

**MATERIAL AND EQUIPMENT STANDARD**  
**FOR**  
**POWER TRANSFORMERS**

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### **Note:**

For Attachments see the end of this Standard Specification.

## 1. SCOPE

**1.1** This Standard Specification gives the minimum technical requirements for design, manufacture, quality control, testing, finishing and shipment of indoor and outdoor power transformers installed in oil, gas and petrochemical industries in Iran under the service conditions stated in Clause 5.

**1.2** Only the general requirements of transformers up to maximum rating of 50 MVA and maximum primary voltage of 66 kV are given.

Requirements of individual transformers will be given in pertinent data sheets, requisitions and/or purchase orders.

**1.3** This Standard covers the oil immersed sealed and conservator types, and also dry-type power and distribution transformers.

**1.4** The application of transformers is as follows:

- dry type transformers up to 500 kVA;
- sealed type transformers up to 2000 kVA;
- transformers over 2000 kVA, conservator type only.

## 2. REFERENCES

Transformers and their accessories and materials shall be in accordance with:

- a)** the provisions stated in this standard,
- b)** the latest edition of the following standards including their amendment(s) and supplement(s) "if not otherwise stated hereafter".

### IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION)

- IEC 38 (1983) " Standard Voltages "
- IEC 76 " Power Transformers "
- IEC 85 (1984) " Thermal Evaluation and Classification of Electrical Insulation "
- IEC 137 (1984) " Bushings for Alternating Voltages above 1000V "
- IEC 214 (1976) " On-Load Tap Changer "
- IEC 296 (1982) " Specification for Unused Mineral Insulating Oils for Transformers and Switchgears "
- IEC 354 (1972) " Loading Guide for Oil-Immersed Transformers "
- IEC 529 (1976) " Degrees of protection provided by enclosures (IP code) "
- IEC 542 (1976) " Application Guide for On-load Tap Changer "
- IEC 551 (1987) " Determination of Transformer and Reactor Sound Levels "
- IEC 726 (1982) " Dry-type power transformers "

### BS (BRITISH STANDARD)

- BS 381C (1987) " Specification for colors for identification coding and special purposes "
- BS 5493 " Code of Practice for Protective Coating of Iron and Steel Structures against Corrosion "

## 3. DEFINITIONS

The definitions given in IEC 76-1 are applicable in this Standard.

## 4. UNITS

Units shall be metric in accordance with IPS-E-GN-100.

## 5. SERVICE CONDITIONS

**5.1** Environmental conditions will be in accordance with Attachment No. 1.

**5.2** The system supply voltage variation will be  $\pm 10\%$  of rated value .

**5.3** The system frequency variation will be  $\pm 5\%$  of rated value.

**Note:**

**Two extremes of voltage and frequency variations shall not be considered to coincide.**

## 6. RATINGS

The specified ratings are the actual ratings required from the transformers when installed in the specified location under specified service conditions. Each transformer shall deliver its rated current under steady loading conditions without exceeding the limits of temperature rise specified in this Standard "assuming that the applied voltage is equal to the rated voltage and that the supply is at rated frequency". Guidance to overloads is given in IEC 354 loading guide for oil immersed transformers.

### 6.1 Rated Power

The rated power shall be in accordance with the requirements of data sheet in Appendix A.

### 6.2 Rated Voltage

**6.2.1** The rated voltages for windings shall be in accordance with the requirements of data sheet in Appendix A .

### 6.3 Rated Voltage Ratio

Rated voltage ratio shall be in accordance with the requirements of data sheet in Appendix A (which is obtained by dividing the specified rated voltages given in the same Appendix).

### 6.4 Rated Frequency

Rated frequency shall be 50 Hz.

### 6.5 Rated Current

The rated current shall be in accordance with the requirements of data sheet in Appendix A.

The rated current of transformer shall be assigned to main winding.

### 6.6 Short Circuit Values

The short-circuit apparent power of the system at the transformer location is as given in data sheet.

The duration of short-circuit current will be assumed 2 second unless otherwise specified.

## 6.7 Impedance Voltage

Impedance voltage of the transformer shall be in accordance with the requirements of data sheet in Appendix A.

## 7. CONSTRUCTIONAL REQUIREMENTS FOR TRANSFORMERS

### 7.1 General

**7.1.1** Transformers shall be manufactured under strict quality assurance procedures. Purchaser reserve the right to review the quality assurance program.

**7.1.2** As a minimum requirement, transformers shall be suitable for continuous operation at full load without excessive temperature rise.

**7.1.3** Transformers shall be capable of delivering the rated current at applied voltages equal to 90% and 110% of the rated voltage.

**7.1.4** In transformers having the same vector group and clockhour number, terminals having identical designation could be paralalled when transformation ratio, tappings and rated impedance voltage are the same.

### 7.2 Core

**7.2.1** The core of transformers shall be constructed from silicon steel. The steel shall be in thin laminations. Both sides of the laminations shall have an insulated or coated surface.

The core shall be so designed and constructed to minimize eddy current losses and noise.

The flux density at any point in the magnetic circuit shall not exceed 1.6 tesla when the transformer is operated on the principal tap at the nominal voltage and frequency on full load.

**7.2.2** Maximum internal temperature at any point in the core must be kept within acceptable limits above the oil temperature.

**7.2.3** The core shall be earthed internally through grounding links.

**7.2.4** Adequate lifting facilities shall be provided for withdrawing the core and winding assembly from the tank .

**7.2.5** The core shall be so assembled to have adequate mechanical strength to support the windings and to prevent shifting of the laminations during transportation.

### 7.3 Windings

**7.3.1** Conductors used for windings shall be made by copper and shall be free from any kind of defect and shall also have rounded corners. The conductors shall be transposed at sufficient intervals in order to minimize eddy current and equalize the distribution of current and temperature along the windings.

**7.3.2** Windings shall be uniformly insulated. Materials used for the insulation and assembly of the windings shall be insoluble, non-catalytic, chemically inactive, and impervious to hot oil under the operating conditions.

**7.3.3** Winding connections inside the transformers shall be brazed or crimped. Soldered or bolted connections beyond possible reach are considered unreliable. All bare copper connections under oil shall be tinned or coated with an impervious and non-catalytic material.

**7.3.4** Transformers shall have separate high and low-voltage windings for all phases.

**7.3.5** Windings shall be of pre-shrunk and no further shrinkage must occur after final assembly and clamping.

**7.3.6** Windings shall be fully insulated from earth.

**7.3.7** The neutral point of secondary side of star connected windings shall be brought out through an insulated bushing for earthing purposes or for connection to a 3 phase 4 wire system.

**7.3.8** Windings shall be of proven construction. The windings and all connections shall be firmly fixed to withstand without damage the electro-magnetic forces and the thermal effects caused by the external short circuit levels and the shocks and vibrations likely to be occurred during transportation.

**7.3.9** Clock-hour number shall be DY5 or DY11 as per data sheet.

## **7.4 Tank, Tank Cover, and Tank Fittings of Oil-Immersed Transformers**

### **7.4.1 Sealed-type transformers**

**7.4.1.1** The sealed transformers shall be provided with bolted cover.

The expansion space in the tank above the oil level shall be filled with nitrogen.

#### **Note:**

**When extreme transport conditions to site can be fore-seen, sealed but not welded top covers and orifices may be specified to facilitate inspection and possible repairs.**

**7.4.1.2** The manufacturer shall state in the quotation the test pressures and the expected internal pressures. The relevant test pressures shall be at least:

$$\begin{aligned} &1+2 \times (P \text{ max.}-1) \text{ bar for the overpressure test} \\ &1 -2 \times (1- P \text{ min.}) \text{ bar for the underpressure test.} \end{aligned}$$

Pmax and Pmin are absolute values of pressure.

**7.4.1.3** The construction of the tank shall ensure against leaks and shall give a container that will withstand not only the operating pressure of the transformer, but also the mechanical stress of shipment and installation.

**7.4.1.4** The use of aluminum tanks is not acceptable.

**7.4.1.5** The use of corrugated tank is not acceptable.

### **7.4.2 Conservator type transformers**

**7.4.2.1** Oil-immersed transformers with a rating above 1600 kVA shall be of the breathing type with an oil conservator.

**7.4.2.2** The main transformer tank and any attached components that will be subjected to operating pressure shall be designed to withstand "without permanent deformation" a pressure 25% greater than the maximum operating pressure resulting from the expansion oil preservation system used. The tank cover and the cooling system shall in addition be capable of withstanding a vacuum of at least 1 mbar for 24 hours.

#### **7.4.2.3 Tank**

**7.4.2.3.1** Tanks of transformers shall be fabricated from hot-rolled low carbon steel plate of adequate thickness and shall be of robust construction. The tank shall be so designed to be oil tight and to shed water.

**7.4.2.3.2** The tank shall be provided with manhole(s) of suitable size to afford easy access to the tap changing mechanisms, lower ends of bushings, terminals, and the upper portions of the coils.

**7.4.2.3.3** Where cooling tubes are welded directly to the tank, the tube pitch centers shall be sufficiently spaced to enable all surfaces to be wire brushed, cleaned down and repainted without undue difficulty by spraygun or hand brushing.

**7.4.2.3.4** Where detachable radiators are fitted to the tank, each radiator shall be provided with an isolating valve at the inlet and outlet and removable plugs shall be fitted at the top and bottom of the radiator for filling and draining the oil.

**7.4.2.3.5** The gaskets used in tanks shall be made of a resilient material which will not deteriorate under the action of hot oil and will remain oil tight. Suitable spacers shall be provided to prevent overtightening of gaskets.

**7.4.2.3.6** Suitable guides shall be provided for guiding the cores and windings as they are being removed from or lowered into the tank.

**7.4.2.3.7** Tank bases shall normally be provided with skids to permit movement of the transformer in any direction, but where rollers are required they shall be capable of being turned through 90°.

**7.4.2.3.8** At least four number of attaching plates for jacking shall be provided on the tank.

#### **7.4.2.4 Tank fittings**

Tanks of transformers shall be provided with at least the following fittings:

**7.4.2.4.1** Oil tight shut-off valves in all pipe entries to tank.

**7.4.2.4.2** Dehydrating breather of the oil sealed siligca-gel type.

**7.4.2.4.3** Closed type thermometer pocket with captive screwed cap. The pocket shall be 120-150 mm deep with an inside diameter of about 20 mm and shall be oil-filled to provide proper heat transmission. The location shall be such that the top oil liquid temperature can be measured even at the lowest (cold) oil liquid level. They shall then be fitted with a thermometer calibrated in degree Celsius, preferably with a dial type indicator with a hand-reset pointer to register the highest temperature attained. The dial shall be located for easy viewing.

**7.4.2.4.4** Pressure relief vent of the diaphragm or 'qualitrol' type. The bottom of the pressure relief vent shall be above the maximum conservator oil level. The relief pressure setting to be approx 0.7 bar.

**7.4.2.4.5** Two Lockable 40 mm filtering valves with screwed connector preferably fixed diagonally on opposite corners.

**7.4.2.4.6** Double element bucholz relay with normally closed alarm (incipient fault) and trip (sudden surge fault) contacts, plus facilities for gas sample testing.

**7.4.2.4.7** Air vent about 15 mm diameter.

**7.4.2.4.8** Lockable oil drain valve with stopper plug and integral oil sampling cock. Drain valve shall be so located as to completely drain the tank.

**7.4.2.4.9** Earthing terminals for the transformer main tank base and for each detachable radiator cooler "if any".

**7.4.2.4.10** Oil conservator with sump, captive topping up filler cap and lockable drain valve, preferably cylindrical in shape with one removable flanged end for cleaning purposes. A prismatic type oil level gage to be fitted at one end of the conservator and to be clearly readable from ground level. The gage to be marked to indicate the minimum and maximum oil levels corresponding to top oil temperatures of 5°C and 95°C respectively. At the minimum oil temperature there shall be at least 20 mm of oil above the top of the expansion pipe where it enters the conservator.

The oil conservator shall have at least 11% of the total oil volume.

The main oil expansion pipe from tank to the conservator shall be inclined upwards at approx 11° to the horizontal and the bore of the pipe shall be of appropriated size.

The conservator shall be so mounted to facilitate draining.

**7.4.2.4.11** Where natural air, forced air or forced oil type coolers are separated from the transformer tank they shall be provided with the following:

- a) a lockable valve at each point of connection to the transformer tank,
- b) a lockable filtering valve, suitable for receiving a 40 mm screwed hose connection at the top and bottom of each cooler, diagonally opposite, the bottom filtering valve shall also serve as a draining valve,
- c) a closed type thermometer pocket with a captive screwed cap on the inlet and outlet branches of each cooler,
- d) air release plugs at the top of each cooler,
- e) forced oil cooling only - suitably calibrated weatherproof oil pressure gages at each point of connection to the transformer tank. The pressure gages to be provided with adjustable tamper-proof normally closed alarm contacts.

**7.4.2.4.12** Additional fittings when specified in data sheet.

## 7.5 Cooling

**7.5.1** Transformers with secondary voltage rating of 400 volt shall be ONAN type and those with secondary voltage rating of more than 400 volt shall be ONAN / ONAF, in which case provisions for future installation of fan(s) shall be provided. Where large size transformers are required ONAF type of cooling will be considered.

**7.5.2** Cooling fans will be supplied from an external source. The starting device including contractor/thermostat shall be supplied with transformer (s)

**7.5.3** Control equipment and alarms shall be provided by the transformer supplier and all oil cooled transformers shall be supplied with the dial type thermometers.

**7.5.4** Pilot light(s) shall indicate the fan(s) running .

## 7.6 Oil

**7.6.1** Oil-immersed transformers should be filled with mineral oil.

**7.6.2** Where environmental and/or fire protection requirements prohibit the use of mineral oil, a synthetic substitute may be used.

**7.6.3** Under no circumstances shall the liquid contain, or be contaminated with, polychlorinated biphenyls (PCBs).

## 7.7 Bushings

**7.7.1** The bushings shall conform to all applicable requirements of IEC 137.

**7.7.2** The bushings shall be compatible with the transformer output rating and the normal voltage.

**7.7.3** The winding neutral terminal bushing irrespective of its location on the transformer shall be insulated for the full winding phase to phase voltage. Occasionally, an external outdoor bushing may be specified for neutral earthing as well as to the neutral terminal.

**7.7.4** Outdoor bushings shall be fitted with removable double gap arcing horn. The gap distances to be compatible with nominal operating voltage under service conditions.

**7.7.5** Bushings shall be tested in accordance with the requirements of IEC 137.

**7.7.6** For altitude exceeding 1000 meter the insulation levels of bushings and the related creepage distances shall be corrected by a correction factor as specified in IEC 137 clause 42.

## **7.8 Disconnecting Chambers**

Oil-filled disconnecting chamber at the primary and secondary sides to be provided for transformers where required.

The chamber shall be equipped with a filling orifice closed with a screw cap, located in the top cover of the chamber, and a drain plug in the lowest part and when specified.

## **7.9 Terminals**

**7.9.1** Terminals shall be adequate for connection of cables or conductors specified in data sheet and, shall be complete with the required nuts, washers and cable lugs and shall be effectively fixed in such a way that rotating/turning of the stem is not possible.

**7.9.2** The terminals shall be logically arranged, circuit by circuit, with adequate barrier shields and spacers in between them, and shall be clearly and indelibly identified in accordance with connection diagram on the rating plate.

## **7.10 Junction Box(es)**

**7.10.1** Junction box(es) shall be provided for the connection of:

- a) the high-voltage side of the transformer,
- b) the low-voltage side of the transformer,
- c) the transformer auxiliary circuits (direct measuring alarm/trip devices, secondaries of CTs, etc.),
- d) the on-load tap changer, (if provided),
- e) The forced air cooling installation, (if provided),
- f) The forced oil circulation installation, (if provided).

**7.10.2** Junction box(es) shall be air-insulated with insulated/shrouded live parts.

**7.10.3** Junction box(es) shall be of ample dimensions to allow sufficient space to terminate and connect the cables or conductors easily.

**7.10.4** Junction box(es) shall be mounted on the side walls of the transformer with all cable glands mounted on the underside.

**7.10.5** On transformers for outdoor use water shedding metal sun/rain canopies with an overhang of at least 50 mm on all sides shall be fitted over all cable connecting boxes leaving an air space (of approx. 50 mm above the top cover) for free ventilation.

**7.10.6** The box cover shall be opened only by means of a tool. The cover bolts or screws shall be of the non-loosening type.

**7.10.7** The enclosures shall offer a minimum degree of protection in accordance with IEC 529 as follows:

- a) for outdoor use IP 53,
- b) for indoor use IP 41,
- c) for indoor use where additional barriers will be provided IP 21.

**7.10.8** The design of the main connecting boxes shall be such that:

**7.10.8.1** The conductors can be connected straight on, to the terminal connectors without introducing troublesome bends inside the box.

**7.10.8.2** When two or more parallel conductors are to be connected, provisions shall be made for straight conductor connections.

## **7.11 Tappings and Tapping Range**

### **7.11.1 General**

Unless otherwise specified the high voltage winding of transformers shall be provided with tappings for constant kVA rating.

#### **7.11.1.1 Tapping range**

a) for off-load tap changers:

Tapping range shall include 4 equal steps of  $\pm 2\frac{1}{2}\%$  and  $\pm 5\%$  of the nominal primary voltage "unless otherwise specified",

b) for on-load tap changers:

Tapping range shall include 12 equal steps of  $+7\frac{1}{2}\%$  to  $-7\frac{1}{2}\%$  of nominal primary voltage.

#### **7.11.2 Off-load tap changer**

The off-load tap changer mechanism shall be such that to satisfy the following requirements:

**7.11.2.1** To be operated externally and manually.

**7.11.2.2** Taps will be changed only when the transformer is deenergized.

**7.11.2.3** Mechanical stops at the ends shall be provided to prevent over running.

**7.11.2.4** The complete tap changer mechanism shall be built with high-electrical, mechanical and thermal safety factors.

**7.11.2.5** The handle shall be provided with pad lock facilities to lock the tap changer in the desired position.

**7.11.2.6** Tap positions shall be clearly marked on tap- changer.

**7.11.2.7** The tap changer control shall be mounted on the side of transformer case or tank at a convenient height for operation from the floor on which the transformer is mounted.

**7.11.2.8** The tap changer shall be capable of withstanding: the full short circuit current of the transformer without injury, and continuous permissible current, preferably not less than 1.20 times the full load current of the winding on which it is installed.

#### **7.11.3 On-load tap changer**

**7.11.3.1** When an on-load tap changer equipment is specified it shall be in accordance with IEC 214 and IEC 542.

**7.11.3.2** The on-load tap changers shall be designed for a rated through-current of 1.20 times the highest tapping current of the winding to which it is connected as specified in IEC 542.

**7.11.3.3** The overload capacity and short circuit capacity shall be as specified in Clause 2.4 of IEC 542.

**7.11.3.4** The tap changer diverter and selector switches shall be in a separate container but inside the oil of the main transformer tank.

**7.11.3.5** The motor drive and the associated control equipment shall be suitable for operation in the environmental conditions specified on the Attachment 1 and shall be complete with terminals and cable connecting facilities for all related auxiliary cables.

Motor-drive mechanisms shall be in accordance with IEC 214 and shall include but not be limited to the following:

- a) local mechanical tap position indicator,
- b) an electrical remote position transmitter,
- c) remote tap change in progress' indication,
- d) direction of rotation protection,
- e) tap changers shall be suitable for motor-drive operation and for manual operation of the motor-drive mechanism.

**7.11.3.6** The nameplates of the tap changers and their drives shall be as in IEC 214 but shall in addition be marked with the purchasers order-number and purchaser's name.

**7.11.3.7** The tap changer oil compartment shall be provided with the following:

- a) oil level indicator with alarm contacts,
- b) bucholz oil/gas alarm and trip device, (if required)
- c) oil sampling facility at accessible height,
- d) on-load oil filter connection orifices and valves at accessible height,
- e) a breather with a silica gel dehydrating capsule,
- f) durable nameplates on each of the devices specified above.

**7.11.3.8** On-load tap changers and the related motor-drive devices shall be tested according with IEC 214.

**Note:**

**Tap changer(s) shall be provided by the supplier of transformer and with his responsibility.**

## **7.12 Protection**

Transformers shall be protected against overloads, short circuits and over voltages which may occur during the operation at service conditions.

### **7.12.1 Overload thermal protection**

**7.12.1.1** Transformers shall be equipped with a liquid temperature indicator with one to three adjustable contacts. (See 7.4.2.4.3) setting range shall be  $\pm 5^{\circ}\text{C}$ .

**Note:**

**First contact shall operate at  $60^{\circ}\text{C}$  to initiate the first stage of cooling fan(s). Second contact shall operate at  $90^{\circ}\text{C}$  either to initiate a second stage of cooling fan(s) if furnished, or to give an alarm. Third contact "if furnished" shall operate at  $105^{\circ}\text{C}$  either to give final alarm and or to reduce the load.**

#### **7.12.1.2 Temperature detector**

Transformers of 10 MVA and above shall be equipped with a temperature detector, which gives direct indication of winding temperature.

### 7.12.2 Short circuit protection

Short circuit protection devices and their application shall be as below:

#### 7.12.2.1 Pressure relief device

Pressure relief device shall be used on all oil immersed transformers and shall operate when the internal pressure exceeds the tripping pressure (0.7 bar).

#### 7.12.2.2 Gas detector relay ( Bucholz relay )

Transformers of 2000 kVA and above shall be equipped with a two element gas detector relay.

Two element gas detector relay, of the approved type should be provided in the pipe connecting the conservator to the main tank. The relay shall be provided with test push-button and "if specified" valve equipment for pumping air for testing the relay function. The supplier shall specify in the instructions the quantity of air and operating pressure necessary for testing the gas-operated relay. The thread for nipple of the test equipment shall also be specified.

The gas-operated relay shall be so arranged and designed that its active parts are accessible for inspection, repairs and replacement without oil being emptied from the conservator.

A copper pipe with appropriate diameter shall be connected to relay test cock to a valve located near ground level to facilitate sampling of the gas.

### 7.12.3 Protection against over voltages

Overvoltages caused by lightning, and faults must be considered in designing transformer protection.

### 7.12.4 Earth fault protection

Where specified by data sheet for the purpose of earth fault protection, provision shall be made for a current transformer to be accommodated between the star point and the neutral earthing bushing.

## 7.13 Rating Plate

**7.13.1** Each transformer shall be provided with a rating plate of stainless steel or other type of non-corrosive durable materials, permanently fixed in a visible position to a non-removable part of transformer.

**7.13.2** The rating plate shall have the following information:

- a) kind of transformer,
- b) specification (s) complying with,
- c) manufacturer's name,
- d) manufacturer's serial number,
- e) year of manufacture,
- f) number of phase,
- g) rated power,
- h) rate frequency,
- i) rated voltage,
- j) rated current,
- k) impedance voltage at rated current,
- l) connection symbol,
- m) type of cooling,

- n) altitude,
- o) indoor or outdoor service,
- p) total mass,
- q) mass and volume of insulating oil,
- r) purchaser's name,
- s) purchaser's order number,
- t) mass of core and winding.
- u) maximum ambient temperature (if site temperature is more than 40°C)

#### **7.14 Lifting Lugs**

Transformers and associated cooling equipment, when transported separately, shall each be provided with adequate lifting lugs to facilitate transport to and assembly at site. If lifting lugs are fitted on the tank walls, additional lugs on the tank covers shall be provided for lifting the cover if this is removable. Any removable parts having a mass of 25 kg or more, shall be provided with lifting lugs.

Lifting lugs and attachments shall have ample factor of safety to allow for possible unequalized lifting forces.

#### **7.15 Pulling Lugs**

The transformer skids shall have rounded off beam ends and be provided with pulling lugs/holes to enable site movements.

#### **7.16 Jacking Pads**

The skids of transformers with an assembled mass of more than 2 t shall be provided with jacking pads.

#### **7.17 Spares and Special Tools**

Special tools for erection, spares for commissioning and list of essential spare parts required for 3 years operation shall be submitted by the manufacturer / supplier.

#### **7.18 Marking**

Transformers and their accessories shall be clearly marked to facilitate assembly and erection at site.

#### **7.19 Finishing**

After de-sealing and removal of rust by shot blasting and cleaning down, all the transformer external metallic surfaces to be immediately given one coat of an oil and heat resisting zinc chromate/red oxide primer with an oil modified alkyd resin base incorporating a rust inhibitor.

Two finishing coats of contrasting color, the final coat being a durable high gloss oil and weather resistant paint, dark admiralty grey color No. 632 of BS 381 C all paint to be Preferably applied by the flood method.

All the transformer internal metallic surfaces including the conservator. Underside of the tank cover, disconnecting link chambers, cable boxes etc., to be similarly treated by shot blasting prior to painting. After shot blasting and cleaning down one-coat of primer to be applied followed by a finishing coat of hard setting, air drying paint. The type of paint shall be impervious to, resist the effect of and shall have no deleterious effect on the filling medium.

However the manufacturer standard practice for paints can be applied if it is superior to above mentioned requirements which shall be subject to approval of purchaser.

## **7.20 Insulation Level**

**7.20.1** Minimum clearances in air between live part of bushings and phase-to-earth, phase-to-neutral, phase-to-phase, and towards terminals of a lower voltage winding shall be in accordance with list 2 of Table 1 in IEC 76-3-1 unless otherwise specified.

**Note:**

If the transformer is specified for operation at an altitude higher than 1000m, the clearance requirements have to be increased by 1 % for every 100 m by which the altitude exceeds 1000 m.

**7.20.2** Insulation level of windings and connected parts shall be so designed to withstand the rated short duration power frequency and the rated lightning impulse voltages.

## **7.21 Temperature-Rise**

### **7.21.1 Temperature - rise limits**

The temperature rises of the windings, cores and oil of transformers designed for operation at altitudes not exceeding 1000 m and maximum air temperatures not exceeding +40°C shall not exceed the limits specified in Table IV of IEC 76-2 (1976) when tested in accordance with Clause 3 of the same standard .

**Note:**

Neither the transformer tank nor any other part of the transformer in direct contact with mineral oil shall exceed 110°C, under any of the specified conditions.

### **7.21.2 Reduced temperature rise for transformer designed for high maximum air temperatures**

If the transformer is designed for service where the maximum air temperature is more than 40°C, the allowable temperature rises for the windings, cores and oil, shall be reduced from the values given in Table IV of IEC 76-2.

- by 5°C if the maximum air temperature is between 40°C and / (including) 45°C,
- by 10°C if the maximum air temperature is between 45°C and / (including) 50°C,
- by 15°C if the maximum air temperature is more than 50°C.

### **7.21.3 Reduced temperature rises for transformers designed for high altitudes**

For air-cooled transformers designed for operation at an altitude greater than 1000 m but tested at normal altitudes, the limits of temperature rise given in Table IV of IEC 76-2 (1976) are reduced by the following amounts for each 500 m by which the intended working altitude exceeds 1000 m.

- Oil-immersed, natural air-cooled transformers                      2.0%
- Oil-immersed, forced-air-cooled transformers                      3.0%

## **7.22 Noise**

**7.22.1** The noise level shall be in accordance with data sheet.

**7.22.2** The noise level shall be tested in accordance with IEC 551.

### 7.23 Losses and Efficiency

The manufacturer shall assign the no load loss and load loss and efficiency at the quotation stage. The assigned losses must be measured according to IEC 76-1 and the efficiency shall be assigned at nominal rated voltage and frequency on the principal tapping at least at 100%, 75% and 50% output load.

Measuring conditions such as the load percentage and measuring temperature shall be notified. Unless other wise specified, tolerances of assigned values shall be as below:

Total loss                    +10% of the total loss

Component losses        +15% of each component loss provided that tolerance for total loss is not exceeded.

### 7.24 Interchangeability

As far as it is practically possible, for a given manufacturer and transformer voltage/rating range, corresponding parts of the transformer shall be interchangeable.

## 8. TESTS

Tests shall be made at the manufacturer,s work at any ambient temperature between 10°C and 40°C.

### 8.1 Test Categories

In this Standard, tests are categorized into 3 types as below .

#### 8.1.1 Routine tests

Tests to which each individual transformer is subjected. List of routine tests are given below:

- a) measurement of winding resistance (IEC 76-1, Sub-clause 8.2),
- b) measurement of voltage ratio and check of voltage vector relationship (IEC 76-1 Sub-clause 8.3),
- c) measurement of impedance voltage (principal tapping) short-circuit impedance and load loss (IEC 76-1 Sub-clause 8.4),
- d) measurement of no-load loss and current (IEC 76-1 Subclause 8.5),
- e) dielectric tests (IEC 76-3),
- f) tests on on-load tap-changers, where appropriate (IEC 76-1 Sub-clause 8.8).

#### 8.1.2 Type Tests

Tests made on a transformer which is representative of other transformers, to demonstrate that these transformers comply with specified requirements "not covered by routine tests"

List of type tests are given below :

- a) temperature-rise tests (IEC 76-2),
- b) dielectric tests (IEC 76-3).

### 8.1.3 Special tests

For special tests see data sheet.

**Note:**

Manufacturer shall guarantee the transformer for compliance with all the above mentioned routine, type and special tests.

## 9. DOCUMENTS

Documents to be submitted by manufacturer / supplier.

### 9.1 At Quotation Stage

Manufacturer/supplier shall give the following as complete:

- report of experience, annual sale for similar transformer(s),
- list of successful operation of similar transformer(s),
- drawings and documents which defines the technical data of the required transformer(s),
- list of routine, type and special tests which may be made on his work,
- list of special tools,
- list of recommended spare parts,
- guarantees policies,
- complaint and compensation policies,
- declaration of any certificate from any impartial laboratory "if any",
- compliance of transformer(s) requirements with IEC 76, - deviations from IEC 76,
- the following information:
  - a) no-load loss at the nominal primary voltage and frequency on the principal tapping (Watt),
  - b) load loss at least at 100%, 75% and 50% output load on the principal tapping (watt),
  - c) maximum magnetic circuit flux density (tesla),
  - d) efficiency at nominal rated voltage and frequency on the principle tapping at 100%, 75%, and 50% output load,
  - e) percentage impedance voltage at rated kVA output on principal tapping,
  - f) secondary winding no-load voltage with the primary winding energized at the specified nominal voltage on the principal tap and over the full tapping range,
  - g) temperature rise of windings, top oil "in the case of oil immersed type",
  - h) installed mass ready for service in kilogram with full filling of oil "in the case of oil immersed type. "including on-load tap changer and separate coolers as applicable,
  - i) total quantity of oil "in the case of oil immersed type" in liter and mass in kilogram for transformer and on-load tap changer and separate coolers as applicable,

- j) noise level data under full load output conditions,
- k) thickness of tank walls, base and cover (mm),
- l) test pressure and the expected internal pressures of the tank,
- m) mass in kilogram of heaviest individual lift,
- n) automatic on-load tap changer and associated equipment data, as applicable.

## **9.2 At Ordering Stage**

### **9.2.1 Drawings and diagrams:**

- outline drawings showing main dimensions, total mass, arrangement of components and minimum clearances required for ventilation and safety during operation and maintenance,
- foundation plan, including foundation loading,
- interconnecting diagrams,
- information about alarm and tripping,
- wiring diagrams.

### **9.2.2 Standards and certificates:**

- standards and specifications related to transformer and accompanied equipments,
- a copy of test certificate,
- quality assurance certificate.

### **9.2.3 Instruction manual**

- operation,
- transport and storage,
- commissioning,
- maintenance,
- routine inspections,
- spare parts and special tools.

**9.2.4** Instruction for repair of holes in tank, conservator and radiator(s).

**9.2.5** Instruction for refilling oil and inert gas.

**9.2.6** Any other documents about transformer and accompanied equipment deemed necessary.

#### **Notes:**

- 1) All documents shall show the relevant order number, item and manufacturer's references.
- 2) All documents shall be in English.

## **10. ADDITIONAL REQUIREMENTS FOR DRY TYPE POWER TRANSFORMERS**

### **10.1 General**

Dry type power transformers shall comply with:

- IEC 726,
- any applicable requirements from other parts of this standard specification,
- and the following additional requirements.

## 10.2 Enclosures

The type of enclosure shall be in accordance with data sheet, (see definition IEC 726 Section 1, Clause 3) and be either:

- a) sealed, (non-breathing),
- b) totally enclosed, (breathes but the air does not circulate to cool),
- c) enclosed, (the air circulates to cool),
- d) non-enclosed. (cooled by ambient air).

## 10.3 Insulation

Dry-type transformers, with the exception of the sealed type, shall have encapsulated windings. The recommended minimum class of insulation shall be B in accordance with IEC 85.

## 10.4 Cooling and Insulating Gas

When sealed dry-type transformers are considered the gas shall be non-toxic, pose no possible threat to the environment and be non-flammable.

## 10.5 Temperature Rise Limits

The temperature rise limits of different parts of dry-type transformers designed for operation at altitudes not exceeding 1000 m and with cooling air temperature not exceeding +40°C shall be in accordance with table IV of IEC 726 (1982).

### 10.5.1 Reduced temperature rises for transformers designed for high cooling air temperatures or special air cooling conditions.

If the transformer is designed for service where the temperature of the cooling air is between 40°C and/including 50°C the allowable temperature rises for the windings shall be reduced:

- by 5°C if the cooling air temperature is between 40°C and/including 45°C,
- by 10°C if the cooling air temperature is between 45°C and/including 50°C.

### 10.5.2 Reduced temperature rises for transformers designed for high altitudes.

Unless otherwise agreed between the manufacturer and the purchaser, for transformers designed for operation at an altitude greater than 1000 m but tested at normal altitudes, the limits of temperature rise given in Table referred to in sub-clause 10.5 are reduced by the following amounts for each 500 m by which the intended working altitude exceeds 1000 m:

- natural-air-cooled transformers: 2.5% ;
- forced-air-cooled transformers : 5 % .

#### Note:

**If transformers which are designed for operation below 1000 m are tested at altitudes above 1000 m, the measured temperature rises are to be reduced by the above-mentioned amounts for each 500 m by which the test altitude exceeds 1000 m.**

**10.6 Temperature Measurement**

The winding temperature shall be determined at least on one location in each winding by means of interchangeable thermistors for alarm purposes. The leads of these thermistors shall be brought out into a terminal box located on the lower part of the transformer enclosure.

The thermistors shall be of the positive temperature coefficient (PTC) type and be supplied complete with auxiliary equipment by the transformer manufacturer under his full guarantee.

**10.7 Tap Changing**

An externally-operated off-load tap changer shall be provided. The specification of tap-changers and the tapping range shall be in according to sub-clause 7.11 of this Standard.



Where to be used: indoor **b**                      outdoor **b**

Type of mounting: ground mounted **b**                      Pole mounted **b**

Type of incoming to and outgoing from transformer:

**a) Incoming from:**

Overhead **b**                      Under ground **b**

Conductor/cable Size-----

Conductor/cable Type-----

Whether cable gland is needed                      Yes **b**                      No **b**

Whether terminal lugs is required                      Yes **b**                      No **b**

**b) Outgoing to:**

Over head **b**                      Under ground **b**                      Bus Ducting **b**

Conductor cable Size-----

Conductor cable Type-----

The provisional size of bus-bar-----

Whether cable gland is needed                      Yes **b**                      No **b**

Whether terminal lug is required                      Yes **b**                      No **b**

**Note:**

Where bus-bar ducting is required full coordination is required between transformer and switchgear manufacturer.

Type of cooling-----

Input voltage of cooling fan(s)  
----- (V)

Tap changers: off-load **b**                      on-load **b**  
(off-circuit)

Tapping range

**a) Number of tappings**-----including the main tap

**b) Tapping quantity** -----% for each tap

Vector group and clock hour no

-----  
--  
-----  
--

Neutral terminal required                      Yes **b**                      No **b**

**(to be continued)**

**APPENDIX A (continued)**



**Appendix A ( continued)**

Tests to be carried out other than routine and type tests mentioned in this standard.

Test	Reference
-	-
-	-

Any other requirements

-----  
--  
-----  
--  
-----  
--

Spares and special tools

-----  
--  
-----  
--  
-----  
--  
-----  
--

**Note:**

For selection of technical data for transformer(s) reference may be made to Appendix B .

(to be continued)

**APPENDIX A (continued)**

**A.2 DETAILS OF EXISTING TRANSFORMER(S)**

**Note:**

The following information shall be given if paralld operation is required with existing transformer(s):

Rated power-----kVA

Rated voltage:

Primary-----kV

Secondary-----kV

Tertiary-----kV

Rated voltage ratio-----

-

Load loss at rated current and rated voltage on the principal tapping -----  
kVA

Impedance voltage at rated current ----- % of rated voltage

Vector group and clock-hour number-----

-

Number of phases:

In Primary b

In Secondary b

Neutral point brought out:

Yes b

No b

Marking of terminal connection

In Primary-----

--

In Secondary-----

--

**ATTACHMENTS****ATTACHMENT 1  
ENVIRONMENTAL CONDITIONS**

- 1.1 Site elevation-----m above sea level
- 1.2 Maximum air temperature-----°C
- 1.3 Minimum air temperature-----°C
- 1.4 Average relative humidity----- % (in a year)
- 1.5 Atmosphere: Saliferrous, dust corrosive and subject to dust stormes with concentration of 70-1412 mg/m<sup>3</sup>, H<sub>2</sub>S may be present.
- 1.6 Lightning storm: Isoceraunic level----- storm-day/year
- 1.7 Earthquake zone-----local earthquake zone

**Note :**

**Blanks to be filled by client.**

## ATTACHMENT 2 INSPECTION / QUALITY CONTROL, AND QUALITY RECORDS

### 2.1 Inspection / Quality Control

**2.1.1** The purchaser's inspection, or his authorized representative shall have free access to the manufacturing plant engaged in the manufacture of the equipment, to carry out necessary inspection at any stage of work.

**2.1.2** Inspection may include the visit to quality control laboratories, work shops testing bay etc.

**2.1.3** The supplier shall make available technical data, test pieces and samples that the purchaser's representative may require for verification in conjunction with pertinent equipment.

If required the supplier shall forward the same to any person or location that the purchaser's representative may direct.

### 2.2 Quality Records

**2.2.1** The supplier shall maintain appropriate inspection and test records to substantiate conformance with specified requirements.

**2.2.2** Quality record shall be legible and relevant to the product involved.

**2.2.3** Quality records that substantiate conformance with the specified requirements, shall be retained by manufacturer and made available on request by purchaser.

**2.2.4** The supplier shall establish and maintain procedure for identification collection, indexing, filing, storage, maintenance and disposition of quality records.

**2.2.5** Supplier shall submit to purchaser: reports, test, schedules, and test certificates (in ----- copies) on completion of tests.

**Note:**

**Blanks to be filled by client.**

### ATTACHMENT 3 TESTS AND CERTIFICATION

#### 3.1 General Requirements

**3.1.1** Test procedure other than those already mentioned as proposed by the supplier shall be agreed upon, and approved by the purchaser before any test is carried out.

**3.1.2** Purchaser may require witnessed tests to be carried out in the presence of his nominated representative who should be informed at least -----weeks in advance of the date of the tests and confirmed ----- weeks before the tests.

**3.1.3** Test certificates and test reports shall refer to the serial No. of the equipment tested and must bear the purchaser's name, order No. and manufacturer's name and seal.

The certificates shall be approved by the purchaser before shipment instruction are given.

**3.1.4** Approval by the purchaser's inspector or representative shall not relieve the vendor of his commitments under the terms of this specification or any associated order.

**3.1.5** The equipment may be rejected if measurement and inspection reveal any discrepancies between quoted figures resulting in purchase order and those measured actually.

**3.1.6** Any charges incurred by the tests quoted under heading of specific requirements for tests to be quoted as a separate item and are not to be included in the cost of the equipment.

**Note:**

**Blanks to be filled by client.**

## ATTACHMENT 4 PACKING

### 4.1 General Requirements

- 4.1.1** Ancillary items forming an integral part of the transformer should be fixed securely to the transformer and adequate precautions taken to ensure that the item do not come loose in transit or be otherwise damaged.
- 4.1.2** All special tools and equipments needed for installing or servicing the transformer and alternatively the ancillary items forming an integral part of the transformer should be packed in a separate container if equipment cased or crated.
- 4.1.3** Packages shall be so packed that all opening to be closed to avoid collection of dirt and other foreign matter.
- 4.1.4** Special attention must be given to protection of all parts against corrosion during transit.
- 4.1.5** The supplier shall provide methods of handling to prevent damage and or deterioration during transit.
- 4.1.6** The requirements of above items shall not relieve the supplier of any of his responsibility and his obligations for delivery of equipment in a sound undamaged and operable conditions at site.
- 4.1.7** All packages shall have a good designation for identifying a particular equipment in the event that a recall or inspection becomes necessary.
- 4.1.8** If the transformer are supposed to be shipped in separate parts each part of main structures shall be provided with a permanently attached readily visible identification tag bearing the equipment number of the assembly to which it is a part.

### 4.2 Special Requirements

- 4.2.1** The transformer and all associated equipment with oil filled compartments shall be prepared for transportation as follows:
- a) Completely filled with insulating oil, or,
  - b) Only filled with sufficient insulating oil to cover the core, windings and connections, etc., or,
  - c) Filled with dry inert gas (nitrogen) above atmospheric pressure with a dewpoint of -40°C or colder.

Where para's (b) and (c) are applicable sufficient insulating oil to complete either the partial filling or the first full filling shall be packed separately in nonreturnable 210 liter sealed steel drums and shipped with the transformer.

The drums shall be new and of top quality. In general, of the type normally used in the oil industry. The external part of drums shall be treated against corrosion and painted with oil and weather resisting paint. The drums shall have a good designation indicating: serial number and the oil and drum net weight. These marking shall be legible and durable.

Where para(c) is applicable, suitably calibrated gas pressure gages shall be fitted. Loose stopper plugs to be provided for the gages bosses after the removal of the gages. Dependent on the size of the transformer, reserve gas cylinders and a pressure regulator to be fitted to maintain the pressure between 0.2. to 0.4 bar.

**ATTACHMENT 5  
SHIPMENT**

**5.1** If equipment shipped in separate parts each shipping section of stationary structures shall be provided with a permanently attached readily visible identification tag bearing the equipment number of the assembly to which it is a part.

**5.2** The greatest care must be taken to ensure that shipping and associated documents with exact description for customs release are accompanied with the shipment.

**ATTACHMENT 6  
GUARANTEE**

**6.1 Clearance of Defects**

The supplier shall guarantee his equipment during commissioning and for one year of operation starting after the completion of seven days continuous service test at site at full load against the following defects:

- all operation defects,
- all material defects,
- all constructional and design defects.

**6.2 Replacement of Defective Parts**

All defective parts shall be replaced by the supplier in the shortest possible time free of charge including dismantling reassembling at site and all transportation costs. The above mentioned period shall not however be longer than 18 months from the date of dispatch from the manufacturer's works.

**6.3 Supply of Spare Parts**

Further more the supplier shall guarantee the provision of spare parts to the purchaser for a minimum period of -----  
-years from the date of dispatch.

**6.4 After Sale Technical Services**

**6.4.1 Commissioning**

**6.4.1.1** The supplier shall quote if required for the services of competent engineer(s) and or technician(s) to assist in installation commissioning and testing of the equipment at site on a per diem basis.

**6.4.1.2** The quoted rates shall be irrespective of duration and frequency and the supplier shall guarantee the services of the engineer(s) and technician (s) on the specified date within a minimum of ----- weeks advance notice by the purchaser.

**6.4.2 Training**

**6.4.2.1** The purchaser may require the supplier to arrange for training of his personnel in the manufacturing plant and or in site for the operation and maintenance of the equipment offered.

**6.4.2.2** The supplier shall quote (if required ) for the cost of any of above mentioned services on a per person per diem basis. The program for the training shall be prepared by mutual agreement. An advance notice of ----- weeks minimum, is required by purchaser for the commencement of training program.

**Note:**

Blanks to be filled by client.

**ATTACHMENT 7**

## **SPARE PARTS**

- 7.1** All spare parts shall comply with the same standards, specification and tests of the original equipment and shall be fully interchangeable with the original parts without any modification at site.
- 7.2** They shall be correctly marked in accordance with client reference and manufacturer part numbers giving also the purchaser's order number.
- 7.3** Spare parts shall be preserved to prevent deterioration during shipment and storage in humid tropical climate.
- 7.4** List of recommended spare parts and interchangeability with spare parts of similar equipment shall be submitted by supplier.

**ATTACHMENT 8  
LANGUAGE**

**8.1** All correspondence drawings, documents, certificates, including testing operation and maintenance manuals and spare part lists etc. shall be in English.

**8.2** Offers in other languages will not be considered.

**ATTACHMENT 9  
COORDINATION RESPONSIBILITY WITH OTHERS**

- 9.1** In case the equipment ordered should be mounted on, aligned, connected, adjusted, or tested with the equipment of other manufacturer(s) the supplier shall contact directly the said manufacturer(s) and supply and obtain all dimensional and technical informations and arrange for any interconnecting equipment and combined test that may be required.
- 9.2** The supplier shall be responsible for correct and timely communication with the said manufacturer(s) and for delay and/or cost claims arising from such communications.
- 9.3** Copies of all correspondence should be sent to purchaser.
- 9.4** The name and address of the manufacturer(s) will be given as soon as their orders have been confirmed.

**ATTACHMENT 10  
GENERAL CONDITIONS OF PURCHASE**

This document will be submitted by purchaser at the time of ordering.

**ATTACHMENT 11  
SAMPLE OF PURCHASER'S DRAWING TITLE BLOCK**

<b>DRAWING NO.</b>	<b>DESCRIPTION</b>				
<b>REFERENCE DRAWINGS</b>					
<b>D</b>					
<b>C</b>					
<b>B</b>					
<b>A</b>					
<b>REV</b>	<b>DATE</b>	<b>DESCRIPTION</b>	<b>REF</b>	<b>CHK</b>	<b>APP</b>
<b>THE NAME OF RELEVANT COMPANY</b>					
<b>DRAWING TITLE :</b>					
<b>DRN. BY</b>	<b>SCALE</b>	<b>MICRO FILM CODE</b>	<b>PROJECT NO.</b>	<b>CHK. BY</b>	<b>APP. BY</b>
<b>JOB NO.</b>	<b>AREA CODE</b>	<b>DWG. NO.</b>	<b>SHEET</b>	<b>REV.</b>	

**Note:**

Appropriate, nomenclature and registered mark shall be used for quotation and ordering by different companies in oil industry.

**ATTACHMENT 12**  
**INSTRUCTIONS OF PURCHASER ABOUT DRAWINGS**

**12.1** Purchaser's drawing title block, "the sample of which is given in Attachment No. 11 shall be shown in the right lower corner of the drawings.

**12.2** Drawings are to be protected and packed. Negatives must be dispatched in a strong card board cylinder.

**12.3** Drawings must be rolled and not folded.

**12.4** All drawings, documents and literatures shall be forwarded under cover of a fully detailed letter to purchaser whose addresses are given in Attachment 13.

**ATTACHMENT 13**  
**FULL ADDRESS OF PURCHASER:**

Code No.....

**P.O. BOX NO.** .....

**Telephone No.** .....

**Telex No.** .....

**Faxsimile No.** .....

**Note:**

**Blanks to be filled by client.**