IBEDC

IBADAN ELECTRICITY DISTRIBUTION COMPANY (Plc.)

SPECIFICATION FOR

33/11KV POWER TRANSFORMER

ISSUED BY:

TECHNICAL OPERATIONS DEPARTMENT
CAPITAL BUILDING
115, RING ROAD,
P.M.B. 5388, IBADAN
OYO STATE, NIGERIA

...Distributing Power, Changing Lives

SPECIFICATION OUTLINE

INDEX	CONTENT	PAGE
1.0	GENERAL PARTICULARS	3
2.0	DESIGN AND STANDARDISATION	4
3.0	GALVANISING & ALLOYS	7
4.0	LABELS AND PLATES, CLEANING & PAINTING	8
5.0	OIL, INSULATION COMPOUND	10
6.0	ELECTRICAL CHARACTERISTICS & PERFORMANCE	11
7.0	CORES	14
8.0	W I N D I N G S	16
9.0	INTERNAL EARTHING ARRANGEMENTS	18
10.0	T A N K S	20
11.0	COOLING PLANT	27
12.0	M O T O R S	31
13.0	VOLTAGE CONTROL	35
14.0	AUTOMATIC VOLTAGE CONTROL EQUIPMENT	40
15.0	TEMPERATURE INDICATING DEVICES, ALARMS, GAS & OIL ACTUATED RELAYS	45
16.0	MARSHALLING KIOSKS, CONTROL & INSTRUMENT WIRING AND TERMINAL BOARDS	49
17.0	PACKING AND SHIPPING, AND DRYING OUT	56
18.0	T E S T S	58
19.0	DRAWINGS	60
	SCHEDULES & GUARANTEES	61

1.0 GENERAL PARTICULARS

1.1 **NOTE:** In this Specification and attached schedules:-

The 'Engineer' shall mean the person or persons nominated by Ibadan Electricity Distribution Company to act as their Representative.

1.2 **NATURE OF WORK**

This Specification provides for the design, Manufacture, testing, Supply, delivery and off-loading on site of the equipment detailed in the attached schedules (Civil Works is not included). This specification covers the supply of new transformers.

2.0 DESIGN AND STANDARDISATION

2.1 DESIGN AND STANDARDISATION

The Construction Works shall be designed to facilitate inspection, cleaning and repairs, and for operation where continuity of supply is the first consideration. All apparatus shall also be designed to ensure satisfactory operation under the atmospheric conditions prevailing at the Sites and under such sudden variation of load and voltage as may be met with under working conditions on the systems, including those due to faulty synchronizing and short circuit.

The design shall incorporate all reasonable precautions and provision for the safety of those concerned in the operation and maintenance of the Construction Works and associated works.

All materials used shall be new and of the best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions arising under working stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

Where made of steel or malleable iron, operating boxes, handles, rods, tubes and other fittings for outdoor equipment shall be galvanized.

All outdoor apparatus and fittings shall be designed so that water cannot collect at any point. Grease lubricators shall be fitted with nipples complying with B.S. 1486 Part 2, Nos. 21A and 21B. Where necessary for accessibility, the nipples shall be placed at the end of extension piping.

All connections and contacts shall be of ample section and surface for carrying continuously the specified currents without undue heating.

All metal jointing surfaces shall be machined or ground. Unmachined flat steel plate covers shall be used only where the corresponding joint flange is machined. The bolt spacing and packing material employed with such covers shall be to approval.

Unless otherwise approved, cast iron shall not be used for chambers of oil filled apparatus or for any part of the equipment which is in tension or subject to impact stresses.

The underside of all tanks shall be ventilated in an approved manner to prevent corrosion.

Kiosks, cubicles and similar enclosed compartments shall be adequately ventilated to restrict condensation. All contactors or relay coils and other parts shall be suitably protected against corrosion.

Where frameworks are of the box type and are used for housing secondary wiring and connections, provision shall be made for fitting suitable low temperature heaters when required by the Engineer.

All apparatus shall be designed to obviate the risk of accidental short circuit due to animals, birds and vermin.

All D.C. equipment, other than tripping devices which shall comply with this specification shall be suitable for operation at the normal D.C. voltages as stated and shall operate satisfactorily between the limits of 20 percent below and 10 percent above normal operating voltage and over the complete range of operating temperature.

2.2 BOLTS AND NUTS

All bolts, studs, screw threads, pipe threads, bolt heads and nuts shall comply with the appropriate National Standard for metric threads, or the technical equivalent.

Terminal bolts or studs used for carrying current of more than 100 amperes shall not be less than 16mm in diameter. Brass terminal bolts or studs of less than 6mm diameter

shall not be used for electrical connections. Where a lesser size is necessary, stainless steel, phosphor bronze or high tensile brass may be used down to and including 4mm diameter provided the current carrying capacity is adequate.

All nuts and pins shall be adequately locked.
Wherever possible bolts shall be fitted in such a manner that in the event of failure, locking resulting in the nuts working loose and falling off, the bolt will remain in position.

All bolts, nuts and washers placed in outdoor positions shall be of approved materials and treated to prevent corrosion of the threads and electrolytic action between dissimilar metals.

Where bolts are used on external horizontal surfaces where water can collect, approved methods of preventing the ingress of moisture to the threads shall be provided.

Each bolt or stud shall project at least one thread but not more than three threads through its nut, except when otherwise approved for terminal board studs or relay steams. If bolts and nuts are placed so that they are inaccessible by means of ordinary spanners, special spanners shall be provided.

The length of the screwed portion of the bolts shall be such that no screw thread may form part of a shear place between members.

Taper washers shall be provided where necessary.

3.0 GALVANISING & ALLOYS

3.1 All galvanizing shall be applied by the hot dip process and shall comply with the appropriate National Standard.

All welds shall be de-scaled, all machining carried out and all parts shall be adequately cleaned prior to galvanizing. The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated materials.

Alternative processes shall not be used without the approval of the Engineer.

3.2 All aluminium alloys shall be of approved composition to the appropriate National Standard.

Aluminium alloy casting shall be free from porosity.

4.0 LABELS AND PLATES, CLEANING & PAINTING

4.1 LABELS & PLATES

All apparatus shall be clearly labeled indicating where necessary, its purpose and service positions. Each phase of alternating current and each pole of direct current equipment and connections shall be coloured in an approved manner to distinguish phase or polarity.

The material of all labels, the dimensions, legend, and method of printing shall conform to Standard. The surface of indoor labels shall have a matt or satin finish to avoid dazzle from reflected light.

Colours shall be permanent and free from fading. Labels mounted on black surfaces shall have white lettering. "Danger" plates shall have red lettering on a white back-ground.

All labels and plates for outdoor use shall be of approved incorrodible material. Where the use of enameled iron plates is approved, the whole surface including the back and edges, shall be properly covered and resistant to corrosion. Protective washers or suitable material shall be provided front and back on the securing screws.

4.2 CLEANING AND PAINTING

Works Processes

a) All steel work, plant supporting steelwork and metalwork except galvanized surfaces or where otherwise specified, shall be completely cleaned of all millscale, rust, dirt, oil or any other matter which may affect the painting process by any means necessary for the operation including shortblasting to B.S. 4232 Class II, pickling or mechanical methods. Although surfaces of coatings shall be filled with an approved two-pack filler and rubbed down to a smooth surface.

b) The interior surfaces of all tanks and oil filled chambers shall be shortblasted in accordance with B.S. 4232 Class IV "White Metal Finish", and painted within a

period of one hour with an oil resisting coating of a type and make to the approval of the Engineer.

c) The interior surfaces of mechanism chambers and kiosks, after preparation and cleaning as required above, shall be painted with one coat Calcium Plumbate primer, one coat Phenolic based under-coating, one coat Phenolic based finishing paint and one coat-anticondensation paint of a type and make to the approval of the Engineer, to a light or white colour, and to a minimum overall paint film thickness of 125 microns.

d) All steel works and metal works except where otherwise specified after preparation and cleaning as required above shall be painted with one coat metallic lead primer and two coasts of Micaceous Iron Oxide paint to an overall minimum paint film thickness of 125 microns.

e) Galvanised surfaces shall not be painted in the works.

f) All nuts, bolts washers, etc. which may be fixed after fabrication of the plant shall be painted as described above after fabrication.

5.0 OIL, INSULATION COMPOUND

5.1 OIL

Unless otherwise specified sufficient oil shall be supplied to fill all the transformer tanks and any other oil-filled portions of the transformers. The oil shall comply with the requirements of B.S. 148 and shall be suitable in all respects for use in the equipment when operated under the conditions laid down in this specification.

5.2 INSULATING COMPOUND

Insulating compound shall comply with the requirements of B.S. 1858 and shall be of the grade as stated. The pouring temperature shall not exceed that as stated. It shall not soften sufficiently to ooze out nor shall it become brittle under any conditions normally encountered during transport or in service.

5.3 EARTHING OF ANCILIARY EQUIPMENT

All metal parts, other than those forming part of any electrical circuit, shall be connected to the main earth system in an approved manner by means of a hard drawn high conductivity copper earth bar with a cross sectional area in accordance with B.S. Code of Practice CP 1013.

6.0 ELECTRICAL CHARACTERISTICS & PERFORMANCE

6.1 TYPES OF TRANSFORMERS AND OPERATING CONDITIONS

Transformers shall comply with the requirements of British Standards or the equivalent International Electrotechnical Commission Recommendations and with the information given in Schedule 'D' Part II.

The types of cooling shall be as specified in Schedule 'D' Part I, the abbreviations used being those of IEC 76. Where a combinations of two methods of cooling is to be applied to a transformer, as for ONAN/ONAF, ONAN/OFAF and ONAN/OFAN units, the transformer shall be capable of operating under ONAN conditions up to the rating specified in Schedule 'D' Part I, after which the cooling equipment shall come into operation and the transformers will operate as ONAF, or OFAN units.

6.2 DUTY UNDER FAULT CONDITIONS

All windings of the transformers shall be capable of withstanding short circuit for the periods of time specified in B.S. 171 when operating on any tapping position, including that corresponding to minimum effective impedance, with the short-circuit MVA available at the terminals not exceeding the values given in Schedule 'D' Part I.

6.3 CONTINUOUS MAXIMUM RATINGS, TEMPERATURE RISES & SUSTAINED OVERLOADS

Each transformer shall have the Continuous Maximum Rating (C.M.R.) specified in Schedule 'D' Part I, and shall be suitable in all respects to work continuously at this rating under the climatic conditions stated in Schedule 'D' Part I. Where this rating differs from the B.S. rating the B.S. rating shall be as stated in Schedule 'D' Part II.

All transformers shall comply as regards B.S. rating, temperature rise, and overload, with the appropriate requirement of B.S. 171 when operating with natural or forced cooling.

Irrespective of the direction of power flow, all transformers shall be capable of operating continuously without injurious heating when supplying a load equal to the C.M.R. with

the transformer on any ratio and with the voltage of the untapped winding maintained at the voltage stated in Schedule ‘D’ Part I.

6.4 VOLTAGE AND RATIO OF TRANSFORMATION

The normal ratio of transformation shall be as specified in Schedule ‘D’ Part I. The total range of tappings and the size of steps shall be as specified in Schedule ‘D’ Part I.

Where the voltage applied continuously to any tapping may exceed that permitted by B.S. 171, the amount of the excess voltage will be as stated in Schedule ‘D’ Part I.

6.5 IMPEDANCE

The impedance voltage at normal ratio of transformation and continuous maximum rating shall be as stated in Schedule ‘D’ Part II and shall comply with the requirements of Schedule ‘D’ Part I.

6.6 VIBRATION AND NOISE

The design and manufacture of the transformers and auxiliary plant shall be such that the level of vibration does not adversely affect any clamping or produce excessive stress in any material.

Where noise measurements are specified, they shall be made at the Manufacturer’s Works in the presence of IBEDC Representative.

The average surface noise level of each transformer shall not be greater than that specified in N.E.M.A. T.R.I. and the measurements shall be made according to N.E.M.A, T.R.I. The sound level meter shall carry a certificate giving its overall calibration and means should be provided for checking the gain of the meter both before and immediately after each test.

Full details of noise measurement shall be submitted by the Manufacturer and the IBEDC reserves the right to reject the transformers having average surface noise levels in excess of those specified.

6.7 SUPRESSION OF HARMONICS

(Tertiary Windings)

The transformers shall be designed with particular attention to the suppression of harmonic voltages, especially the third and fifth, so to minimize interference with communications circuits. The tertiary winding shall be required for the purpose of suppressing such harmonics, of providing a connection for reactive compensation equipment, and perhaps a connection for an earthing transformer.

6.8 LEAKAGE FLUX

The transformer shall be designed to ensure that leakage flux does not cause overheating in any part of the transformer.

7.0 CORES

7.1 MAGNETIC CIRCUITS

The type of joints in the magnetic core shall be to Standard. Particular care shall be taken to secure even mechanical pressure over the whole of the core laminations. Each lamination shall be insulated with a material that will not deteriorate under pressure and the action of hot oil.

Where clamping bands are used, the material shall be to Standard. Where used the frame and core bolts shall be effectively insulated from the core.

Where the magnetic circuit is divided into packets, tinned copper strip bridging pieces shall be inserted to maintain electrical continuity between packets.

The magnetic circuit shall be earthed through the link specified in clause 4.2. The framework and clamping arrangements shall be earthed in accordance with Clause 4.3.
The core shall be free from overfluxing liable to cause damage or to cause mal-operation of the protection equipment when operating under the continuous over-voltage condition specified in the Schedule. Under this steady over voltage condition the maximum flux density must not exceed 1.9 tesla and the magnetizing current must not exceed 5% of the rated load current at normal rated voltage.

7.2 MECHANICAL CONSTRUCTION OF CORES

The cores, framework, clamping arrangements and general structure of the transformers shall be capable of withstanding any shocks to which they may be subjected during transport, installation and service.

Adequate provision shall be made to provide movement of the transformer relative to the tank and the method of supporting the core structure in the tank and of carrying the weight of the core and windings when suspended shall be to approval.

Structural members shall be made of steel, or, subject to approval, of non-magnetic material or high resistance alloy.

All castings shall be fettled and structural steel adequately cleaned before being built into the structure.

Approved fitments shall be provided to enable the core and windings to be lifted.

After cutting and punching, core laminations shall be free from burrs.

8.0 W I N D I N G S

8.1 WINDINGS

Winding insulation and all materials used in winding stacks shall be so treated that no further shrinkage shall take place after assembly.

Coils shall be constructed to avoid abrasion of the insulation, (e.g. on transposed conductors), allowing for the expansion and contraction set up by changes of temperature encountered during normal operation

The coil clamping arrangement and the finished dimensions of all oil ducts shall be such as not to impede free circulation of oil through the ducts.

The windings shall be designed to reduce to a minimum the out-of-balance forces in the transformer.

Tappings shall be arranged at such positions or the windings as will preserve, as far as possible, the electro-magnetic balance of the transformer at all voltage ratios.

Tappings shall not be brought out from the inside of a coil nor from intermediate turns except when specifically approved.

All windings shall be fully insulated or graded as specified in Schedule ‘D’ Part I, and as defined in IEC 76.

Neutral points shall be insulated for the voltages specified in Schedule ‘D’ Part I.
In multi-winding transformers, where one or more windings may be unloaded in service, the transformer shall be designed so that with the specified impulse test voltage applied to the other windings, the maximum surge that can be transferred to the unloaded winding does not exceed the specified insulation level of the latter. Compliance with this

requirement shall be proved either by measurements taken during impulse testing or by separate recurrent surge oscillograph measurements.

8.2 BRACING OF WINDING

The windings and connections of all transformers shall be braced to withstand shocks, which may occur during transport or due to switching or other transient conditions during service.

Where the yoke supporting channels are adapted for taking up shrinkage in the windings, the arrangements shall be such as to throw a minimum amount of stress on the core bolt insulation.

Coil clamping rings, if provided, shall be to the approval of the Engineer and shall be of steel, or of suitable insulating material built up from flat laminations.

Axially laminated material other than bakelised paper shall not be used. Where bakelised paper rings are used with the layers of paper lying in axial direction, the rings shall only be relied upon to provide the major insulation between the windings and earth, provided the creepage voltage stress obtained by dividing the full line voltage by the creepage distance to earth does not exceed 0.2kV/mm. Steel clamping rings shall be maintained at a definite potential and if earthed shall comply with the requirements of Clause 4.4.

If the transformer winding is built up of sections or disc coils, separated by spacers, the clamping-arrangements shall be such that equal pressure is applied to all columns of spacers. All such spacers shall be securely located and shall be of suitable material.

9.0 INTERNAL EARTHING ARRANGEMENTS

9.1 INTERNAL EARTHING GENERAL

All metal parts of the transformer with the exception of the individual core laminations, core bolts and associated individual side plates shall be maintained at some fixed potential.

9.2 EARTHING OF MAGNETIC CIRCUIT

The magnetic circuit shall be earthed to the clamping structure at one point through a removable link with a captive bolt and nut, accessibly placed beneath an inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection, and taken from the extreme edge of the top yoke in close proximity to the bridging pieces referred to in Clause 4.3

9.3 EARTHING OF CORE CLAMPING STRUCTURE

The main yoke clamping structures shall be connected to the tank body by a copper strap located at the top of the tank. If there is no metal-to-metal contact between the top and bottom clamping structures, or between the tank base and the bottom clamping structure, the latter shall be earthed by one or more of the following: -

a) By connection through vertical tie rods to the top structure.

b) By direct metal-to-metal contact with the tank base, maintained by the weight of the core and windings.

c) By a connection to the top structure on the same side of the core as the main earth connection to the tank.

9.4 EARTHING OF COIL CLAMPING RINGS

Where coil clamping rings are of metal at earth potential each ring shall be connected to the adjacent core clamping structure on the same side of the transformer as the main earth connection.

9.5 SIZE OF EARTHING CONNECTIONS

All earthing connection with the exception of those from the individual coil clamping rings shall have a cross-sectional area of not less than 80mm^2. Connections inserted between laminations shall have a cross-sectional area of not less than 20mm^2.

10.0 T A N K S

10.1 TANK CONSTRUCTION

Transformer tanks shall be designed so as to allow the complete transformer in the tank, with oil, to be lifted by crane or lacks and transported by road, rail or water without overstraining any joints and without causing subsequent leakage of oil.

The bases of each tank shall be so designed that it will be possible to move the complete transformer in any direction without injury when using roller plates or rails. A design which necessitates slide rails being placed in particular positions shall not be used.
Unless specifically approved, detachable under-bases shall not be used.

Tank stiffeners shall be continuously welded to the tank and designed to prevent retention of water. Where cooling tubes are attached directly to tanks, the arrangement shall be that the tubes can be readily cleaned and painted in position.

The main tank body, including tap changing compartments, radiators and coolers, shall be capable of withstanding a vacuum of 500mm of mercury when empty of oil.

All tanks constructed to mild steel or aluminium shall have a minimum thickness of base plate in accordance with the figure given in the table included in Schedule 'D' Part I. The plate thickness for the tank sides shall be sufficient to comply with the deflection tests specified in Schedule 'F', with a minimum thickness of 6mm.

For tanks of aluminium alloy construction, precautions shall be taken to prevent corrosion between the base or under base of the tank and the concrete plinth following movement to the site position.

Where tanks are constructed of material other than aluminium or mild steel the plate thickness shall be to approval.

Wherever possible, the transformer tank and its accessories shall be designed without pockets where gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe. The vent pipes shall have a minimum inside diameter of 20mm except for short breach pipes which may be 6mm.

All joints other than those which may have to be broken shall be welded. Caulking of defective welded joints will not be permitted. Such defective joints may be re-welded subject to the written approval of the Engineer.

Unless otherwise approved, all oil pipe flanges shall be in accordance with B.S. 10 Part 2, Table D. Valves and valve mountings for cooler and radiator connections shall be provided and located as specified under "Cooling Plant".

10.2 LIFTING AND HAULAGE FACILITIES:

Each tank shall be provided with: -

a) An approved arrangement of lugs or trunnions suitable for lifting the transformer complete with oil.

b) A minimum of four jacking lugs in accessible positions to enable the transformer complete with oil to be raised or lowered using hydraulic screw jacks.

Unless otherwise approved, the minimum height of the lugs above the base shall be:-

i) Transformers up to and including ten tones mass – 300mm.

ii) Transformers above ten tones mass – 500mm.

c) Draw holes suitably located to permit the tank to be hauled in any direction or slewed. Where possible the draw holes shall be combined with the jacking lugs specified under (b). As an alternative to draw holes, rope fairings may be provided at each corner at not more than 750mm above the base to enable hawsers to be placed round the tank for haulage purposes.

The method of bracing the core for transport shall be to approval.

10.3 TANK COVERS

Tank covers shall not distort when lifted. Inspection openings shall be provided of ample size to give easy access to bushings, for changing ratio or winding connections and for testing the earth connections.

The tank cover shall be designed to avoid all pockets wherein gas may collect instead of flowing to the gas and oil actuated relays.

The tank cover shall be fitted with the following thermometer pockets, which shall be located in the position of maximum oil temperature at continuous maximum rating:-

i) For winding temperature apparatus;

ii) For oil temperature indicating device.

10.4 PRESSURE RELIEF DEVICE

A pressure relief device shall be provided of sufficient size for the rapid release of any pressure that may be generated within the tank, and which might result in damage to the equipment, but it shall be capable of maintaining the oil tightness of the transformer under all conditions of normal service. The device shall operate at a static pressure of less than the hydraulic test pressure for transformer tanks specified in Schedule 'F'.

Unless otherwise approved, the relief device shall be mounted on the main tank and if on the cover shall be fitted with a skirt projecting inside the tank to prevent gas accumulation.

If a diaphragm is used, it shall be of approved design and material.

One of the following methods shall be used for relieving or equalizing the pressures in the pressure relief device: -

a) An equalizer pipe connecting the pressure relief device to the conservator, or

b) The fitting of a separate de-hydrating breather to the pressure relief device, the breather being mounted in a suitable position for access at ground level.

Means shall be provided to: -

i) Prevent the ingress of rain into any part.

ii) Prevent oil flow from the transformer following the operation of the device to relieve an internally generated pressure, which shall be independent of an electrical power supply.

10.5 CURRENT TRANSFORMER ACCOMMODATION

When specified in Schedule 'D' Part I accommodation for current transformers shall be provided in the terminal housings or in chambers forming an integral part of the bushing insulators. The dimensions of the housings or chambers shall be to approval.

The removal of a bushing shall involve disturbing only the connection to its own current transformers.

10.6 JOINTS AND GASKETS

All gaskets used for making oil-tight joints shall be of approved material.

10.7 EARTHING TERMINALS

Approved terminals shall be provided on the tank cover and at the base of the tank for earthing purposes. Terminal studs shall not be less than 22mm diameter.

10.8 CONSERVATOR VESSELS, OIL GAUGES AND BREATHERS

A conservator complete with filling cap, sump and drain valve shall be provided and shall have a capacity between highest and lowest visible levels of not less than 7.5% of the total cold oil volume in the transformer and its associated tap change and cooling equipment. A sump shall be provided, and it shall have a minimum depth of the tenth of the inside diameter of the conservator or 75mm, whichever is less.

Each conservator shall be so designed that it can be completely drained by means of the drain valve.

One end of the conservator shall have a removable end cover, complete with integral lugs for lifting purposes and secured by nut and bolt fixings, to permit internal cleaning of the conservator.

An oil gauge of approved type shall be provided for each conservator. The gauge shall be either of the direct reading prismatic or reflex type, or alternatively of the float operated magnetic type. It shall indicate clearly to an observer standing at ground level the oil level in the conservator.

Where it is necessary to fit two or more gauges of the prismatic type in order to cover the full expansion range, they shall be so disposed that the oil level is in view at all parts of the range.

The minimum indicated oil level shall be with the feed pipe to the main tank covered with not less than 12mm depth of oil and the indicated range of oil level shall correspond to average oil temperature of from plus 5^{O}C to plus 80^{O}C. The oil levels at 15^{O}C and 35^{O}C shall be marked on the gauges.

Taps or valves shall not be fitted to oil gauges. The main oil feed pipe from the conservator vessel to the transformer shall be connected to the highest point of the tank and shall be arranged at a rising angle towards the conservator from 3 to 7 degrees to the horizontal and shall consist of: -

i. For transformers up to and including 1000KVA – 25mm inside diameter pipes.
ii. For transformers from 1001 to 10000KVA – 50mm inside diameter pipes.
iii. For transformers of over 10000KVA – 75mm inside diameter pipes.

The pipework between the conservator and the transformer shall also comply with the requirements of clause 10.2.

A valve shall be provided at the conservator to cut off the oil to the transformer. Whether or not the oil is in direct contact with air or gas the air outlet from each conservator vessel

shall be connected to either a silica-gel breather which shall be mounted at approximately 1500mm above ground level.

10.9 VALVES-GENERAL:

Valves shall be of the full-way type with individual screw and shall be opened by turning counter-clockwise when facing the handwheel. They shall be suitable for working temperatures between plus $5^{O}C$ and plus $105^{O}C$ and where applicable shall withstand the tests specified in Schedule 'F'.

Means shall be provided for padlocking all valves other than individual radiator valves in the "open" and "closed" positions. Valves other than filter and drain valves shall be provided with an indicator, readily visible from ground level, to show clearly the position of the valve.

All valves flanges shall be machine-faced and shall comply with the requirements of B.S. 10, Part 2, Table D.

All valves opening to atmosphere shall be fitted with blanking plates.

10.10 VALVES, SAMPLING DEVICES & AIR RELEASE PLUGS

Each transformer tank shall be fitted with the following: -

a. One 50mm valve at the top and one 50mm valve at the bottom of the tank, mounted diagonally opposite each other, for connection to oil circulating and oil filtering equipment. The lower valve shall also function as a drain valve. These valves shall be fitted with blank flanges.
b. An oil-sampling device of an approved type, at the top and bottom of the main tank.
c. All oil containing parts liable to entrap air shall be fitted at their highest points with a flanged type air release plug to permit release of any air following oil filling.

10.11 RATING DIAGRAM & PROPERTY PLATES

Each transformer shall bear the following plates of approved size which shall be fixed to the transformer tank at an approximate height, where possible, of 1500mm above the ground level:-

a) A rating cap bearing the data specified in IEC 76.

b) A diagram plate bearing the data specified in IEC 76. Where links are provided for changing the transformer IEC Group Symbol and/or ratio, approved means shall be provided for indicating clearly the IEC Group Symbol and/or ratio for which the transformer is connected. The transformer voltage ratio shall indicate for each tap.

c) A property plate of approved design and wording

d) A title plate

e) A valve location plate showing the location and function of all valves, drain and air release plugs and oil sampling devices

11.0 COOLING PLANT

11.1 COOLING PLANT – GENERAL

Radiators and coolers shall be designed so that all painted surfaces can be readily cleaned and subsequently painted in position. To facilitate this, groups of radiators or cooling tubes shall be arranged such that there is a minimum of 600mm between adjacent groups.

Radiators and coolers shall be designed so as to avoid internal pockets in which gas may accumulate and shall withstand the pressure tests specified in Schedule 'F' for the tanks to which they are fitted.

The cooling plant shall be designed to withstand a vacuum of 500mm of mercury applied above oil level to the tank when the complete transformer is assembled as in service. The design and manufacture of cooling plant shall be such as to reduce noise and vibration to a minimum.

11.2 DETACHABLE RADIATORS

Detachable radiators connected to the main tank or to a separate cooler assembly shall be provided with machined flanged inlet and outlet pipes and with an isolating valve on the tank or cooler at each point of connection.

Plugs shall be fitted at the top and bottom of each radiator for filling and draining.

11.3 COOLERS

The oil circuit of all coolers shall be provided with the following:-

a) A valve at each point of connection to the transformer tank

b) A valve in the main oil connection at the bottom of each cooler

c) Loose blanking plates to permit the blanking off of the main oil connection to the top of each cooler.

d) A 50mm oil filtering valve at the top and bottom of each cooler; the bottom valve shall also function as a drain valve.

e) A thermometer pocket fitted with a captive screwed cap on the inlet and outlet oil branches of each cooler, each pocket so situated that the thermometer would be vertical.

f) Machined flanges.

g) Flanged air release plugs.

h) Visual oil flow indicators in the pipework adjacent to the coolers. In the event that this will offer impedance to oil flow under ON conditions a differential pressure gauge of approved design and manufacture may be connected across the pumps as an alternative.

Mal-operation of gas and oil actuated relays shall not occur on starting or stopping of forced-oil circulation.

The material of the tube plates and tubes shall be to approval and shall be such that corrosion shall not take place due to galvanic action.

11.4 OIL & WATER PIPING & FLANGES

The necessary oil piping shall be provided for connecting each transformer or transformer group to the coolers and oil pumps and for any equalizing connections when more than one transformer is connected to any cooling equipment. The arrangement of piping for single phase transformers forming a bank shall be such that under running conditions similar oil levels and equal oil circulation will be maintained in each transformer.

The oil piping shall be of approved material with machined flanged joints. Cast iron shall not be used.

All water and oil pipe flanges shall comply with B.S. 10 Part 2, Table D.

An approved flexible piece shall be provided in each oil pipe connection between the transformer and the oil coolers.

The external air clearances between pipe work and live parts of the transformer shall be as stated in Schedule 'D' Part I, unless the pipework is shielded by adequate earthed metal.

Drain plugs shall be provided in order that each section of pipework can be drained independently.

11.5 OIL PUMPS

Each forced oil cooler shall be provided with a fully weatherproof motor driven oil pump suitable for direct on-line starting. The motor shall be of the submersible type and shall comply with clause 7.1 where applicable. It shall be possible to remove the pump and motor from the oil circuit without having to lower the level of the oil in the transformer or coolers.

The pump shall be capable of dealing with the maximum output and head which may occur in service and with a varying head due to changes in the viscosity of the oil.

11.6 BLOWERS & DUCTS

Blowers shall be suitable for continuous operation outdoor and capable of dealing with the maximum output and head required in service.

The blowers shall be capable of withstanding the stresses imposed when being brought to speed by the direct application of full line voltage to the motor.

The blowers, air ducting and coolers shall be designed so that they operate with a minimum of noise or drumming so as to comply with the requirements of Clause 1.8.

All necessary ducts and casings shall be provided and made of galvanized steel not less than 2mm thick suitably stiffened.

It shall be possible to remove the fan, complete with a motor and supporting structure without disturbing or dismantling the cooler framework or pipework.

Wire mesh guards galvanized after manufacture shall be provided to prevent accidental contact with the fan blades. Metal guards shall also be provided over all other moving parts. The guards shall be designed such that neither the blades nor other moving parts can be touched by Standard Test Fingers Type ‘B’ and/or ‘D’ to B.S. 3042.

Motors shall comply with Clause 7.1.

12.0 MOTORS

12.1 GENERAL

Motors shall be of the squirrel cage type and shall be adequately rated to meet the plant requirements under the specified conditions. All motors shall comply with British Standard 2613 or British Standard 170 as applicable and shall be of approved manufacture. The dimensions shall comply with British Standards 2048 and 3979 where appropriate.

The motors shall be capable of operating continuously under actual service conditions without exceeding the specified temperature rises; determined by resistance, at any frequency between 48 and 51 hertz together with any voltage between $\pm$5 percent of the nominal value.

Unless otherwise specified, the slip speed of the motors at 75 percent of the nominal voltage at 50 hertz shall not exceed the percentage stated in Schedule 'D' and the motors shall be capable of operating at this voltage for a period of five minutes without injurious heating.

Unless otherwise approved, A.C. motors shall be suitable for a nominal supply of 415 Volts, three phase, 50 hertz and shall be fuse protected.

Motors shall be statically and dynamically balanced.

The motors shall operate to the Engineer's approval without undue vibration and with a minimum amount of noise.

All motors shall be totally enclosed, and if situated in the open they shall be weatherproof and suitable for outdoor working. They shall be provided with a suitable means of drainage to prevent accumulation of water due to condensation and with suitable means of breathing.

All submersible motors shall be adequately protected against the corrosive properties of the surrounding fluid.

Motors operating in an ambient temperature not exceeding $40^{O}C$ shall have Class 'E' insulation or better, but where the ambient temperature may exceed this figure or where the motor may be appreciably affected by conducted heat Class 'B' insulation or better shall be used.

Details of the stator insulation shall conform to Standard. The outside of all end windings shall be coated with oil-resisting, non-hygroscopic varnish or compound.

All motors shall be provided with a machined boss and tapped for a bolt of suitable size for earthing purposes.

All motors shall be suitable for direct starting at full voltage. The starting current of motors shall not exceed six times full load current.

Except for oil submerged motors, motors shall preferably have sealed ball or roller bearings, otherwise bearings shall comply with the lubrication requirements of British Standard 1486, Part 2, type number 21A and 21B.

Vertical spindle motors shall have bearings capable of withstanding the thrust due to the weight of the moving parts and the action of the impeller.

The three line connections of A.C motors shall be brought out to a terminal box. The terminal arrangement shall be suitable for the reception of aluminum cable.

Terminal markings shall be made in a clear and permanent manner and shall comply with British Standard 822. A permanently attached diagram or instruction sheet shall be provided giving the connections for the required direction of rotation.

Motor terminals shall comply with Clause 11.3

All terminal boxes shall be of the totally enclosed type designed to exclude the entry of dust and moisture and sealed from the internal air circuit of the motor. All joints shall be flanged with gaskets of neoprene or other approved material. Natural rubber insulation shall not be used.

For motors of 1MW and above, electrical clearances and creepage distances with the correct terminations in position shall comply with the requirements of B.S. 542.

12.2 MOTOR CONTROL

Each motor or group of motors shall be provided with a three-pole electrically operated contactor and with control gear of approved design for starting and stopping the motor by hand and automatically from the contacts on the temperature indicating device. Overload and single-phasing protection shall be provided.

Where small motors are connected in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring on a single motor. The control and protection equipment shall be accommodated in the control cabinet or marshalling kiosk, and shall comply with the requirements of Clause 11.1.

Motor contactors shall comply with B.S. 775, mechanical duty class 1, with type 52 enclosure protection and a utilization category AC4. They and their associated apparatus shall be capable of switching the stalled current and shall have a continuous current rating of at least 50% greater than the full load current of the motors they control, with a minimum rating of 40 amperes unless otherwise approved.

All terminals shall comply with Clause 11.3.

All contacts and other parts, which may require renewal, adjustment or inspection, shall be readily accessible.

Transformers with air blast cooling (OFAF or ONAF only) shall be provided with a device to operate an alarm, supplied under a separate contract, in the event of a fan failure.

The operating currents of overload trips fitted to motor contractors shall be substantially independent of ambient temperature conditions, including the effect of direct sunlight on the enclosure in which the contactors are installed.

Where multiple-fan cooling, using single-phase motors is employed, the motors on each cooling bank shall be grouped so as to form an approximately balanced three phase load.

13.0 VOLTAGE CONTROL

13.1 VOLTAGE CONTROL - GENERAL

Approved equipment for varying the turns ratio without producing phase displacement shall be provided. All leads and connections to fixed and moving contact assemblies and between the main transformer and the voltage control device shall be supported and adequately braced to withstand the short circuit current for which the associated transformer is designed.

13.2 OFF-CIRCUIT VOLTAGE CONTROL EQUIPMENT

Equipment for varying the effective turns ratio when the transformer is dead shall consist of tap-changing switches located inside the tank under oil and rigidly attached to the core structure as near as possible to the tapped coils. The switches shall be operated mechanically from the outside of the tank, the operating spindle passing preferably through the tank cover; the arrangement shall be such that it can be operated with the transformer out of its tank. The design shall be such as to prevent the ingress of moisture into, or the leakage of oil from the tank. Means shall be provided to ensure that the operating mechanism can be locked; such equipment shall be suitable for padlocking in any switch position. Non-ferrous padlocks with different key changes and two keys for each lock shall be provided.

Off load tapping selectors shall be provided with mechanical end stops which prevent movement beyond an end position.

13.3 ON-LOAD VOLTAGE CONTROL EQUIPMENT

Equipment for varying the effective turns ratio on-load shall consist of tap changing gear or other approved apparatus arranged for remote electrical operation. It shall be provided with local hand operating gear and arranged for remote electrical operation. It shall also be so designed that it may be easily adapted to operate by automatic control.

The tap changing switches and mechanism shall be mounted in an accessible position in oil tanks or compartments and shall be supported from the main tank or its base. It shall be possible to examine or repair both selector and diverter switches including their associated equipment without lowering the oil level in the main transformer tank. Drop down tanks, which necessitate the provision of pits in the foundations, shall not be used.

Unless otherwise approved it shall not be possible for the oil in those compartments of the tap change equipment which contain contacts used for making and breaking current to mix with the oil in the main transformer or with the oil in the compartments containing contacts not used for making or breaking current.

A 50mm drain valve shall be provided.

The oil in those compartments of the main tap change apparatus which do not contain contacts used for making current shall be maintained under conservator head by means of a-25mm inside diameter pipe connection from the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay specified in Clause 10.2.
Any enclosed compartment not oil filled shall be adequately ventilated and designed to prevent the ingress or vermin. All contactors relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation.

Each compartment in which the oil is not maintained under conservator head shall be provided with an oil gauge of approved design. The voltage of supply for electrical operation of the control and indicating gear shall be as specified in Schedule ‘D’ Part I.

Limit switches shall be provided to prevent over-running of the mechanism and shall be connected in the circuit of the operating motor. Limit switches may be connected in the control circuit of the operating motor provided that an approved mechanical de-clutching mechanism is incorporated.

A mechanical stop or other approved device shall be provided to prevent over-running of the mechanism under any condition.

Thermal devices or other approved means shall be provided to protect the motor and control circuits. All relays, switches, fuses, etc, shall be mounted in the marshalling kiosk specified in Clause 11.1 and shall be clearly marked to indicate their purpose. Switches for the initiation of a tap change shall bear the inscription “Raise Tap Number” or “Lower Tap Number”, as applicable.

Tripping contacts associated with any thermal device used for the protection of tap changing equipment shall be suitable for making and breaking 150KVA at 0.35 power factor between the limits of 30 and 250 volts A.C. and D.C. and for making 500VA between the limits of 110 and 250 volts D.C.

A device shall be fitted to the tap-changing mechanism to indicate the number of operations completed by the equipment.
Cabling and wiring shall comply with Clause 11.2 and the necessary cable box glands and/or conduit entries shall be provided at the marshalling kiosk and at the tap changing driving mechanism.

A permanently legible lubrication chart shall be fitted within the driving mechanism chamber.

The terminals of the operating motor shall be clearly and permanently inscribed with numbers corresponding to those on the leads attached thereto.

Equipment for local and remote electrical and local hand operation shall comply with the following conditions:

a) It shall not be possible to operate the electric drive when the hand operating gear is in use.

b) It shall not be possible for any two electrical control points to be in operation at the same time.

c) Each step movement shall require separate initiation at the control point.

d) All electrical control switches and the local operation gear shall be clearly labeled in an approved manner to indicate the direction of tap changing.

e) The local control switches shall be housed in the marshalling kiosk specified in Clause 11.1

The equipment shall be arranged so as to ensure that when a step movement has been commenced it shall be completed independently of the operation of the control relays or switches. If a failure of the auxiliary supply during a tap change, or any other contingency, would result in that movement not being completed, approved means shall be provided to safeguard the transformer and its auxiliary equipment.

Apparatus of approved type shall be provided: -

f) To give indication mechanically at the transformer and electrically at the remote control point of the tapping in use. The indicator at the transformer shall show the number of tapping in use and the indicator at the remote control point shall show clearly the actual voltage in kilovolts and the tap number representing this voltage. The numbers shall range from 1(one) upwards.

g) To give indication at the remote control point that a tap change is in progress by means of an illuminated lamp and alarm buzzer. If the tap change is not completed in its specified time the buzzer shall continue to sound until switched off by hand but the lamp shall remain illuminated until the tap change is completed.

h) To give indication at the remote control point by means of an approved illuminated indicator and the buzzer alarm as described in (g) above when the units of a group of transformer arranged to operate in parallel are operating at different ratios.

All indicating devices shall operate correctly at any voltage between the limits of 85% - 115% of nominal value.

If specified in Schedule ‘D’ Part 1, on-load tap changing equipment shall be suitable for supervisory control and indication and a separate multi-way switch, having one fixed contact for each tap position, shall be provided for this purpose and wired to the marshalling kiosk or cabinet specified in Clause 11.1. All other components of the supervisory gear will be supplied under a separate contract.

14.0 AUTOMATIC VOLTAGE CONTROL EQUIPMENT

Where the on-load tap changing equipment is fully automatic a voltage regulating relay shall be provided. The relay shall be responsive to variations in voltage of one per cent from the setting and means shall be provided for varying by hand adjustment, the setting over the range specified. A calibrated scale shall be incorporated within the instrument readily to show the relay setting in terms of the rated voltage. The relay shall be fitted with a time delay device capable of adjustment over a range of 0. to 90 seconds and the device shall be of the slow-setting type.

Where specified in Schedule 'D' Part 1, a line drop compensating device shall be provided and shall be designed to give a progressive boost from zero at no-load to a predetermined amount at full load; the range of boost shall be as specified in Schedule 'D' Part 1.

The voltage and current transformers for these devices will be provided under a separate contract.

On-load tap-change transformers provided with fully automatic control and required to operate in parallel as a group shall be provided with means to ensure that the voltage control equipment is automatically maintained in step. An "out-of-step" indicator shall be provided having contacts suitable for initiating an alarm which will be supplied under a separate contract.

14.1 BUSHING INSULATORS, CABLE BOXES, DISCONNECTING AND SEALING END CHAMBERS

BUSHING INSULATORS

Outdoor bushing insulators shall be designed for the operating conditions specified in Schedule 'D' Part 1. Bushing Insulators for 33kV shall be filled with the transformer oil and there shall be no connection with the oil in the transformer.

An oil gauge shall be provided. The visible oil levels in the gauge shall correspond to average oil temperatures of from $+5^{O}C$ to $+60^{O}C$. The oil level at $15^{O}C$ shall be marked. Where lower voltage bushing insulators are not oil filled the type of filling shall be approved. Where stated in Schedule 'D' Part 1, bushings shall be equipped with a capacitance tapping.

For bushings of 8000 amperes and above, where special technical features are involved, the design shall be to approval. All porcelain shall be sound, free from defects and thoroughly vitrified. The glaze, which shall not be depended upon for insulation, shall be smooth, hard, of a uniform shade of brown and shall cover completely all exposed parts of the insulator. Bushing insulators and fittings shall be unaffected by atmospheric conditions due to the weather, proximity of the coast, fumes, ozone, acids, alkalis, dust or rapid changes of air temperature.

Porcelain shall not engage directly with hard metal and, where necessary, approved gaskets shall be interposed between the porcelain and fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

All fixing materials used shall be of approved quality and properly applied and shall not enter into chemical action with the metal parts or cause fracture by expansion in service.

Cement thicknesses shall be as small and even as possible and proper care shall be taken to centre and locate the individual parts correctly during cementing.

Special precautions shall be taken to exclude moisture from the insulation during manufacture, assembly, transport and erection.

The exposed surfaces of all paper insulators shall be finished with approved non-hygroscopic varnish which can not be easily damaged.

When specified in Schedule 'D' Part 1, bushings for 33kV shall be provided with arcing rings or horns of approved type. The design shall be such as to minimize corona discharge and radio interference.

Connections from the main windings to bushings shall be flexible. Clamps and fittings made of steel or malleable iron shall be galvanized.

Bolt threads shall be greased before erection. Every bushing and each porcelain component shall have marked upon it the manufacturer's identification mark and such other mark as may be required to assist in the representative selection of batches for the purposes of the specified sample tests. Each porcelain part shall, in addition, be marked to indicate the date of firing. These marks shall be clearly legible and visible after assembly of fittings and shall be imprinted and not impressed. For porcelain parts the marks shall be imprinted before firing and for synthetic resin bonded paper bushings before varnishing.

Where a batch of bushings bearing a certain identification mark has been rejected no further bushings bearing this mark shall be submitted and the contractor shall satisfy the Engineer that adequate steps will be taken to mark or segregate the bushing constituting the rejected batch in such a way that there shall be no possibility of the bushings being resubmitted for test or supply to the Authority.

14.2 CABLE BOXES

Cable boxes shall be of approved design and unless otherwise specified shall be suitable for oil filling. They shall be designed to accommodate all the cable joint fittings required by the manufacturer of the cable; they shall comply with the requirements specified in Schedule 'D' Part 1, and be capable of withstanding the pressure tests specified in Schedule 'F'.

Oil-filled cable boxes shall not be constructed of cast iron. Unless otherwise approved, the flanged joints of oil filled boxes shall be machined and the spacing of bolts for these joints shall not exceed 100mm centres.

Provision shall be made to allow for the expansion of the filling medium and drain plugs of ample size shall be provided for enabling the filling medium to be removed.

Unless otherwise approved, universally tapped brass glands shall be provided in all cable boxes. Combined armour and earthing clamps shall be provided with cable boxes for armoured cables. Glands for single-core and three-core cables shall be insulated from the cable box in an approved manner and removable earth connections shall be provided. Gland insulation shall be capable of withstanding a dry high voltage test of 200 volts A.C. for one minute.

Where cable boxes are provided for three core cables the sockets on the outer phases shall be inclined towards the centre to minimize bending of the cable cores. Provision shall be made for earthing the body of each cable box.

14.3 DISCONNECTING & SEALING END CHAMBERS

Where cables for 11KV and above are terminated in a cable box, an oil-filled disconnecting chamber with removable links shall be provided for testing purposes. A barrier shall be provided in both sides of the disconnecting chamber to prevent ingress of the oil used for filling the chamber into the cable box or transformer.

Where sealing chambers are provided, the disconnecting chamber may be omitted and the facilities for testing shall be provided in the sealing end chamber itself; a barrier shall be provided between the sealing end chamber and the main tank.

Disconnecting and sealing of chambers shall be of approved design and unless otherwise specified shall be suitable for oil filling.

Oil filled chambers shall not be constructed of cast iron. Unless otherwise approved the flanged joints of all oil filled chambers shall be machined and the spacing of bolts for these joints shall not exceed 100mm centres.

Provision shall be made to allow for the expansion of the filling medium and drain plugs of ample size shall be provided for enabling the filling medium to be removed.

The disconnecting or sealing end chambers shall have removable cover and the design of the chambers shall be such that ample clearances are provided to enable either the transformer or each cable to be subjected separately to high voltage tests. The disconnecting links shall be flexible or flexibly attached at one end.
A drain plug of ample size shall be provided.

The oil level in disconnecting or sealing end chambers shall be maintained from the main conservator tank by means of a connection to the highest point of the chamber and this connection shall be controlled by a valve. The connection to the conservator shall be made by means of a pipe of not less than 25mm inside diameter so that any gas leaving the chamber shall pass through the gas and oil-actuated relay.

An earthing terminal shall be provided in each disconnecting or sealing end chamber to which the connections from the transformer winding can be earthed during cable testing.

Terminals shall be marked in a clear and permanent manner.

15.0 TEMPERATURE INDICATING DEVICES, ALARMS, GAS & OIL ACTUATED RELAYS

15.1 TEMPERATURE INDICATING DEVICES & ALARMS

An oil temperature indicating device or winding temperature indicating devices shall be supplied as specified in Schedule 'D' Part 1.

Oil temperature indicating devices shall be fitted with two sets of contacts adjustable over the range 50^{O}C. One set of contacts shall be used to initiate a D.C. operated alarm and the other to initiate tripping of the circuit breaker controlling the transformer.

Winding temperature indicating devices shall indicate the temperature of the hottest spot of the winding and shall have a load-temperature characteristics approximating to that of the main winding. They shall incorporate normally open, electrically separate sets of contacts which close at pre-determined settings, one of which shall be used to initiate a D.C. operated alarm and the other to initiate tripping of an associated circuit breaker.

For transformers having or being suitable for mixed or forced cooled ratings, whether the forced cooling is to be supplied initially or at a later date, an additional set of normally open switch contacts shall be provided to control automatically the forced cooling plant. Temperature indicating devices shall incorporate a dial and a pointer indicator and a separate pointer to register the maximum temperature reached. The capillary connected sensing bulbs of temperature indicators shall be positioned in separate oil-tight pockets arranged in the top oil.

Where winding temperature indicators are specified there shall be supplied a separate indicator for each loaded winding associated with one phase only. In the case of auto-transformers there shall be separate indicators for the series and common windings.
Calibration of the winding temperature indicators and their heating devices shall be in accordance with IEC 76.

The winding temperature indicating devices shall be so designed that it shall be possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment. The working parts of the instruments shall be made visible by the provision of out-away dials and glass fronted covers.

The characteristics of the winding temperature indicating devices shall be forwarded to the Engineer for approval prior to the delivery of the transformers and shall also be included in the operating and maintenance instruction.

All temperature indicators shall be housed in the marshalling kiosk or cabinet specified in Clause 11.1 and shall be mounted so that they will not be affected by vibration. If specified in Schedule 'D' Part 1,

A remote repeater indicator shall be provided for mounting on a control panel supplied under a separate contract.

The arrangement for bringing out the leads from the current transformer secondaries, resistance coil etc., shall conform to Standard.

15.2 GAS AND OIL ACTUATED RELAYS

Gas and oil actuated relays shall be fitted to each transformer and shall be alarm contacts which close on collection of gas or at low oil level and tripping contacts which close following an oil surge. The operational limits of the relays shall be as specified in Schedule 'D' Part 1.

The relays shall be fitted in the expansion pipe connecting the transformer tank to the conservator and a straight run of pipework shall be provided for a length of five times the internal diameter of the pipe on the tank side of the relay. The pipework shall be so arranged that all gas arising from the transformer shall pass into the relay. Sharp bends in the pipework shall be avoided.

A machined surface shall be provided on the top of each relay to facilitate setting and checking the mounting angle.

Calibration of the winding temperature indicators and their heating devices shall be in accordance with IEC 76.

The design of the relay mounting arrangement and associated pipe-work and the cooling plant shall be such that the relays will not sustain damage during transformer processing, transport, or service, or mal-operation due to vibration under service conditions.

When the transformer is provided with more than one conservator the gas and oil actuated relays shall be arranged as follows: -

a) If the conservators are connected to the transformers by a common oil expansion pipe, a single relay shall be installed in the common pipe.

b) If the conservators are piped separately to the transformer, a relay shall be installed in each pipe connection.

Each relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.

A 5mm inside diameter pipe shall be connected to the gas release of the relay and brought down to a point approximately 1500mm above ground level where it shall be terminated by a cock.

Each relay shall be provided with a window through which a scale indication can be seen in order that the quantity of gas collected within the relay housing can be determined. The scale shall be calibrated in milliliters in 100ml increments and the volume available shall not be less than 400ml. A second window incorporating the calibrated scale.

15.3 OIL FLOW INDICATORS, OIL PRESSURE GAUGES & DIFFERENTIAL PRESSURE GAUGES

Forced oil cooled transformers with no natural cooling shall be provided with a visual oil flow indicator in each outlet pipe connection from the cooler. These indicators shall

incorporate two sets of electrically separate switch contacts which close under conditions of mobile-flow, one set to initiate a D.C. operated alarm and the second set to initiate starting of the oil circulating pump of the stand by oil cooler.

16.0 MARSHALLING KIOSKS, CONTROL & INSTRUMENT WIRING AND TERMINAL BOARDS

16.1 MARSHALLING KIOSKS AND MARSHALLING CABINETS

A kiosk located adjacent to the transformer, or a cabinet mounted on the side of the transformer shall be provided with each transformer for marshalling the auxiliary cabling and control wiring, etc., and for housing ancillary apparatus.

Marshalling kiosks or cabinets shall be constructed of steel and shall be vermin proof, well ventilated, heated and weatherproof. The interior and exterior painting shall be in accordance with Clause 6 of section 2.

Marshalling kiosks or cabinets shall be divided into separate compartments for the accommodation of the following where specified:-

a. The temperature indicators, cooler control “auto-hand” change-over switch, and change-over links for the winding temperature indicators circuits.
b. The control and protection equipment for the tap changing gear, including an isolating switch in the incoming circuit capable of carrying and breaking the full load current of the motor and of being locked in the open position, and interposing relays for supervisory control equipment if required.
c. The control and protection equipment for the cooling plant, including an isolating switch in the incoming circuit capable of carrying and breaking the full load current of all cooling plant motors and of being locked in the open position.
d. The terminal board and gland plates for incoming and out-going cables except for the power supply cable for tap change and cooler motors, which shall terminate at the base of compartments in which the supply is required.

All the above except (d) shall be mounted on panels within the respective compartment.

All instruments shall be mounted in such a manner that they will not be affected by shock or vibration.

Each compartment shall be provided with an access door at the front and in the case of kiosks also at the rear.

Kiosks doors shall be of the lift-off and hinged type. Cabinet doors shall be of the lift-off type. Internal handles shall be employed for fastening the doors. Provision shall be made for locking each door.

The temperature indicators shall be so mounted that the dials are not more than 1700mm from ground level and the door(s) of the compartment shall be provided with glazed windows of adequate size, so that the indicator can be read from outside the kiosk or cabinet.

Facilities shall be provided to permit the temperature indicators to be removed from the kiosk or cabinet without the necessity of passing the capillary tubing and bulb through the various compartments. Mechanical protection shall be provided and sharp bends avoided where the capillary tubes enter the kiosk or cabinet.

Where metalclad heaters are provided they shall be controlled by a watertight ironclad rotary switch mounted externally and a 5 amperes fuse shall be provided inside the kiosk or cabinet. Ventilation louvers shall be provided and divisions between compartments shall be perforated.

Cables shall enter the kiosk in an upward direction. The gland plates shall be not less than 450mm from the ground and shall be suitable for accommodating glands, the number and size of which shall be approved by the Engineers.

A separate cable-sealing box shall be provided for each incoming cable. Each sealing box shall project at least 20mm above the gland plate to prevent any moisture draining into the

cable crutches from the gland plate and shall be easily removable without disturbing other sealing boxes fixed to the gland plate.

All three-phase relays, contactors, isolating switches and thermal devices shall be marked in accordance with the phase colour code to be approved by the Engineer.

A durable copy of the applicable wiring diagram shall be attached to the back of the door of the kiosk or cabinet.

16.2 CONTROL CONNECTIONS & INSTRUMENT WIRING

Unless otherwise approved the external cabling between the main equipment and the ancillary equipment shall consist of P.V.C. – insulated and sheathed steel wire armoured cable with P.V.C. overall.

The wiring shall enter the bottom compartment of the ancillary equipment through the gland plate in such a manner that the rear is kept clear for access.

There shall be no possibility of oil entering boxes used for terminating cables for wiring.

Cubicle connections shall be insulated with P.V.C. to B.S. 6231 of an approved grade and shall be neatly and securely fixed in such a manner that wherever practicable, wiring can be checked against diagrams without removing cleats. Cleats shall be of porcelain, non-rustable metal, or approved moulded insulating material and of the limited compression type. Plastic strapping shall be used for bunched wires. All wiring to a panel shall be taken from approved terminal boards.

Wiring shall, in general, be accommodated on the sides of the cubicle and the wires for each circuit shall be separately grouped. Back-of-panel wiring shall be arranged so that access to the connecting stems of relays and other apparatus is not impeded.

Where provision is made for addition of equipment not required initially, approved means shall be adopted for supporting and terminating wiring during the interim period.

Wires shall not be jointed or teed between terminal points. Bus wires shall be fully insulated and run separately from other wiring along the top or bottom of the cubicle. Fuses and links shall be provided to enable all circuits in a cubicle, except a lighting circuit, to be isolated from the bus wires. In the case of tripping circuits a fuse shall be provided in positive pole and a link in the negative pole.

Wherever practicable all circuits in which the voltage exceeds 126 volts shall be marked on the associated terminal boards. Except for the lighting circuit the working pressure of A.C. circuits brought into indoor relay or control cubicles shall not exceed 125 volts, unless otherwise approved.

The D.C. trip and A.C. voltage supplies and wiring to main protective gear shall be segregated from those for back-up protection and also from protective apparatus for special purposes. Each such group shall be fed through separate fuses or from the bus wires. There shall not be more than one set of supplies to the apparatus comprising each group.

It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard dead.

Where practicable, the clearance between relay stems or connecting studs shall not be less than 300mm unless otherwise approved. Resistance shall be provided with stud terminals. Set screws shall not be used.

All wiring diagrams shall show the terminal boards arranged as in service. All diagrams shall show which view is employed and shall be clearly marked with the numbers, which are shown on the ferrules of the individual cores.

A durable copy of the applicable wiring diagrams shall be attached to the back of the door of each kiosk compartment.

The spare cores of all multicore cables shall be numbered and terminated at a terminal block in the cubicle. Where cables are terminated in a junction box and the connections to a relay or control cubicle are continued in conduit an approved number of spare cores shall be taken through the conduit and terminated in the cubicle.

The screens of screened pairs of multicore cables shall be earthed at one end of the cable only. The position of the earthing connections shall be shown clearly on the diagrams.

All wires on panels and all multicore cables shall have ferrules, which bear the same number at both ends. The change of numbering shall be shown on the appropriate diagram of equipment. The same ferrule number shall not be used on wires in different circuits on the same panels.

Ferrules shall be of white insulating material and shall be provided with glossy finish to prevent the adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by damp or oil.

All wires associated with the tripping circuits shall be provided with red ferrules marked “Trip”. If required all wiring shall conform to the colour code specified in Schedule ‘D’ Part 1.

Unless otherwise approved, no insulated wire shall have less than seven strands and each strand shall be not less than 0.75mm diameter.

If single conductor is approved, annealed copper of circular cross section shall be used and the diameter of the copper shall be not less than 2mm.

When connections rated at 380 volt and above are taken through junction boxes or marshalling kiosks, they shall be adequately screened and “DANGER” notices shall be affixed to the outside of the junction boxes or terminal cubicles.

16.3 TERMINALS, TERMINAL BOARDS & FUSES

Terminal boards shall be to approval and shall be of good quality non-flammable insulating material, with comparative tracking index (C.T.I) of not less than 500. Terminal boards shall be mounted vertically at the side of the cubicles and set obliquely towards the rear door to give easy access to terminations and to enable ferrule numbers to be read without difficulty.

Unless otherwise approved, terminal boards shall be spaced not less than 100mm apart, or to provide adequate space for cable tails and spacing shall be related to the number of terminals in any one bank and the terminals shall be arranged in such a way that there is easy access to them.

All terminals boards shall have a minimum of 20% spare terminals and all spare cores in interconnection cables shall be terminated on the terminal boards. Terminal blocks of the insertion type shall incorporate captive pinching screws and have separated clamping plates with an inherent locking feature. Studs of stud type terminal boards shall be locked in the base to prevent turning and all connections shall be made on the front of the terminal board using lock nuts or approved lock washers.

Where crimped type terminations are provided, the tool used shall be of the type that ensures that the required deformation is achieved before the terminal can be removed from it. At least two sets of crimping tools must be supplied for each installation.

The method of stripping end insulation of wires or cable cores shall be such as to preclude damage to the conductor.

Terminal boards shall have pairs of terminals for incoming and outgoing wires and not more than two wires shall be connected to any one terminal. Insulating barriers shall be provided between adjacent connectors. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals.

Where terminal studs are provided all wiring shall be secured with brass nuts, phosphor bronze lock washers and plain brass washers.

No brass bolts or studs of less than 6mm size shall be used for electrical connections. Where a lesser size is necessary, stainless steel, or high tensile brass may be used down to and including size 4mm with the approval of the Engineer, provided the current-carrying capacity is adequate.

Covers of the transparent insulating material shall be provided on terminal boards and identification labels shall be provided on the fixed portion of the terminal boards. Such covers shall be sectionalized so that groups of associated terminals may be exposed without uncovering the whole board.

No live metal shall be exposed at the back of the terminal boards. Unless otherwise approved, terminal boards shall not be used as junction points for wires, which are not required in the associated cubicle.

Fuses and links shall be grouped according to their function and shall be labeled in accordance with the diagram.

It shall not be possible to make accidental contact with any current carrying part when withdrawing or replacing the fuse or link carrier.

Where fuse carriers are mounted vertically the incoming (supply) side shall be the bottom terminal.

17.0 PACKING AND SHIPPING, AND DRYING OUT

17.1 PACKING AND SHIPPING

The method of packing shall be such as to adequately protect the tank, and its contents and external fittings during transportation. The packing and shipping of all other items shall be in accordance with Clause 20 of Section 1.

When the Authority requires the transformers to be transported filled with a medium other than oil, the medium is specified in Schedule 'D' Part I, otherwise, the filling medium shall be stated by the Contractor in Schedule 'D' Part II.

Transformers to be transported in oil shall be filled to such a level as completely to cover the windings.

Transformers to be transported in gas shall be filled and maintained by the Contractor at a pressure in excess of atmospheric pressure until the gas is replaced by oil. The gas pressure in the transformer shall be recorded before dispatch. Approved means shall be provided for measuring the pressure in the tank.

Where oil for the first filling of the transformer is to be provided it shall be supplied in non-returnable drums.

The outline of the transformer when prepared for shipping shall meet the rail transport limitations as shown in Plate 1.

17.2 DRYING OUT

Transformer shall be dried out by an approved method at the Manufacturer's Works and so arranged that they may be put into service without further drying out. Should a transformer arrive on Site without positive pressure of gas in the tank, it shall be dried out on Site by an approved method and at the Contractor's expense. Clear instructions in English shall be included in the Maintenance Instructions regarding any special precautionary measures (e.g. strutting of tap changer barrier or tank cover), which must be

taken so that vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand vacuum treatment shall be provided with each transformer. The maximum vacuum, which the complete transformer, filled with oil, can safely withstand without any special precautionary measures being taken, shall also be stated in the Maintenance Instructions.

Where specified in Schedule ‘D’ Part I, oil handling equipment shall be provided and shall be of the type stated in Schedule ‘D’ Part II.

18.0 T E S T S

The following tests shall be made on each transformer and accessories in accordance with the details specified in British Standards 171 or the equivalent IEC 76 (1967).

Tests are to be carried out at the manufacturer's works (unless an alternative place of testing is specified or approved) and tests certificates supplied and approved before shipment.

i) Transformers – routine, special, type and site tests.

ii) Voltage Control Equipment – routine and type tests

iii) Cable boxes and disconnecting chambers – routine tests

iv) Bushings – routine, sample and type tests

v) Tanks and ONAN coolers – routine and type tests

vi) Cooling plant with forced oil circulation – routine and type tests.

vii) Pumps, motors, pipework, oil sampling devices and valves – Routine, Type and Site tests.

viii) Oil – Sample tests

ix) Gas and oil Actuated relays – routine and sample tests

x) Secondary wiring – routine tests

xi) Galvanising – sample tests

18.1 ROUTINE TESTS SHALL COMPRISE

(a) Measurement of winding resistance

(b) Voltage ratio measurement, check of polarity and phase relationship.

© Measurement of impedance values

(d) Measurement of no-load loss and current at principal and extreme taps.

(e) Measurement of load loss

(f) Induced overvoltage withstand test

(g) Separate source voltage withstand test

18.2 TYPE TESTS

Unless otherwise stated, type tests when called for shall be made on equipment which has previously passed its routine tests.

Type tests shall comprise: -

a) Test of temperature rise

b) Full wave impulse voltage withstand test

18.3 TESTING METHODS

At the choice of the manufacturer, anyone of the following methods may be applied: -

- Direct loading
- Back to back method
- Short circuit method

The following special test shall be made on one power transformer in each group of power transformers with the same characteristics and the same ratings of which type tests are made:

a) Impulse voltage withstand test including chopped waves

18.4 SAMPLE TESTS

The following sample tests shall be carried out on transformer bushings in accordance with IEC publication 137 (1962).

a) Hot dielectric thermal stability test

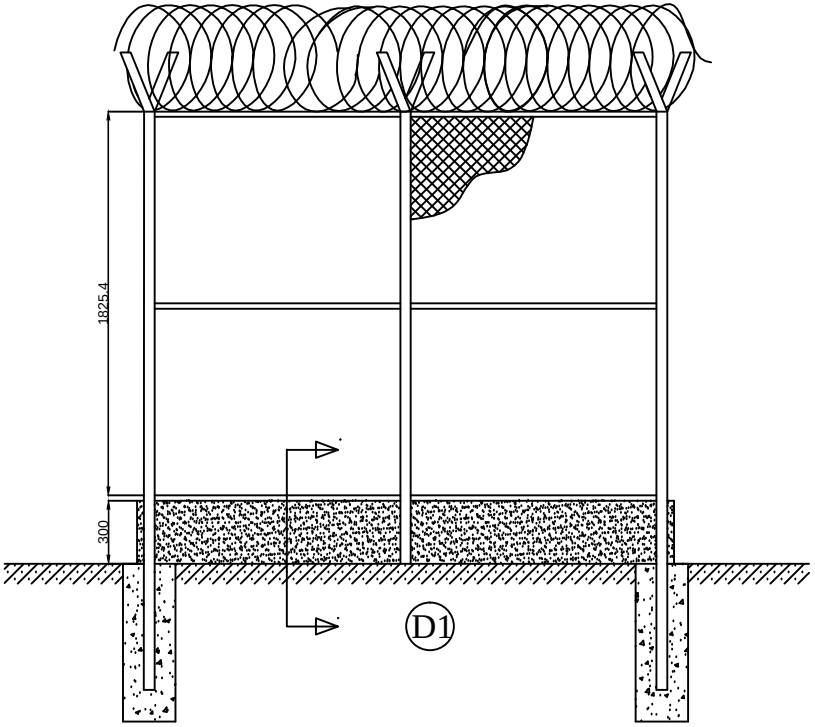
b) Efficiency of seal test

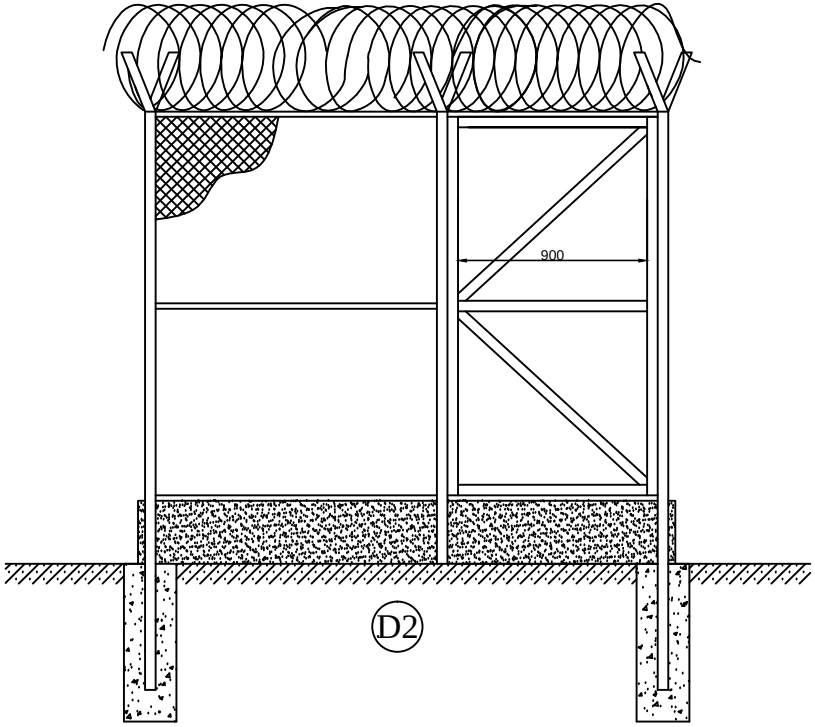
The number of samples to be taken shall be in accordance with Clause 23 of IEC Publications 137 (1962)

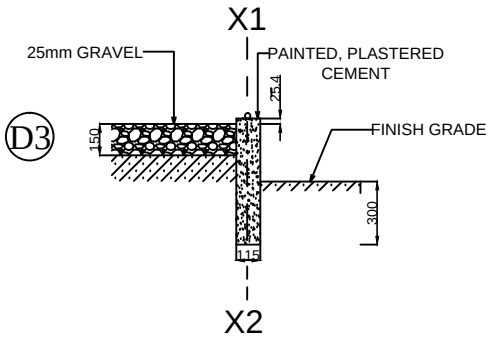
19.0 DRAWINGS

The Contractor/manufacturer is to submit with his tender general dimensioned drawings of all the essential items of the transformer (including rating plate, terminal marking plate, conservator etc) being offered together with sufficient details to enable the general arrangement of the plant to be determined. Successful Tenderer shall be required to supply six copies of detailed drawings showing the actual arrangement of the transformer tap-changer, bushing insulator, rating plates, etc. and the diagram of winding connection for each rating of transformer and each voltage ratio.

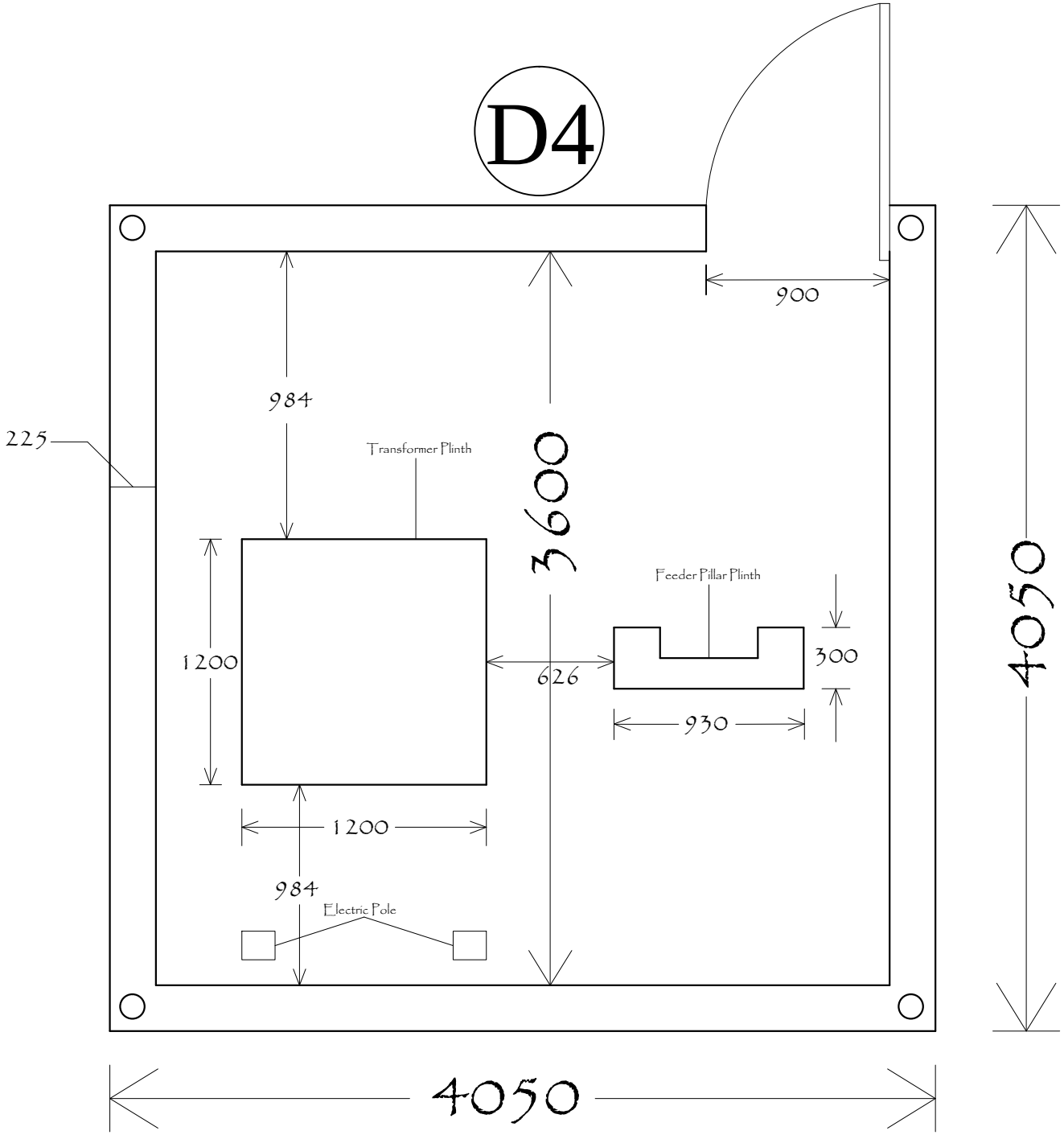
CONSTRUCTION SPECIFICATION FOR DISTRIBUTION SUBSTATION





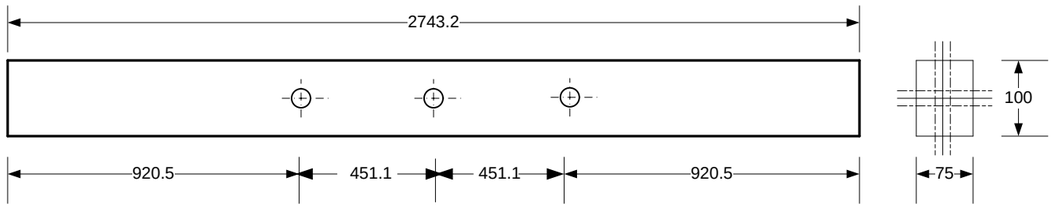


SYMBOL	DESCIPTION
D1	SIDE VIEW
D2	FRONT VIEW WITH GATE
D3	TOE WALL DETAILS
D4	FLOOR PLAN

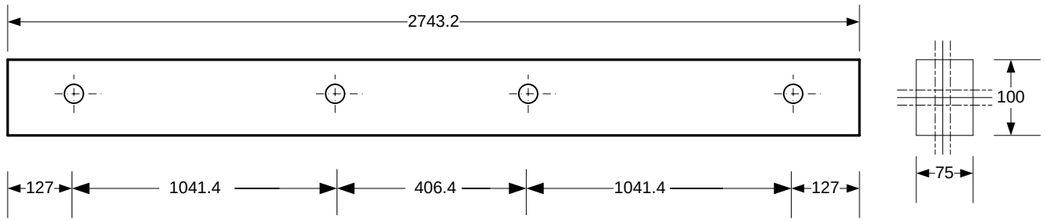

D4
900
984
225
Transformer Plinth
3600
4050
Feeder Pillar Plinth
1200
626
300
930
1200
984
Electric Pole
4050

9ft FIBER CROSS-ARM SPECIFICATION

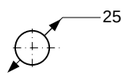
POLE SIDE



LINE SIDE



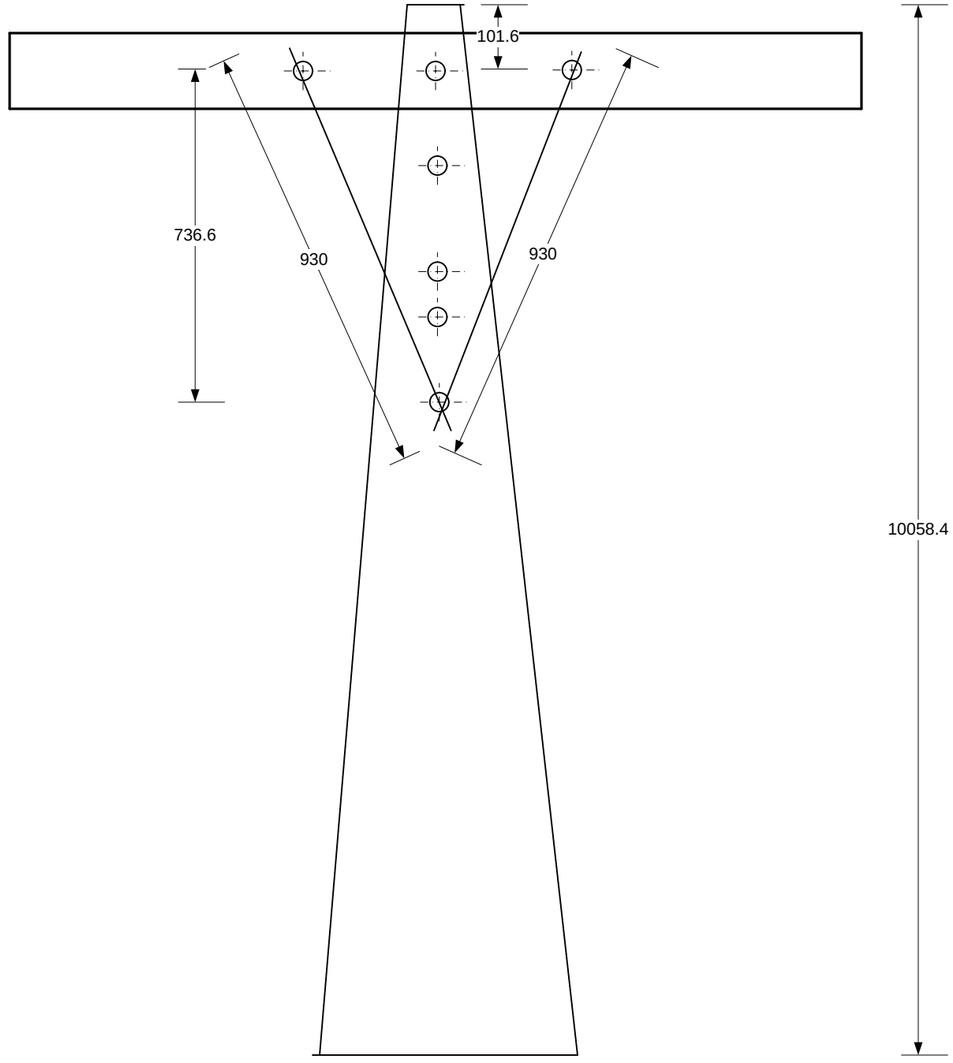
IBADAN ELECTRICITY DISTRIBUTION COMPANY PLC.



ALL HOLES = 25mm (DIAMETER)

DIMENSIONS IN mm

33kV TIE STRAP SPECIFICATION



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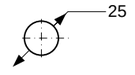
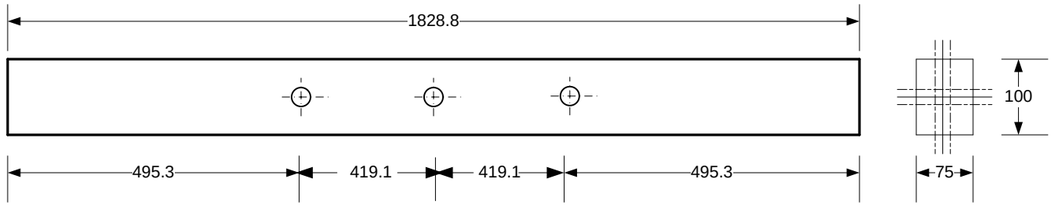


ALL HOLES = 25mm (DIAMETER)

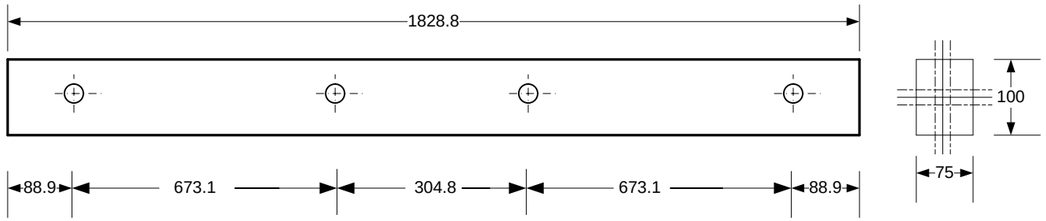
DIMENSIONS IN mm

6ft FIBER CROSS-ARM SPECIFICATION

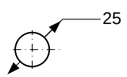
POLE SIDE



LINE SIDE



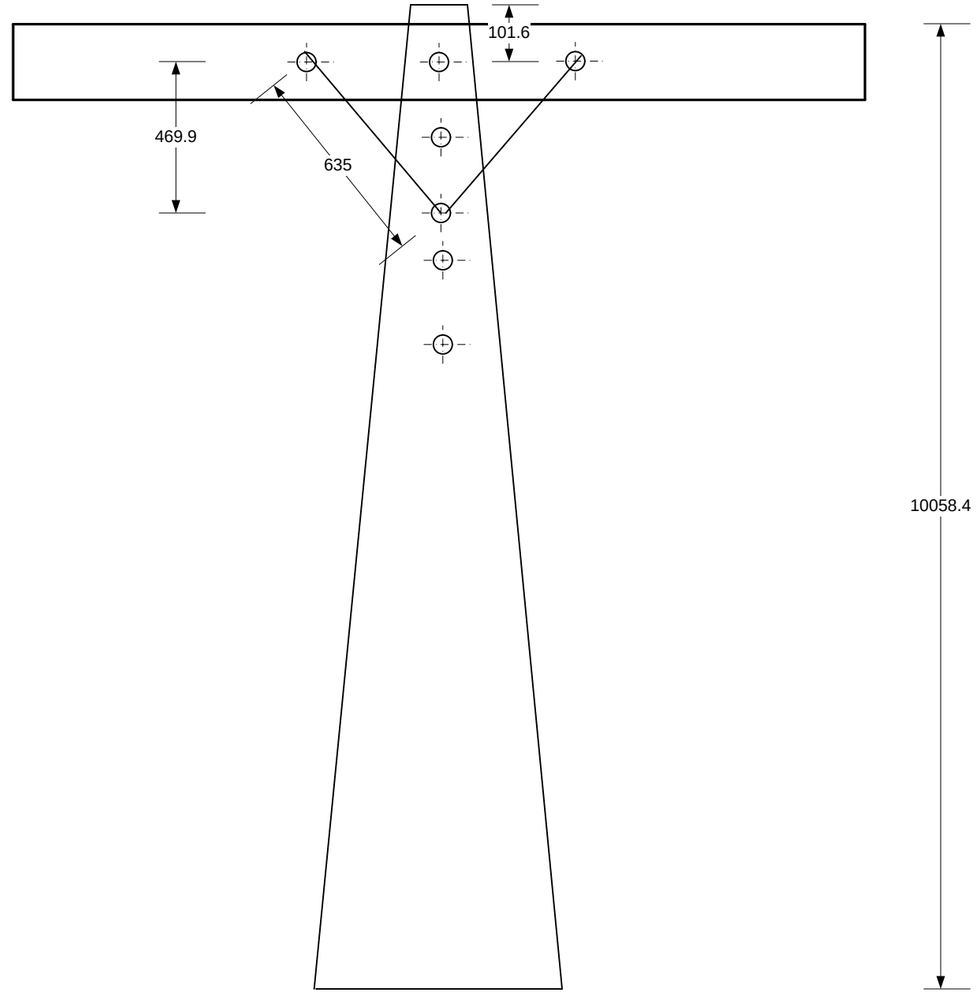
IBADAN ELECTRICITY DISTRIBUTION COMPANY PLC.



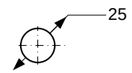
ALL HOLES = 25mm (DIAMETER)

DIMENSIONS IN mm

11kV TIE STRAP SPECIFICATION



IBADAN ELECTRICITY DISTRIBUTION COMPANY PLC.



ALL HOLES = 25mm (DIAMETER)

DIMENSIONS IN mm

TECHNICAL DATA & GUARANTEES

FOR

INJECTION POWER TRANSFORMERS

SPECICIAL INSTRUCTIONS

1. All schedules in this Technical Proposal must be completed. Failure to do so may lead to disqualification.

2. Clear copies of brochures of equipment manufactured by the bidder must be attached in all the four copies of the proposal.

3. The Financial offer must be submitted in a different envelope and shall contain the Bid Bond. The letter of bid submission should only indicate that the Bid Bond is enclosed in the Financial offer. On no account shall a photocopy of the Bid Bond be enclosed in the Technical offer as this will expose the value of the financial offer.

1. The manufacturer shall be fully responsible for the bid preparation and submission of all requested information. The Employer shall have the right to disqualify any submission found to be non-responsive and no inquiries shall be entertained.

MANUFACTURERS AND PLACES OF MANUFACTURE TESTING AND INSPECTION

Component Part	Manufacturer	Place of Manufacture	Place of Testing & Inspection
Main transformers complete Core plates Tanks Radiator Marshalling kiosks and/or Cabinets Bushings Porcelain for insulators Voltage control apparatus (tap changer) Tap Changer Remote Control Panel Temperature indicators Oil Oil valve Oil coolers Air Blowers Motor control gear Alarm devices Gas and oil actuated relays			

Any deviation from this schedule shall be notified as soon as possible for the Engineer's approval

SCHEDULES OF DATA AND GAURANTEES FOR POWER TRANSFORMERS

S/N	DESCRIPTION	AS SPECIFIED			PROPOSED AND GUARANTEED		
		2.5MVA	7.5MVA	15MVA	2.5MVA	7.5MVA	15MVA
1	Description of transformer	Step down	Step down	Step down			
2	Indoor or outdoor installation	Outdoor	Outdoor	Outdoor		NOT APPLICABLE	
3	Site conditions:- a) Altitude m b) Cooling medium temperature -m Air: reference ambient .. .. C^o	Less than 1000 45	Less than 1000 45	Less than 1000 45			
4	Continuous maximum ratings irrespective of tapping position when operating under site conditions:- a) H.V. terminal rating MVA b) L.V. terminal rating MVA	2.5 2.5	7.5 7.5	15 15			
5	Maximum ONAN ratings, irrespective of tapping position when operating under site conditions:- a) H.V. terminal rating MVA b) L.V. terminal rating MVA	2.5 2.5	7.5 7.5	15 15			
6	Rated frequency H_Z	50	50	50			
7	Rated voltage:- a) H.V. KV b) L.V. KV	33 11	33 11	33 11			
8	System highest voltage:- a) H.V. KV b) L.V. KV	36.3 12.1	36.3 12.1	36.3 12.1			

9	Method of system earthings: a) H.V. system b) L.V. system	Impedance Solid	Impedance Solid	Impedance Solid			
10	Method of transformer earthing a) H.V. winding b) L.V. winding	Impedance solid	Impedance solid	Impedance solid			
11	Type of cooling	ONAN	ONAN	ONAN			
12	Impedance voltage at 75^{O}C at CMR and normal and ratio on base of CMR	6	8	10			
13	Impulse withstand level (full wave 1.2/50 micro second) under site conditions a) H.V. b) L.V.	170 75	170 75	170 75			
14	Switching surge withstand level:- a) H.V. winding b) L.V. winding	140 62	140 62	140 62			
15	Phase Connections:- a) IEC vector group reference b) Whether links are required for alternative IEC vector group	Dyn1 NO	Dyn1 NO	Dyn1 NO			
16	a) Whether star connected windings (if any) shall be fully insulated or graded b) IEC category of grading	Full insulation	Full insulation	Full insulation			
17	a) Whether one winding is a stabilizing winding only b) If so, whether the winding is to be brought out to separate bushing insulator(s) or cable box terminal for test purpose (for earthing- see item 10) Whether 'on-load' or 'off-circuit' tap changing	N/A	N/A	N/A			

	equipment or links are required						
18		Off load	On load	On load			
	Approximate total range of variation of turns ratio:-						
	i. HV/LV – Increasing ratio plus %						
19	ii Decreasing ratio minus %						
	These values are calculated on the basis of the tapchanger being situated on the winding preferred in item 22.	5 7.5	5 15	5 15			
	Approximate size of steps %						
20	Excess of continuously applied voltage above 105% rated voltage of any tapping that is allowed by IEC 76 %	2.5	2.5	2.5			
21		NIL	NIL	NIL			
	Whether tappings are preferred on any particular winding						
	a) On HV winding						
22	b) On LV winding						
	c) Category of regulation						
		YES	YES	YES			
	Whether on-load tap changing equipment shall be suitable for supervisory control and indication	NO C.F.V.V	NO C.F.V.V	NO C.F.V.V			
23	Whether remote tap change control panel is required	NO	NO	NO			
	Automatic voltage control equipment						
24	a) Whether required	NO	YES	YES			
	b) Whether to be suitable for current compounding						
	c) Range of compound required %						
25							
	Whether equipment shall be provided to permit automatic synchronized operation of on-load tap equipment in parallel with similar transformers	NO N/A N/A	YES YES 10	YES YES 10			
	Bushing insulators or cable boxes or sealing end						
26	chambers for line terminals:-	NO	YES	YES			
	a) H.V.						
	b) L.V.						

	c) Filling medium for cable boxes						
27	Whether disconnecting chambers are required	Bushing Cable Air	Bushing Cable Air	Bushing Cable Air			
28	Bushing insulator or cable box for neutral terminals if any a) H.V. b) L.V. c) Filling medium for cable boxes	No	No	No			
29	*These values are calculated on the basis of the tapchanger being situated on the winding preferred in Item 22.	N/A Cable box Air	N/A Cable box Air	N/A Cable box Air			
30	Whether accommodation for current transformers shall be provided on a) H.V. Terminals b) L.V. Bushings Whether tapping shall be brought out from each condenser type bushing insulator to a separate/area for power factor testing on site, on:- a) H.V. Bushings b) L.V. Bushings	 No No	 Yes Yes	 Yes Yes			
31	Whether pressure release device is to be fitted						
	Whether first filling oil shall be supplied for the transformer and its associated oil-filled equipment	N/A N/A	N/A N/A	N/A N/A			
32	Whether transformer shall be transported filled with oil or with a suitable gas	Yes	Yes	Yes			
33	Whether marshalling unit shall be provided, if so a) Whether kiosk or cabinet b) Whether metal clad heater to be provided	Yes	Yes	Yes			
34		Gas/Oil	Gas/Oil	Gas/Oil			

	Type of breather a) Silica gel						
35	b) Automatic of the repetitive cycle type	Kiosk	Kiosk	Kiosk			
		Yes	Yes	Yes			
36	Whether wheels are required						
	If so	Yes	Yes	Yes			
	a) Whether plain of flanged	No	No	No			
	b) Whether required to turn through 90^{O}						
	c) Gauge of track						
37	Whether oil or winding temperature indicators are required	No	No	No			
	Whether winding temperature indicator remote repeaters are required						
38	Whether the forced cooling equipment is to be operated automatically from contacts on the winding temperature	Yes	Yes	Yes			
39	indicator	No	No	No			
	Whether electrical energy will be provided on site for						
40	erection a) If so b) Maximum available power	No	No	No			
41	Supply voltage for transformer auxiliaries						
	Whether control and instrument wiring shall conform to specified colour code	Yes tobe discussed	Yes tobe discussed	Yes tobe discussed			
	Impulse type tests	415V, 3-phase	415V, 3-phase				
42	a) Whether RSO tests are to be carried out			415V, 3-phase			
	b) i. Whether H.V. winding to be directly impulse	Yes	Yes				
43	tested ii. Whether chopped waves to be included			Yes			

44	c) i Whether L.V. winding to be directly impulse tested	No	No				
	ii. Whether chopped waves to be included	Yes	Yes	No			
				Yes			
		Yes	Yes				
	Fault MVA:-						
	a) System fault level available at H.V. terminals with L.V. windings open circulated.			Yes			
	b) System fault level available at L.V. terminals with H.V. winding open circuited but energized						
		1500MVA	1500MVA				
45	Losses:-						
	For the purposes of comparing tenders, the transformer capitalized cost indicated in the specifications shall be adopted.	500MVA	500MVA	1500MVA			
				500MVA			
46	Capitalised costs of each transformer shall be entered in the schedule of particulars and guarantee.						
	C.T.'s on Transformer Bushings						
	Burden (VA)						
	Class						
	C.T Ratio						
	Losses:	N/A	30				
	No Load (kW) max.	N/A	CL 1.0, 5P20				
47	Load (kW) max.	N/A	4X300/1/1/1A	30			
				Cl 1.0, 5P20			
				4x300/1/1/1A			
		3.8	9.4				
48		29.4	54				
				16			
				89			

SCHEDULE - CONTROL, OPERATION, INDICATION AND ALARM CIRCUITS FOR 7.5/15MVA POWER TRANSFORMERS

S/N	DEVICE	FUNCTION	OPERATING SUPPLY VOLTAGE	IF REQUIRED	PROPOSED
1	Gas and/or oil actuated relay	a) Alarm b) Trip	110 V.D.C. 110 V.D.C.	Yes “	
2	Winding Temperature indicator	a) Alarm b) Trip	110 V.D.C. 110 V.D.C.	Yes “	
3	Winding temperature indicator remote repeater	Indication	-	No	
4	Oil temperature	a) Alarm b) Trip	110 VDC 110 VDC	Yes “	
5	Tap Changing equipment	a) Control b) Indication	240 VAC 110 VDC	Yes “	
6	Remote electrical indicator to show if units of a group of transformers are in parallel on different tappings	a) Indication b) Alarm	110 VDC 110 VDC	Yes “	
7	Transformer “tapchange in progress “ remote electrical indication	a) Indication b) Alarm	110 VDC 110 VDC	Yes “	
8					

	Transformer 'voltage ratio' remote electrical indication	Indication	110 VDC	Yes	

SCHEDULE – BUSHINGS

S/N	DETAILS	PRIMARY	SECONDARY
1	Rated service voltage kV	33	11
2	Maximum system voltage …. KV	36.3	12.1
3	Site altitude for which bushings are to be suitable where this exceeds 1,000m ….	Below 1000m	
4	Whether to be designed for:- a) Normally polluted atmosphere (creepage of 17mmm per KV)		
	b) Moderately polluted atmosphere	Yes	Yes
	c) Heavily polluted atmosphere (creepage of 25mm per (See B.S. 223) KV		
5	Arcing Horns or rings:- a) Whether required b) Minimum gap setting mm	 Yes 140	 N/A N/A
6	Switching surge withstand level KV	140	N/A

7	Impulse withstand level (full wave 1.2/50 micro sec.)	170	75
8	Maximum symmetrical fault current KA	-	-

SCHEDULE – POWER TRANSFORMERS (CONT.)

(5) MINIMUM CLEARANCE IN AIR FOR TRANSFORMERS

The clearance to earth shall be adequate for the impulse level and where applicable, the switching surge withstand level specified in Schedule'D'Part1 (1)

The clearance between phases shall be 15 per cent greater than the clearance to earth, or to suit the spacing of the phase isolated busbars, whichever is the greater.

The minimum clearance between live metal and oil pipe work, including whichever is the conservator and oil pressure relief device shall be as stated in the table below. The safety clearances to conductor (section clearance) and to insulation (Ground Clearance) shall also be as stated below:-

Rated Service Voltage	KV	33	11
Live metal to oil pipe work clearance	m.	0.48	-
Section clearance	m.	2.9	-
Ground clearance	m.	2.5	2.5

NOTES: 1. For every 100m of altitude in excess of 1000m above Sea level, the above clearance shall be increased by 1.25%

2. Due regard must be paid to the risks from vermin.

GAS AND OIL ACTUATED RELAYS

The surge float contacts shall close at a rate of steady oil flow between the following limits. As far as possible the limits shall also be met when the relay is subjected to oil surge conditions produced by rapid opening of a lever operated gate valve.

Oil Pipe Connection Internal Diameter	Operational limits for relay rising angles of 1^{O} to 9^{O}
Mm	Steady oil flow (Millimetres/second)
25	700-1300
50	750-1400
75	900- 1600

The gas collection contacts shall operate within the angle test limits detailed in Schedule 'F'

MINIMUM THICKNESS OF TANK BASE PLATE

Length of tank base (mm)	Minimum Thickness (mm)	
	Mild Steel	Aluminium
With Flat base		
Not exceeding 1250	10	-
Exceeding1250 not		

exceeding 2500	12.5	-
Exceeding2500 not exceeding 5000	20	26
Exceeding 5000	To approval	To approval
With fabricated under-base		
Not exceeding 2500	10	-
Exceeding 2500	12.5	12.5

SCHEDULE OF CAPITALISED COST, PRICE AND DELIVERY **SCHEDULE - 'E'**

Capitalised Cost =N(CIF Cost) + $\frac{(30 \times kW\ Loss) + (10\ X\ kW\ Copper\ Loss)}{0.12}$

Description		Unit Cost F.O.B (Naira)	Unit Cost C & F (A) (Naira)	Iron Loss Cost (B) 30xkW Pfe (Naira)	Copper Loss © 10xkW pcu (Naira)	Capitalised Cost A* (B C) / 0.12 (Naira)	Total Price (Naira)
MVA Rating	Voltage Ratio						
2.5	33/11 Kv						
7.5	33/11 kV						
15	33/11 kV						

Date……