</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short circuit current at secondary</td>
<td>kA</td>
<td>14</td>
</tr>
<tr>
<td>- On load tap changer on tap 1</td>
<td>kA</td>
<td></td>
</tr>
<tr>
<td>- On load tap changer on median tap</td>
<td>kA</td>
<td></td>
</tr>
<tr>
<td>- On load tap changer on tap 16</td>
<td>kA</td>
<td></td>
</tr>
<tr>
<td>Transformation ratio</td>
<td>kV</td>
<td></td>
</tr>
<tr>
<td>- On load tap changer on tap 1</td>
<td>187/27.5</td>
<td></td>
</tr>
<tr>
<td>- On load tap changer on median tap</td>
<td>220/27.5</td>
<td></td>
</tr>
<tr>
<td>- On load tap changer on tap 16</td>
<td>242/27.5</td>
<td></td>
</tr>
<tr>
<td>Power at primary winding - 4/4 of secondary load</td>
<td>MVA</td>
<td>40 / 50</td>
</tr>
<tr>
<td>Duration of admissible short-circuit</td>
<td>Seconds</td>
<td>3</td>
</tr>
<tr>
<td>Efficiency (not accounting for the power drawn by the secondary)</td>
<td>%</td>
<td>99.6 minimum</td>
</tr>
<tr>
<td>- 4/4 of secondary load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions of complete transformer:</td>
<td>m</td>
<td>4.5x3.0x4.2</td>
</tr>
<tr>
<td>Length/Width/Height (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight of complete transformer (*)</td>
<td>kg</td>
<td>90,000</td>
</tr>
<tr>
<td>- with oil</td>
<td>kg</td>
<td>70,000</td>
</tr>
<tr>
<td>- with inert gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handling, i.e. under hooks height required for travelling crane to enable handling (*)</td>
<td>m</td>
<td>10.5</td>
</tr>
<tr>
<td>Overall dimension drawing number</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4) NOISE LEVEL

Transformer alone (per testing mode stipulated in IEC standards) dB

Overall noise level at a distance of 1.5 m dB
- at rated voltage and no load 75 dBA
- at 110% of rated voltage and no load dB
- at maximum over-induction dB

### 5) MISCELLANEOUS INFORMATION

- Thermal time constant of oil h
- Thermal time constant of transformer h
- Maximum value of energising current at no load A peak
- Value of direct and reverse impedance Ω
  - as seen from primary terminals Ω
  - as seen from secondary terminals Ω

Degree of protection for auxiliary circuit IP55

Cooling system

- Number and type of fans
- Rated voltage AC V 415/230
- Fan rotating speed rpm
- Power per fan kW
- Fan starting current A
- Total power drawn by cooling equipment kW
- Air output per fan m3/h
- Total air necessary m3/h

(* Approximately)
## 2.2 ON LOAD TAP CHANGER FOR 220 / 27.5 KV TRANSFORMER

<table>
<thead>
<tr>
<th>INDICATIONS</th>
<th>U VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Required</td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Place of manufacture</td>
<td></td>
</tr>
<tr>
<td>Port of embarkation</td>
<td></td>
</tr>
<tr>
<td>Manufacturer drawing reference</td>
<td></td>
</tr>
<tr>
<td>Standards</td>
<td>IEC 60214</td>
</tr>
</tbody>
</table>

### 1) ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>item</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated frequency</td>
<td>Hz 50</td>
</tr>
<tr>
<td>Cooling mode</td>
<td>ONAN/ONAF</td>
</tr>
<tr>
<td>Rated insulation voltage</td>
<td>kV 245</td>
</tr>
<tr>
<td>OPERATING VOLTAGE</td>
<td>kV 220</td>
</tr>
<tr>
<td>Rated Power frequency withstand voltage-one minute</td>
<td>kV r.m.s. 395</td>
</tr>
<tr>
<td>Rated Impulse withstand (1.2/50 micro second)</td>
<td>kV peak 950</td>
</tr>
<tr>
<td>Rated current</td>
<td>A As per transformer current rating</td>
</tr>
<tr>
<td>Short-circuit withstand current</td>
<td>kA r.m.s. kA peak</td>
</tr>
<tr>
<td>- Thermal (2seconds)</td>
<td></td>
</tr>
<tr>
<td>- Dynamic</td>
<td></td>
</tr>
<tr>
<td>Tap voltage</td>
<td>V 3667</td>
</tr>
<tr>
<td>Number of taps</td>
<td>15 (+6,-9)</td>
</tr>
<tr>
<td>Mechanical and electrical contact reliability</td>
<td>Operation 50 000</td>
</tr>
</tbody>
</table>

### Motor drive

- Technical data
- Rated voltage
- Rated current Vdc 110V DC /230V (1 Ph) /415V (3 Ph)
- Protection system
- Overcurrent protection device
- other protections RS 1000

Degree of environment protection for auxiliary cubicle IP55
3. **TEST SHEET**

3.1 **TRACTION TRANSFORMERS**

<table>
<thead>
<tr>
<th>INDICATIONS</th>
<th>TYPE of TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type</td>
</tr>
<tr>
<td>Temperature rise</td>
<td>X</td>
</tr>
<tr>
<td>Lightning impulse withstand voltage</td>
<td>X</td>
</tr>
<tr>
<td>Noise level **</td>
<td>X</td>
</tr>
<tr>
<td>Short circuit withstand **</td>
<td>X</td>
</tr>
<tr>
<td>Tank, Expansion vessel &amp; Radiator Water tight</td>
<td>X</td>
</tr>
<tr>
<td>Piping welds &amp; joints Water tight</td>
<td>X</td>
</tr>
<tr>
<td>Windings resistance</td>
<td>X</td>
</tr>
<tr>
<td>Transformation ratio</td>
<td>X</td>
</tr>
<tr>
<td>Short circuit voltage, impedance</td>
<td>X</td>
</tr>
<tr>
<td>Losses &amp; current without load</td>
<td>X</td>
</tr>
<tr>
<td>Withstand voltage at 50 Hz</td>
<td>X</td>
</tr>
<tr>
<td>Induced voltage</td>
<td>X</td>
</tr>
<tr>
<td>On load tap changer functioning</td>
<td>X</td>
</tr>
<tr>
<td>On load tap changer Aux. circuits insulation</td>
<td>X</td>
</tr>
<tr>
<td>Painting &amp; external visual inspection</td>
<td>X *</td>
</tr>
<tr>
<td>Core Insulation resistance</td>
<td>X *</td>
</tr>
<tr>
<td>Insulation oil breakdown strength</td>
<td>X</td>
</tr>
<tr>
<td>Aux. circuits insulation</td>
<td>X</td>
</tr>
<tr>
<td>Aux. circuits operation</td>
<td>X</td>
</tr>
<tr>
<td>Instrumentation &amp; relays calibration</td>
<td>X</td>
</tr>
<tr>
<td>Cooling system</td>
<td>X</td>
</tr>
<tr>
<td>Dissolved Gas Analysis (DGA)</td>
<td>X</td>
</tr>
<tr>
<td>Frequency Response Analysis (FRA)</td>
<td>X</td>
</tr>
</tbody>
</table>

* Tests to be performed just prior shipment.

** These are special tests.
### 3.2 ON LOAD TAP CHANGER

<table>
<thead>
<tr>
<th>INDICATIONS</th>
<th>TYPE of TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type</td>
</tr>
<tr>
<td>Mechanical operation</td>
<td></td>
</tr>
<tr>
<td>Oil tank tightness</td>
<td></td>
</tr>
<tr>
<td>Selector operation</td>
<td></td>
</tr>
</tbody>
</table>

These tests shall be performed before the assembly of the tap changer with the transformer.