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REPLACEMENT OF DE AAR WEST TRANSFORMER

ANNEXURE C – SCOPE OF WORK

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(a) BACKGROUND

De Aar West is supplied with 6.6 kV from the De Aar Main Substation by two 10 MVA 22/6.6 kV power transformers which were manufactured in 1959. The 22 kV isolators, breakers, CTs and VT are all open air and mounted on metal platforms. The 6.6 kV is taken to an overhead structure before being routed to the 6.6 kV incomer panels within the substation via underground cables. All cabling on site is done in underground cable ducts covered with concrete slabs.

The transformers are each fitted with a Ferranti tap changer on the 22 kV side working on a master-follower control system. Each tap changer has its own control panel on the inside of the substation building equipped with its indication and relays. Each 22 kV breaker has its own control panel on the inside of the substation which is equipped with its indication and relays.

Transformer 1 has failed due to internal core problems and has been taken out of service. The remaining transformer is leaking oil and is considered a huge risk.

Refer to Annexure D for pictures of the existing equipment.

(b) EXTENT OF THE WORKS

This specification provides for the design, manufacture, testing and handing over to the Employer in a satisfactory operating condition of the complete contract as set-out in the specifications, schedules drawing and summaries as follows:

- a) The design and manufacture of two 10MVA power transformers complete with on-load tap changers and control panels that caters for two on load tap changers and the associated control and protection equipment. Control method to change to circulating current.
- b) Factory Acceptance Testing.
- c) Packaging of the complete units for transport.
- d) Removal of the existing transformers from the substation (including handling of all oil and associated actions).
- e) Delivery to site and installation of the new transformers, control panels and metering panel with all associated work such as cabling, 22 kV busbars modification and connection, 6.6 kV busbar modification and connecting.
- f) Commissioning of the new transformers and tap changers with all needed tests.
- g) Servicing of the 22 kV isolator and busbars.
- h) Supply, installation and commissioning of new 22 kV circuit breakers, CTs and VTs.
- i) Complete service and replacement of oil of the 6.6 kV panels. Relays and protection working to be tested and certified.
- j) Servicing of other equipment in the yard and substation building.
- k) Testing and calibration of individual and integrated (22 kV & 6.6 kV) protection systems – Transformer, tap changer, incomer and feeder panels.
- l) The preparation of a detailed O&M manual as prescribed.
- m) Training of the municipal personnel.

The contractor including all his specialized sub-contractors (when applicable) shall comply fully to all requirements as set-out in the contract and related documentation.

(c) PROGRAMME AND MANAGEMENT

It shall be noted that the programme shall be so arranged that progress can be tracked on a monthly cycle by indicating planned and actual. Refer to more detail on this under the detail specification.

ANN C.1 GENERAL SPECIFICATIONS

INDEX

<i>NO</i>	<i>DESCRIPTION</i>
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C.1 .1	DESIGN AND STANDARDISATION
C.1 .2	BOLTS AND NUTS
C.1 .3	GALVANISING
C.1 .4	ALUMINIUM AND ALUMINIUM ALLOYS
C.1 .5	LABELS AND PLATES
C.1 .6	CLEANING AND PAINTING
C.1 .7	OIL AND INSULATING COMPOUND
C.1 .8	SULPHUR HEXAFLUORIDE GAS (SF 6)
C.1 .9	EARTHING AND ANCHILLARY EQUIPMENT
C.1 .10	LUBRICATION
C.1 .11	MOTORS
C.1 .12	MOTOR CONTROL GEAR
C.1 .13	DEGREES OF PROTECTION
C.1 .14	MAINS SUPPLY CONNECTION
C.1 .15	GASKETS AND PACKING
C.1 .16	FUSES AND LINKS
C.1 .17	MINIATURE CIRCUIT BREAKERS
C.1 .18	CURRENT RATING AND TEMPERATURE LIMITATIONS
C.1 .19	CORONA DISCHARGE AND RADIO INTERFERENCE
C.1 .20	GUARD RINGS AND ARCHING HORNS
C.1 .21	BI-METALLIC CONNECTORS
C.1.22	INSTRUMENTATION TRANSFORMERS (CT'S AND VT'S)
C.1.23	CABLES AND ACCESSORIES
C.1.24	NEUTRAL EARTH RESISTORS
C.1.25	POWER TRANSFORMERS
C.1.26	APPLICABLE STANDARDS

ANN C.1 GENERAL TECHNICAL SPECIFICATION

C.1.1 DESIGN AND STANDARDISATION

The Contract 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 in all atmospheric conditions prevailing at the Site and under such sudden variation of load and voltage as may be met with under working conditions on the system, including those due to faulty synchronising and short circuit.

The design shall incorporate all reasonable precautions and provision of the safety of those concerned in the operation and maintenance of the Contract Works and of associated works supplied under other contracts.

All outdoor and apparatus and fittings shall be designed so that water cannot collect at any point.

All water and oil pipe flanges shall be to BS 4504 as regards both dimensions and drilling, 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.

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

All apparatus shall be designed to obviate the risk of accidental short circuit due to animals, birds, insects, mites, rodents or micro-organisms.

Corresponding parts shall be interchangeable. Where required by the Engineer the Contractor shall demonstrate this quality.

Terminal boxes, cubicles, panels and mechanism boxes shall be complete with all necessary gland plates, approved cable glands and vermin proofing, whether specified in detail or not.

C.1.2 BOLTS AND NUTS

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

Except for small wiring current carrying terminal bolts or studs, for mechanical reasons, shall not be less than 6 mm in diameter. All nuts and pins shall be adequately locked.

Wherever possible bolts shall be fitted in such a manner that in the event of failure of 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 treated to prevent corrosion of the threads and electrolytic action between dissimilar metal.

Where bolts are used on external horizontal surfaces where water can collect, methods of preventing the ingress of moisture to the thread 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 stems. 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 plane between members.

Taper washers shall be provided where necessary.

C.1.3 GALVANISING

All galvanising shall be applied by the hot dip process and shall comply with the requirements of SABS 763 or SABS 935 as applicable.

Galvanising of wires shall be applied by the hot dip process and shall meet the requirements of BS 443.

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

The threads of all galvanised bolts and screwed rods shall be cleared of spelter by spinning or brushing. A die shall not be used for cleaning the threads unless specially approved by the Engineer. All nuts shall be galvanised with the exception of the threads which shall be oiled.

Surfaces which are in contact with oil shall not be galvanised or cadmium plated.

Partial immersion of the work will not be permitted and the galvanising tank must therefore be sufficiently large to permit galvanising to be carried out by one immersion.

C.1.4 ALUMINIUM AND ALUMINIUM ALLOYS

Aluminium alloy castings shall be sound and free from porosity.

C.1.5 LABELS AND PLATES

All apparatus shall be clearly labelled indicating, where necessary, its purpose and service positions.

Warning labels shall be provided at all points where no operation interlocking is provided or when operation is possible which could damage equipment or endanger operating and maintenance personnel.

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 and the dimensions, legend, and method of printing shall be to approval. Inscriptions shall be consistent with the Council's established practices.

The surface of indoor labels shall have a matt or satin finish to avoid dazzle from reflected light. The inscriptions shall comply with the minimum requirements given in the Schedules.

Indoor labels shall preferably be made from engraved three layer sandwich board. Painting of labels will not be permitted except on control/indication mimics and for identifying individual gas compartments on switchgear.

The colours to be used shall be as specified in the Schedules. They shall be permanent and free from fading.

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

Unless separately itemised in the Schedules, all labels will be deemed to be included in the prices of the associated equipment in the Schedules.

C.1.6 CLEANING AND PAINTING

All metal parts shall be painted or coated except where galvanised or of non-corrodible material.

The painting or coating system adopted and surface preparation process shall be suitable for:

- a) Application on the base material, with due consideration to any previous treatment or surface process carried out.
- b) The atmospheric conditions at the place of manufacture and site and to which the equipment may be subject during transport to site.
- c) The purpose for and position in which the item will be used in service.
- d) Readily making good any damage after delivery and erection.

All paints, coatings and process to be used shall be in accordance with the paint manufacturers' specifications. These shall be approved by the Engineer.

The dry film thickness of all painting and coating systems shall be approved by the Engineer.

The colours of the finished surfaces shall preferably be as specified in the Schedules. The colours to be supplied shall be approved by the Engineer.

After erection at Site, surfaces shall be thoroughly examined and any damage made good to the original full specification. The methods of making good shall be specified by the paint manufacturer.

Any nuts, bolts, washers, etc., which have been removed during site erection, or which may be required to be removed for maintenance purposes shall be restored to their original condition.

All paintwork shall be left clean and perfect on completion of the Works.

C.1.7 OIL AND INSULATING COMPOUND

Sufficient oil shall be supplied for the first filling of all oil portions of the equipment. The oil shall comply with the requirements of SABS 555 or IEC 296 and shall be suitable in all respects for use in the equipment when operated under the conditions laid down in this Specification. Oils shall be PCB free and with a dielectric strength of 80kV.

The size of the breathers shall be determined by the volume of oil in the transformer. They shall also be easily accessible from ground level.

Insulating compound shall comply with the requirements of BS 1858.
Resin insulation shall comply with the requirements of IEC 455.

C.1.8 SULPHUR HEXAFLUORIDE GAS (SF 6)

The SF 6 gas shall comply with the requirements of IEC 376, and sufficient quantity shall be provided to fill all SF 6 equipment supplied under this Contract plus an additional 10 %.

The high pressure cylinders in which the SF 6 gas is shipped to, and stored on site, shall comply with the requirements of local regulations and bylaws.

C.1.9 EARTHING AND ANCILLARY EQUIPMENT

All metal parts, other than those forming part of any electrical circuit, shall be connected to the main earth system by means of a hard drawn high conductivity copper earth bar with a cross section area such that the current density is not greater than 200 A/mm² for a one second fault durations and 100 A/mm² for 3 second fault durations with a minimum of 30 mm².

C.1.10 LUBRICATION

Bearings which require lubrication either with oil or grease shall be fitted with nipples complying with BS 1486 Table 1. Where necessary for accessibility, adaptors or bushings shall be provided.

C.1.11 MOTORS

All motors shall comply with or IEC 34 and dimensions with IEC 72. They 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 Hz together with any voltage between $\pm 5\%$ of the nominal value.

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.

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

The temperature rise of motors at rated output shall not exceed the allowable rise for the type of insulation used under worst case conditions. A safety margin on temperature rise is preferred e.g. Class B rise at rated output with Class F insulation.

All motors shall be suitable for direct starting at full voltage. Motors shall be sealed ball or roller bearings.

The three line connections of AC motors shall be brought out to a terminal box. The terminal arrangement shall be suitable for the reception of copper cable. Terminal markings shall be made in a clear and permanent manner and shall comply with or IEC 34. A permanently attached diagram or instruction sheet shall be provided giving the connections for the required direction of rotation. All joints shall be flanged with gaskets of neoprene or other approved material. Natural rubber insulation shall not be used.

Where single phase motors are employed the motors shall be grouped so as to form, approximately, a balanced three phase load.

C.1.12 MOTOR CONTROL GEAR

Control gear shall comply with the requirements of IEC 292, the control gear being rated according to the duty imposed by the particular application.

Motor contactors shall comply with IEC 158 class of intermittent duty 0 -3 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.

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

Where small motors are connect 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.

Each motor or group of motors shall be provided with control gear for starting and stopping by hand and automatically. Overload and single-phasing protection shall be provided.

C.1.13 DEGREES OF PROTECTION

The following degrees of protection shall be provided in accordance with IEC 144 and IEC 529. For outdoor applications, IP 55.

For indoor applications where purpose built accommodation is provided, e.g. switch and control and relays rooms IP 41. Where dust can adversely affect equipment housed with a degree of protection of IP 50.

C.1.14 MAINS SUPPLY CONNECTION

All incoming supplies of greater than 125 V to earth shall have their terminations shrouded by a suitable insulating material.

C.1.15 GASKETS AND PACKINGS

All packing and gaskets must be clean cork and rubber free. Type TE Z1 or Cork Rite grade or the equivalent.

C.1.16 FUSES AND LINKS

Carriers and bases for fuses and links shall be in accordance with IEC 269 and colour coded to permit identification of the circuit rating.

The fuses and links mounted in cubicles for tripping circuits and protective gear test links shall be mounted on the front of the panel. Other links and fuses shall be accommodated within the cubicle or above the cubicle doors. Fuses and links shall be grouped and spaced according to their function in order to facilitate identification.

All incoming circuits in which the voltage exceeds 125 volts shall be fed through insulated fuses and/or links, the supplies being connected to the bottom terminal. The contacts of the fixed portion of the fuse or link shall be shrouded so that accidental contact with live metal cannot be made when the moving portion is withdrawn.

Main supply fuse links shall be of the high rupturing capacity cartridge type.

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

Where either fuses or circuit breakers are used it should be ensured that proper discrimination between main and sub-circuits is maintained.

C.1.17 MINIATURE OR MOULDED CASE CIRCUIT BREAKERS

Miniature or moulded case circuit breakers shall be designed and tested in accordance with IEC 157 and supplementary requirements of this specification. They shall be suitable for use over the full range of expected voltage variation as specified in the Detail Technical Specification.

They shall be suitably rated for both the continuous and short circuit loadings of the circuits they are protecting under all service and atmospheric conditions stated in the specification and ensure that correct discrimination is maintained between main and sub-circuits.

For three phase circuits, the miniature circuit breaker shall be of the three pole type; for single phase circuits they shall be of the single pole type and for dc circuits they shall be of the double pole type.

Where miniature circuit breakers are used in circuits containing inductive loads e.g. operating coils, they shall be suitable for satisfactory operation in the circuit in which they are used.

Miniature circuit breakers shall be mounted in such a manner so as to give easily visible indication of breaker position and shall be grouped and spaced according to their function in order to facilitate identification and easy replacement.

C.1.18 CURRENT RATING AND TEMPERATURE LIMITATIONS

Every current carrying part of the equipment including isolating equipment and connections, shall be capable of carrying under the atmospheric conditions existing at Site, its specified rated current continuously and in no part shall the temperature rise exceed the values specified in BS 115, BS 169 or other relevant Standards.

C.1.19 CORONA DISCHARGE AND RADIO INTERFERENCE

All equipment shall be designed so as to minimise electrical discharges and interferences with radio and TV receiving equipment. Tests shall be carried out as specified in the Schedules.

C.1.20 GUARD RINGS AND ARCHING HORNS

Guard rings or arcing horns or rings of approved types, size and material shall be attached in an approved manner to all suspension and tension insulator sets. The design of the arcing horns or rings shall be such as to reduce, as far as reasonably possible, cascading and damage to the conductors, clamps, insulator units, and to other fittings under all flash-over conditions. The guard rings or arcing horns shall be of substantial design.

C.1.21 BI-METALLIC CONNECTORS

Bi-metallic connectors or clamps shall be of approved aluminium-to-copper type in which the aluminium fitting shall be of the compression type and the copper fitting shall be of the bolted type, unless otherwise approved. Exposed contact between copper and aluminium shall be prevented by watertight insulating washers.

C.1.22 INSTRUMENTATION TRANSFORMERS (CT'S AND VT'S)

C.1.22.1 CURRENT TRANSFORMERS

- a) Current transformers shall comply in all respects with BS 3938: 1973, and the P1 terminal shall be towards the circuit breaker.
- b) Each current transformer shall have an output which is adequate for the working current of the associated protection devices and instruments over the required range of load and fault duties as per protection function diagram.
- c) Each current transformer secondary winding circuit shall be earthed at only one point. Earthing of a current transformer winding circuit shall be via a link which shall be mounted in the associated protection or instrument cubicle. Wherever possible the connection to earth shall be to the S2 terminals.
- d) When multi-ratio transformer windings are specified, the requirements shall be met by the use of sectioned secondary windings.
- e) Current transformers secondary circuits for bus bar one protection and for tariff metering duties shall be routed via suitable test blocks in easily accessible locations. Test blocks shall also be provided in current transformer secondary circuits associated with general protection and indication.

C.1.23 CABLES AND ACCESSORIES

C.1.23.1 DESIGN

Technical data affecting the design of the cables is given in the Schedules. The equipment shall further be designed to meet the tests specified in the Schedules.

The Contractor shall specify particulars and guaranteed performance of the cables offered in the Schedules. Unless approved by the Engineers, changes in make-ups or minus tolerances in material thickness will not be permitted.

C.1.23.2 CONDUCTORS

The conductor shall be composed of plain annealed copper or aluminium wires as stated in the Schedules, which before shaping shall be smooth, uniform in quality, free from scale, inequalities, spills, splits and other defects.

The conductor properties shall comply with the requirements of IEC 28 in case of copper and with IEC 111 in case of aluminium.

C.1.23.3 FILLERS AND BEDDING OF SOLID INSULATION CABLES

The type and application of fillers shall be such as to facilitate the flow of heat away from the cores.

Bedding shall consist of a continuous impermeable extruded layer of polyvinyl chloride (PVC), closely fitting the equalizing binder. The bedding shall be treated so as to make it fire retardant.

C.1.23.4 ARMOURING

Single core cables shall be arranged with one layer of tinned hard-drawn copper wires to provide a degree of mechanical cable protection. Armouring of pressurised cables shall withstand radial forces due to static internal pressure, changes in internal pressure due to load cycles and axial forces due to installation methods.

Armouring in conjunction with other metal sheathing (if any) shall provide an earth continuity path of the quality required by the Specification. The Tenderer shall submit proposals for bonding and earthing the armouring of the cable installation.

Where joints in the armouring are necessary they shall be brazed or welded and any surface irregularities shall be removed. A joint in any wire shall be not less than 2 m from the nearest joint in any other reinforcement wire in the completed cable. Armouring shall be laid on helically to an approved lay.

Means shall, however, be provided to establish electrical contact between the sheath of paper insulated cables and the armouring.

The lay of armouring shall be such that no buckling or over-riding of wires takes place when the completed cable is wound in coils or on to drums of an approved diameter or the cable is bent round the approved minimum bending radius specified in the Schedules.

C.1.23.5 OUTER COVERING

The outer covering of the cable shall consist of a continuous, impermeable extruded layer of PVC, closely fitting the underlying armour wires or the equalising binder, and shall be of an approved flame retardant type.

The PVC shall comply with the requirements of the relevant sections of BS 6746. The completed covering shall comply with the voltage withstand test specified and shall be treated to enable the test to be carried out before backfilling.

Means shall be provided to prevent adhesion between turns and layers of the cable in coils or on the drum and between the cable and the drum or container at such temperatures as may be met with during transit to the Site, on Site before laying or in storage.

The design and efficiency of the coverings shall not be affected by the cleating or clamping arrangements supporting the cable.

C.1.23.6 CUBICLE WIRING

Cubicle connections shall be insulated with PVC to SABS 150-1970 or IEC 228. Wires shall not be jointed or teed between terminal points. Bus wires shall be fully insulated and run separately from one another, 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.

The DC trip and AC 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 from the bus wires. There shall not be more than one set of supplies to the apparatus comprising each group. All wires associated with the tripping circuits shall be provided with red ferrules marked "Trip".

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

All small wiring and multi core cables shall be fitted with interlocking numbered ferrules in accordance with the circuit diagram. Double ferrules shall be installed where necessary when connecting up equipment of different suppliers.

All conductor ends shall be terminated with pre-insulated crimped lugs of the proper type and size for the terminals in use. Only the correct crimping tool and dies shall be used strictly in accordance with the manufacturer's instructions.

Cable tails shall be neatly laced in a cable form, each core branching off to its appropriate terminal.

Identification ferrules shall be of insulating material with a glossy finish to prevent the adhesion of dirt and shall not be affected by damp or oil.

Ferrules shall be engraved black on a white background. For tripping circuits an additional ferrule with a letter T engraved black on a red background shall be provided.

Insulated stranded wire shall not have less than seven strands and each strand shall not be less than 0,67 mm diameter. If single conductor is used it shall be annealed copper of circular cross sectional area of not less than 2,5 mm².

When connections rated at 400 volt and above are taken through junction boxes they shall be adequately screened and "DANGER" notices shall be affixed to the outsides of junction boxes or marshalling kiosks.

Where connections to other equipment and tele-control equipment are required the connections shall be grouped together.

The colour code for cubicle wiring is specified in the Schedules.

C.1.23.7 MULTI CORE CABLES AND CONDUIT WIRING

The external cabling between the main equipment and the ancillary equipment shall form part of the Contract Works and shall consist of PVC insulated and sheathed steel wire armoured cable with PVC overall, to IEC 228 or SABS 150.

Where conduit is used the runs shall be laid with suitable falls and the lowest parts of the run shall be external to the equipment. All conduit runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.

Multi core cable tails shall be so bound that each wire may be traced without difficulty to its cable. The spare cores of all multi core 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, a number of spare cores shall be taken through the conduit and terminated in a cubicle.

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

All wires on panels and all multi core cables shall have ferrules which bear the same number at both ends. At those points of interconnection between the wiring carried out by separate contractors where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment. The same ferrule number shall to be used on wires in different circuits on the same panels.

Where cables are laid to equipment provided on other contracts the contractor will be responsible for leaving sufficient lengths of tails at each end of the multi core cables to connect up to the terminal boards.

He shall strip, insulate, ring through and tag the tails, and seal the cable boxes. The other Contractors shall be responsible for re-checking the individual cores and for the final connecting up and fitting of numbered ferrules.

C.1.23.8 TERMINAL BOARDS AND TERMINAL BLOCKS

Terminal boards shall be of good quality non-flammable insulating materials, with a comparative tracking index (CTI) of not less than 500, to IEC 112. Thermoplastic terminal insulation material will not be acceptable.

Rows of terminals shall be spaced not less than 100 mm apart. For relay and control panels they shall be mounted at the sides of the cubicle, and set obliquely towards the rear doors to give easy access to terminals and to enable ferrule numbers to be read without difficulty. The bottom of the terminal boards shall be spaced at least 200 mm above the cable crutch of incoming multi core cables.

Insulating barriers shall be provided between adjacent pairs of terminals. The height of the barriers and the spacing of the terminals shall be such as to give adequate protection while allowing access to terminals.

Terminations shall be grouped according to function and on terminal blocks assembled from individual terminals, separating insulating barriers shall be inserted between groups. Labels shall be provided on the fixed portion of the terminal boards showing the function of the group.

Terminals shall be of the stud type, alternatively for up to and including 4 mm², wire size, insertion clamp type terminals of approved type may be used in relay in control panels and the like.

Terminal boards for stud type terminals shall have pairs of terminals for incoming and outgoing wires and not more than two wires shall be connected to any one terminal. All connections shall be made to the front of the terminal boards. Current shall not be carried through the board by the studs.

Covers in insulating material, preferably transparent, shall be provided on terminal boards on which connections for circuits with a voltage greater than 125 volts are terminated. No live metal shall be exposed at the back of the terminal boards.

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 lock washers. Where crimped type terminations are provided at least two sets of crimping tools must be supplied for each installation.

Terminals of the insertion clamps type shall incorporate captive pressure screws which do not bear directly on the wire but on a serrated clamping plate. The pressure screws shall have an inherent locking feature.

Where connections are to be made between the multi core cables supplied and telephone type multi core cables, then the terminal board shall comprise a stud or clamp type terminal for the multi core cable and a soldered tag for the telephone cable joined by a withdrawable insulated link. These terminals shall also be provided with facilities for the insertion of test probes on both sides of the link.

The use of terminal boards as junction points for wires which are not required in the associated cubicles shall be avoided wherever practical be.

Terminals used shall be to approval and all terminal boards shall have a minimum of 20 % spare terminals.

C.1.23.9 MARSHALLING KIOSKS AND JUNCTION BOXES

The Contractor shall provide on the site adjacent to each circuit breaker a marshalling kiosk to which all outgoing connections from the associated main equipment will be run.

All outdoor boxes and kiosks shall be protected in accordance with Class IP55 or IEC 144 and shall be termite and rodent proof.

Where specified heaters shall be provided and shall be controlled by a watertight switch mounted externally. Ventilation louvres shall be provided and divisions between compartments shall be perforated.

At least one single phase switched socket outlet with earth leakage protection shall be provided in each marshalling kiosk.

All cables shall enter boxes and kiosks at the base. The base plate shall be 3mm thick (at least) and earthed with a 6mm earth stud.

Each compartment of all kiosks and junction boxes shall be provided with access doors at the front and rear. Doors and access covers shall not be secured by nuts and bolts but shall be fastened with integral handles with provision for locking.

Doors for kiosks shall be of the lift off and hinged type and shall be provided with glazed windows of adequate size to facilitate reading of indicators from outside the kiosk. Facilities shall be provided to permit removal of the temperature indicators without the need to pass the capillary tubing and bulb through the various compartments.

Doors and covers under 15 kg mass may be of the slide on pattern but above this mass hinged doors shall be used.

If three phase connections are taken through a box or kiosk they shall be adequately screened or insulated and suitable marked with the phase colour code; a danger notice stating the voltage shall be fixed on the inside and outside of the kiosk or box.

Labels shall be provided inside each kiosk or box to describe the functions of the various items of equipment.

C.1.24 NEUTRAL EARTH RESISTOR

The neutral earth resistor will be connected directly to the 6.6 kV star point of 22 kV/6.6 kV transformers.

The resistors will be of the metal grid- or oil submersed metal element type.

Referring to the metal grid type, all the grids which form the resistor must be of a robust steel alloy and mounted on a framework. All metal parts will be protected against rust.

All the resistors will be cooled to such an extent as to eliminate overheating, especially when the specified earth fault current flows for the period mentioned.

The design of the resistors will be such that the fault current will be between 50 to 150 percent of the specified current for all periods until the maximum.

All bushings and interconnections will be such that the through-fault current may be carried for a minimum period of ten seconds in the event of an internal fault.

All sheet metal will be of a sufficient quality and gauge for the application. The necessary attachments to lift the resistor must be fitted.

Oil filled resistors will not be sealed units and oil level indicators of high quality must be fitted. If the oil is to be used as a coolant as well, air filters and temperature indicators must be fitted.

The resistors will be of the outdoor type.

C.1.25 POWER TRANSFORMER

C.1.25.1 STANDARD SPECIFICATION

The transformers shall comply with IEC60076 and with the requirements of this specification and the data submitted by tenderers on the relevant Detail Technical Specification.

C.1.25.2 TYPE OF TRANSFORMER

The transformers shall be of double wound fully insulated oil immersed core type having a no-load voltage of as specified in the detail specification. Rating shall be continuous with type ONAN cooling.

An alternative design and offer must be submitted to overload the transformers up to 25% of their full rated load capacity and will depend on factors such as building constraints, as well as the continuous load. This will probably enforce the use of forced cooling.

Windings shall be connected according to the vector group as specified in the detail specification. Means shall be provided for adjustment of the voltage ratio while under load as specified later, and all provisions of this specification shall apply irrespective of the tap position under which operation occurs.

Transformers must also be suitable to operate in parallel with each other.

C.1.25.3 TERMINAL ARRANGEMENTS

On the 22 kV side three bushings shall be provided on top of the transformer tank, suitable for the connection of copper bus bars leading from the terminals of 22 kV equipment.

On the 6.6 kV side four bushings shall be provided on top of the tank, suitable for connection to overhead copper bus bars.

All terminals shall be clearly and permanently marked according to the BS Specification quoted.

C.1.25.4 COOLING ARRANGEMENTS: TANKS AND RADIATORS

The transformers shall be fitted with built-on cooling radiators.

The tank cover shall be fitted with pockets in the positions of maximum oil temperature at C.M.R. for the fitting of thermometers and winding temperature indicator bulbs. Such pockets shall be designed to prevent the ingress of water and to allow the removal of the indicator bulbs without lowering of the oil level in the tank. Special protection shall be provided for capillary tubes.

No holes shall be drilled to bolt the cover to the tank. The main tank/cover joint shall be welded. A fire-proof gasket shall be included to prevent foreign material entering the transformer during welding or de-welding. The joint shall be designed to permit removal of the weld with minimum damage to mating flanges, and to leave them adequate for re-welding.

Prior to welding, a suitable seal shall be placed between the cover and tank and the two shall then be clamped together to form an oil tight sealed unit.

Corrugated tanks are not acceptable.

Tanks and fittings shall be of such a shape that water cannot collect at any point on the outside surfaces. It must also not be possible for gas to collect inside the tank unless such voids are connected by means of pipes to the main explosion ventilator pipe.

Guides shall be provided inside each tank to locate the core and windings centrally.

The tank base of each transformer shall be so designed that it shall be possible to move the complete transformer, filled with oil, in any direction or to jack it up without structural injury or impairment of the oil-tightness of the transformer. A design which necessitates slide rails being placed in a particular position or special detachable base, shall not be used unless specifically approved.

Suitably proportioned manhole covers shall where possible be provided in the tank cover to afford easy access to the lower ends of bushings and upper portions of the core and winding assembly.

The radiators shall be detachable with lifting eyes and shall be provided with drain plugs or valves at the lower points and vent plugs at the highest point. Isolating valves shall be provided immediately adjacent to the main tank to enable the radiators to be removed without draining the oil in the transformer tank or cooler bank.

All oil-pipe connections above 12 mm diameter, shall be flanged.

The transformer tank, radiators and complete tap-changer (including boards) shall be capable of withstanding a full vacuum (i.e. 760 mm of mercury at sea level).

The tank and cooling equipment shall be so designed that the vacuum treatment can be done on site.

Tank stiffeners shall not be installed in positions where welded seams can be covered up.

The tank and cover shall be designed so that local heating due to stray flux in any structural parts, shall not exceed the temperature limit specified for the transformer, and shall not cause temperature indication errors in the thermometer pockets.

C.1.25.5 GASKETS

All gasket joints shall be of the groove and "O"-ring type. Grooves shall be properly dimensioned and the mating surfaces machined. Gaskets shall be replaced each time a seal is broken. Where cork packing is used it must be clean cork of high quality like Cork Rite Type TE Z1 or equivalent.

C.1.25.6 OIL

Each transformer shall be supplied complete with the first filling of class B.30 Oil to BSS 148. The oil must be PCB free and indicated like that on the transformer. Oil dielectric strength must be 80kV or more.

C.1.25.7 ON-LOAD VOLTAGE CONTROL

An on-load tap changing mechanism shall be provided on each transformer with full capacity tapplings on the primary windings for adjustment of the transformation ratio in stages of 1¼ %. This tap changer must be suitable for parallel operation.

The driving motor for the mechanism shall be suitable for a 3 phase 50 cycle 400/420 volt supply and shall be complete with protection.

Electrical operation of each transformer shall be controlled from a control panel, housed indoors in an adjacent building.

The control panels must be supplied by the tenderer. The tap changer must be mounted to the side of the transformer so that maintenance can be done at ground level.

C.1.25.8 CONTROL EQUIPMENT

The on-load tap changing equipment shall be arranged for the following methods of control:

- a) Hand operation: In case of emergency, means shall be provided to enable the tap changer to be operated by hand. A Tap position indicator with associated transformation ratio plate shall be provided on the transformer. Means shall be provided to operate the tap changer electrically by hand from the tap change control panel.
- b) Fully automatic operation: Fully local automatic control shall be provided for the transformer with a variable time delay which can be set to prevent operation until the deviation in voltage has persisted for a specified period. The reference voltage shall be 110 volt 50 cycles per second, yellow phase earthed. Suitable interlocking being provided to prevent simultaneous operation by hand and automatically.
- c) Parallel operation using circulating current mechanism: The transformers will at the option of the municipality be operated as follows:
 - (i) As an individual (automatic/manual) unit;
 - (ii) Automatically in parallel with each other;
 - (iii) Controllable by means of future supervisory control system.
- d) Lamp indications and alarm relays: The following lamp indication and alarm relays shall be included in the tap change control panel.
 - (i) Indication of tap positions with associated transformation ratios;
 - (ii) Indication of tap changer supply, with alarm;
 - (iii) Indication of incompleteness of tap change or failure to operate, with alarm;
 - (iv) Indication of tap change in progress;
 - (v) Indication of out-of-step, with alarm, when operated in parallel;
 - (vi) Indication of interlocking device in operation. An interlock device shall be fitted on the tap changer to prevent operation of the tap changer driving motor when more than two steps out-of-step operation should occur.
 - (vii) Indication of the voltage (kV) on the secondary side.

A registering device shall be fitted to the tap change mechanism to indicate the number of operations completed.

The tap change mechanism shall be designed so that a tap change operation, once initiated, will be completed irrespective of the positions or the operation of control switches and relays.

No hazard shall, however, result in any part of the tap change mechanism or the transformer should a tap change operation be interrupted.

e) Additional requirements for tap-changers in connection with supervisory control

(i) To sum up, the required operation should be as follows:

From Control room:

Activate control (a) i.e Supervisory control over the group.

Activate control (c) or (d) on one transformer as circumstances require.

Activate control (b) Reset transformer group.

(ii) Indication: A normally open contact is required to indicate that the tap-changer has been override by the supervisory control. This is common for all transformers.

Tap position indication. For this purpose a rotary, multi-position switch, coupled to the tap-change mechanism is required. Contacts, which are normally open, should be provided for i.e. K, k1 --- k17 as shown on schematic diagram.

These contacts should be extended by means of a multi-core cable to the control panel where all the other Supervisory control terminals are to be terminated.

(iii) Over and above the normal alarms, the following alarms are required for the Supervisory control (Normally open contacts).

Tap-changer (fault 11D and 11D3)

Out of step

Supply faulty

Tap-changer in progress

(iv) General: All wiring required for the supervisory control should be provided for, on the terminal point in the tap-change control panel.

The Supervisory control override relay should be common to all operation i.e. all the transformers in the group should be able to be controlled by means of the Supervisory control irrespective of local control settings.

Only the increase or decrease of the tap position should be able to be done individually.

No supply is provided for from the Supervisory control equipment therefore the local 30 Volt DC supply should be used.

In the case where a group of transformers is taken over by the Supervisory control, the out of step alarm should still operate but the tap-changer control equipment should not lock-out under these circumstances, although this facility is required when the tap-changer operated under normal conditions.

C.1.25.9 TRANSFORMER SAFETY ACCESSORIES

The transformer shall be fitted with the following safety equipment:

a) An oil temperature dial type indicator with maximum temperature point which can be reset by hand. Alarm contact, adjustable between 50 °C and 100 °C and shall be fitted to the indicator.

The alarm and relay (trip) for this feature must be housed in the tap changer panel.

b) A winding temperature indicating device to register the winding temperature.

Indication shall be on a dial with a maximum temperature pointer which can be reset by hand. Alarm contacts shall be fitted to this indicator and shall be adjustable over the range 50 °C to 120 °C.

The alarm and relay (trip) for this feature must be housed in the tap changer panel.

- c) A double element combined type gas and oil actuated relay situated in the pipe between the highest point of the transformer tank and the conservator. The relay shall have alarm contacts which close on collection of gas or low oil level, and tripping contacts which close following an oil surge. Facilities for testing the relay shall be provided.

The alarm and relay (trip) for this feature must be housed in the tap changer panel.

- d) A low oil level alarm actuated by a float switch situated in the oil conservator shall be fitted.

All the above alarm contacts shall be wired to suitable indicating devices on the respective tap change panels.

The tripping contact of the Buchholz relay shall be wired to suitable terminals in the tap-change panel, conveniently placed to facilitate further wiring.

- e) Both the transformer winding oil compartment and the tap-change panel oil compartment will be equipped with the above mentioned equipment. The oil of these two compartments will in no way be allowed to mix.

The alarms and relays (trips) for the tap changer's protection features must be housed in the tap changer panel.

Allowance must be made for two master trip relays on each tap changer panel that will integrate with the 22 kV breaker and 6.6 kV incomer panel of the specific transformer. Abovementioned relays (trips) will trigger one of the two master trip relays that will either open the 22 kV breaker or 6.6 kV breaker (or both). Exact protection scheme to be finalised at a later stage before installation and commissioning. Allowance must include all cabling, setting/programming, testing, calibration and commissioning.

The transformer shall also be equipped with the required CT on the secondary side's neutral and connected to the Standby Earth Fault Relay within the substation. This relay is housed on the 6.6 kV incomer panel.

C.1.25.10 HANDLING FACILITIES

In order to handle the units effectively the following handling facilities shall be provided:

- a) On the transformer-tank: Flat bottom plate which also allows for bi-directional rotation. Jacking pads on the tank sides for lifting by means of jacks. Integral lifting lugs or eyes capable of supporting the gross mass of the transformer, including oil fill. Lifting eyes on all heavy components such as tap changer tank, conservator, etc.
- b) On the radiator assembly, if supplied: Lifting lugs or eyes to support the nett mass without oil.

C.1.25.11 TESTS

Each transformer shall be fully tested in accordance with BS Specification No 171 and the latest SANS and IEC specifications.

- I. Testing of all transformer protection :
 - 1. DC Winding Resistance,
 - 2. Ratio,
 - 3. Current Transformers,
 - 4. SFRA test,
 - 5. Leakage Reactance,
 - 6. Excitation Current,
 - 7. Tan-delta (bushings and winding),
 - 8. Ancillary tests, Insulation Resistance tests
 - 9. And Buchholtz relay.

- II. Test the thermal protection and cooling system of the transformer.
- III. Test the oil at an accredited laboratory.
 1. Furan,
 2. Dissolved Gas Analyzes,
 3. Acid,
 4. Di-electric strength,
 5. Corrosive Sulphur,
 6. Tan Delta
 7. And PCB tests)
 8. The Tan Delta of the oil must comply with IEC 60422 specifications.

Certificates of test covering all details in accordance with these standards shall be submitted in duplicate, including all oscillogram. The municipality will not take over the contract unless test certificates have been submitted as specified.

All transformers will be transported with event recorders. The transformers will be tested before loading, after the loading and then transported. The transformer will be tested before off loading and again when on plinth at site.

C.1.25.12 OFF-LOADING AND PAINTING

The tenderer shall take full responsibility for off-loading at site, and shall provide all transport, tackle, tools and equipment to carry out this work.

The entire transformer unit shall be finished in a high gloss light grey colour best quality paint to BSS No 381 C, Shade 631.

C.1.25.13 DRAWINGS AND INSTRUCTION

- a) Tender drawings: Each tender shall be accompanied by the drawings:
 - (i) General arrangement, showing all elevations and plan giving major dimensions;
 - (ii) Typical sectional drawing giving main constructional details;
 - (iii) On-load tap change mechanism details;
 - (iv) Tap change control gear details;
 - (v) Any other drawings deemed necessary by the tenderer.
- b) Contract drawings: The successful tenderer shall submit the following drawings in duplicate as soon as possible and in any case prior to despatch of the transformer from his works:
 - (i) Details of foundations required, within 8 weeks of receipts of order;
 - (ii) Outline, general arrangements, sectional and detail drawings of the transformer;
 - (iii) Diagram of connections of the transformer and voltage control equipment showing exact turns ratios, voltage ratios, impedance values and the polarity of the transformer.
 - (iv) Full details of tap changing mechanism
 - (v) Diagram of connections of tap change mechanism
 - (vi) Diagram of connections of tap change control panel.

c) Instructions: The successful tenderer shall supply, together with the drawings under (a) above, three copies each of the following installation, operation and maintenance instructions:

(i) Transformer unit;

(ii) Protective relays and indicators:

(iii) Tap changing mechanism:

(vi) Tap change control panel

C.1.25.14 SPECIAL TOOLS

The tenderer shall state in his tender which special maintenance or assembly tools are necessary and shall, in his price allow for the supply of such tools in a lockable steel box.

C.1.25.15 DEVIATION FROM SPECIFICATION

Tenderers may put forward their nearest standard design provided that any deviation from the specification is of minor import, and provided that such procedure would result in an earlier delivery date.

C.1.25.16 ADJUDICATION OF TENDERS

Other things being equal, tenders will be adjudicated on the following basis:

a) Capitalised costs in S A currency = $A + C1P0 + C2Pc$

Where A = Cost of transformer-unit delivered and off-loaded on PLINTH including first filling of oil (R);

P0 = No-load (iron) losses (kW);

Pc = Load (copper) losses (kW);

C1 = Capitalised cost of iron loss (R/kW);

C2 = Capitalised cost of copper loss (R/kW);

The values of the co-efficient are as follows:

(C1 = 2 188, 36 and C2 = 998, 99)

Where 'maximum' indicates the highest figure attainable when applying the %-variation in losses permissible under BS 171.

C.1.25.17 GUARANTEE

The successful tenderer shall guarantee to replace, free of cost to the municipality for a period of twelve months calculated from the date of handing over, any or all parts of the equipment covered under this contract which may fail mechanically or electrically due to faulty design, bad workmanship or material.

C.1.25.18 SURGE ARRESTERS

The surge arrester shall be mounted on the transformer top task plate. The design of equipment shall be to approval and shall be in accordance with the recommendations of IEC 99.1. The surge arresters shall be suitable for operation under the conditions specified in the Detail Technical Specification and for live spray washing.

Surge arresters shall be designed to pass the rated impulse rest discharge current and the low amplitude long time current specified in the Schedules.

The rated voltage of the arrester shall be the maximum RMS power frequency line to earth voltage at which the arrester can operate continuously. This voltage shall be as stated in the Schedules.

The arresters shall be of robust construction and shall be designed to facilitate handling, erection and cleaning, and so as to avoid pockets in which water can collect.

The method of assembly of the arrester shall be such that adequate contact pressure is at all times maintained between the faces of the series non-linear resistance blocks and the design of the series gaps and voltage grading resistors, when used shall be such that the gap setting cannot be affected by vibration, mechanical shock or change in temperature.

All joints shall be made in an approved manner such that the arrester is hermetically sealed with material which will not deteriorate under any service conditions.

C.1.26 APPLICABLE STANDARDS

Reference	Title
ISO 9001	Quality management systems
IEC 60028	International standard of resistance for copper
IEC 60034	Rotating electrical machines
IEC 60044	Current transformers
IEC 60052	Voltage measurement by means of standard air gaps
IEC 60060	High-voltage test techniques
IEC 60071	Insulation co-ordination
IEC 60072	Dimensions and output series for rotating electrical machines
IEC 60076	Power transformers
IEC 60085	Electrical insulation - Thermal evaluation and designation
IEC 60137	Insulated bushings for alternating voltages above 1000 V
IEC 60156	Insulating liquids - Determination of the breakdown voltage at power frequency
IEC 60214	Tap Changers
IEC 60216	Electrical insulating materials - Thermal endurance properties
IEC 60270	High-voltage test techniques - Partial discharge measurements
IEC 60289	Reactors
IEC 60296	Fluids for electro technical applications – Mineral insulating oils for electrical equipment
IEC 60354	Loading guide for oil-immersed power transformers
IEC 60404-8-7	Magnetic materials specifications for individual materials. Cold-rolled grain-oriented electrical steel strip and sheet delivered in the fully processed state (British Standard)
IEC 60422	Mineral insulating oils in electrical equipment - Supervision and maintenance guidance
IEC 60475	Method of sampling insulating liquids
IEC 60505	Evaluation and qualification of electrical insulation systems
IEC 60507	Artificial pollution tests on high-voltage ceramic and glass insulators to be used on AC systems
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60542	Application guide for on-load tap-changers
IEC 60567	Oil-filled electrical equipment - Sampling of gases and analysis of free and dissolved gases
IEC 60616	Terminal and tapping markings for power transformers
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 60865	Short-circuit currents - Calculation of effects
IEC 60947	Low-voltage switchgear and control gear
IEC 61083	Instruments and software used for measurement in high-voltage impulse tests

IEC 61869	Instrument transformers
IEC 62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC 62535	Insulating liquids - Test method for detection of potentially corrosive sulphur in used and unused insulating oil
ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories
NEMA-TR1	[<i>NEMA Standard test methods of</i>] Transformers, regulators, and reactors
BS 171	Power transformers
BS 729	Specification for hot dip galvanized coatings on iron and steel articles
BS 1872	Specification for electroplated coatings of tin
BS 3523	Specification for granular desiccant silica gel impregnated with cobalt chloride
BS 3938	Specification for current transformers
BS 4360	Specification for weldable structural steels
BS 4504	Circular flanges for pipes, valves, and fittings (PN designated)
BS 5135	Specification for arc welding of carbon and carbon manganese steels
SANS 156	Moulded-case circuit-breakers
SANS 780	Distribution transformers

ANN C.2 PROJECT INFORMATION

C.2.1 NATURE OF WORK

This Specification provides for the design, manufacture, testing at factory, supply, delivery, off-loading on site onto an existing concrete plinth (information of concrete plinth under Pricing Instructions – C2.1) or a newly constructed plinth if existing plinths need to be altered, installation within existing busbars, testing and commissioning of new power transformers and on load tap changers with control and metering panels.

It further provides for the comprehensive testing and calibration of the protection systems and equipment on both the 22 kV and 6.6 kV side.

It also addresses the servicing of existing 22 kV and 6.6 kV equipment

C2.2 EXTENT WORK

The Contract Works to be supplied shall include all work incidental thereto whether specified in detail or not, and is to be carried out by the Contractor in accordance with the Conditions of Contract and in general shall comprise the following:

C2.2.1 DEFINITE WORK

The design, manufacture, supply, testing, delivery to the site, erection, testing on site, completion, setting to work, and maintenance of plant in accordance with the Conditions of Contract and this Specification at the prices stated in the Detail Technical Specification, on the following basis:

a) Work at Schedule Prices

The switchgear, transformer and accessories of which the numbers, quantities and details are specified in the Detail Technical Specification, the types, voltage and ratings as described and of which particulars of the detailed equipment are given, such equipment including all accessories, wiring, cabling on site and in buildings as specified and as shown on the drawings, and other work required to complete the equipment other than measured work at Detail Technical Specification rates.

b) Measured work at Schedule Rates

If and when required to do so by the written instructions of the Engineer any or all of the following work described:

The power and control cables, racks, cable boxes, bare conductors, connections and wiring and other work necessary at such Schedule Rates as may be agreed by the Engineer during the course of the Contract Works (other than those included in the Definite Work):

- (i) To make all electrical connections other than those included in the Definite Work between apparatus provided under this Contract and apparatus provided under other contracts.
 - (ii) To make any external electrical connections between the separate items of plant included in other contracts.
 - (iii) To make all electrical connections other than those included in the Definite work between existing apparatus and other apparatus provided under this Contract.
 - (iv) To design and do alterations or install additional ventilation where the transformers are installed in a building.
 - (v) To take note of existing transformer plinths and to assure the design of existing plinths. If any alterations are needed, the employer must be notified in writing and the alterations to plinths, if necessary, will be done by the employer.
 - (vi) Design cooling according to building and load profile.
- The Definite Work will be divided into the Sections specified in the Schedules, for the purpose of payment taking over.

c) Work at time and material rates

If and when required to do so by the written instructions of the Engineer, this will comprise any work which is not covered by work at fixed schedule prices or measured work at schedule rates.

C2.3 GENERAL DESCRIPTION OF THE SYSTEM AND OPERATING CONDITIONS

The following is a general description of the design and working of the system of which the Contract Works will eventually form a part:

- a) Electrical energy will be supplied from one or more power stations and substations as three-phase current and at a frequency of 50 Hz.
- b) Electrical energy will be transmitted by means overhead transmission lines and/or underground cables.
- c) The system will be in continuous operation during the varying atmospheric and climatic conditions occurring at all seasons, and the plant shall be suitable in all respects to work continuously at its rated capacity under the Site conditions as specified in the Detail Technical Specification.
- d) The system highest voltage and the system nominal voltage will be as stated in Detail Technical Specification.
- e) The neutral points of the various sections of the system will be grounded, either directly or through a resistance or reactance or a combination of both or through a voltage transformer as may be decided by the municipality.
- f) The load on the system will or may consist of domestic loads, static transformers, induction and synchronous motors, static converters, power-factor correction equipment, filters, and rectifiers for the supply of motive power, traction, lighting, control and electro-chemical work.

C2.4 GENERAL PARTICULARS AND GUARANTEES

The Contract Works shall comply with the general particulars and guarantees specified in the Detail Technical Specification.

All plant and apparatus supplied under this Contract shall be to approval.

The Contractor shall be responsible for any discrepancies, errors or omissions in the particulars and guarantees, whether or not such particulars and guarantees have been approved by the Engineer.

The Contract shall be executed in accordance with the quality assurance requirements stipulated in the Detail Technical Specification.

The Contractor shall render such assistance as may be required by the Engineers in auditing the quality programs. Where audits have been carried out by other inspecting authorities approved by the Engineers, the results of such audits may be accepted.

Where necessary to maintain control over the execution of the work covered by the Contract; the Engineers will prepare quality verification procedures in accordance with the Engineer's quality assurance manual, for discussion and agreement with the Contractor.

C2.5 COMPLIANCE WITH SPECIFICATION

All apparatus shall comply with the Specification. Any departures from the requirements of this Specification shall be as agreed between the Engineer and the Contractor, and are as stated in the Detail Technical Specification. No other departures will be permitted except as provided for in the General Conditions of Contract.

C2.6 PLACES OF MANUFACTURE

The manufacturers and places of manufacture, testing and inspection of the various portions of the Contract Works shall be stated in the Detail Technical Specification.

C2.7 SUB-CONTRACTS

The Contractor shall supply three copies of all orders placed with sub-contractors. Information is to be given on each sub-order sufficient to identify the material or equipment to which the sub-order relates and to notify the sub-contractor that the conditions of the Specification apply.

C2.8 TESTING AND INSPECTION

The Contractor shall carry out the tests stated in accordance with the conditions of this Specification and without extra charge, such additional tests as in the opinion of the Engineer are necessary to determine that the Contract Works comply with the Specification under either test (in manufacturer's works, on the Site or elsewhere) or ordinary working conditions. Type tests may be omitted at the discretion of the Engineer if satisfactory evidence is given of such tests already made on identical equipment.

All materials used shall be subjected to and shall withstand satisfactorily such routine tests as are customary in the manufacture of the types of plant included in the Contract Works.

All tests shall be carried out to the satisfaction of the Engineer and in his presence at such times as he may reasonably require. The Contractor shall be responsible for notifying the Engineers of readiness for testing. Not less than two weeks' notice of all tests shall be given to the Engineer in order that he may be represented if he so desires. As many tests as possible shall be ranged together. Four copies of the Contractor's record of tests shall be supplied to the Engineer.

Measuring apparatus shall be approved by the Engineer and if required shall be calibrated at the expense of the Contractor at an approved laboratory.

The Contractor shall be responsible for the proper testing of the work completed or plant or materials supplied by a sub-contractor to the same extent as if the work, plant or materials were completed or supplied by the Contractor himself.

All labour apparatus, instruments, connections and material required for the above tests shall be provided by the Contractor.

The municipality will provide free of charge on site electrical energy, if available, for the purpose of approved preliminary tests and for the official tests. If further preliminary tests are necessary or if further official tests are required due to the Contract Works not complying with the conditions of this Specification, the municipality may call upon the Contractor to pay the costs of providing the additional electrical energy required.

The Contractor shall supply suitable test pieces of all materials as required by the Engineer. If required by the Engineer, test specimens shall be prepared for check testing and forwarded at the expense of the Contractor to an independent testing authority selected by the Engineer.

The cost of all tests and/or analyses shall be borne by the Contractor, but the costs of check tests and/or analyses effected elsewhere than at the manufacturer's works or on the site, and the results of which are approved, will be refunded to the Contractor by the Council.

No inspection or lack of inspection or passing by the Engineer of work, plant or materials, whether carried out or supplied by the Contractor or sub-contractor, shall relieve the Contractor from his liability to complete the Contract Works in accordance with the Contract or exonerate him from any of his guarantees.

C2.9 STANDARDS

Except where otherwise specified or implied the Contract Works shall comply with the latest applicable specifications of South African Bureau of Standards (SABS) the British Standards Institutions (BS) or the International Electro-Technical Commission (IEC) Recommendations. The Contractor may submit for approval equipment or materials conforming to technically equivalent National Standards of the Country of origin. In the latter case, copies of the relevant Standards or parts thereof, in the English language shall be submitted.

Reference to a particular standard or recommendation in this Specification does not relieve the Manufacturer of the necessity of providing the Contract Works complying with other relevant standards or recommendations.

C2.10 INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTION MANUALS

Two months before the major items of the Contractor Works are delivered to site, the Contractor shall submit duplicate draft copies of the installation, operating and maintenance instructions and diagrams for discussion with the Engineer. After approval and before commissioning tests commence on site further copies shall be supplied in durable form. The number of copies required is given in the Schedules.

The Contractor shall also provide operating and maintenance instructions for any spare apparatus and material which he may be called upon to supply.

The manuals shall include at least:

- i) General description of all equipment supplied, the operation of the equipment and data relating to all settings and levels that should be maintained for normal operation.
- ii) Descriptions and operation of the specific equipment, electrical, hydraulic and/or pneumatic control circuits, etc supplied.
- iii) Details of the erection, setting up and site commissioning procedures to be followed at the time of initial installation, subsequent maintenance or repair, including all settings and levels that shall be established and checked.
- iv) A description of the procedures to be followed sufficient for dismantling and re-assembling any part of the equipment for the purposes of repair or maintenance.
- v) Recommended maintenance periods and procedures.
- vi) Complete lists of parts and the supplier of the part included in all the equipment. The part reference that appears on the contract drawings shall be included in the list.
- vii) A complete list of the drawings that are applicable to the equipment.
- viii) A record of all the settings established when initially setting up and commissioning the Contract Works.

Blank (master) tables, schedules, etc. in which the information of viii) will be eventually printed shall be included in the manuals supplied before commissioning commences. The completed tables with the actual setting shall be submitted separately within 2 months of completion of the Commissioning. These will be added to the manuals by the Engineer. Space shall be left for these to be easily bound into the documents.

C2.11 SPARES

The Contractor shall list details of recommended spare parts together with their individual prices. The municipality may order all or any of the parts and those ordered with 2 months of placing the Contract shall be available at the time of commissioning the Plant.

The spares shall include consumable items sufficient for plant operational period of two years after commissioning, as well as essential replacement parts to cover the event of a break-down which would affect the availability or safety of the Plant.

The spares, apparatus, parts and tools shall be subject to the same specification, tests and conditions as similar material supplied under the Definite Work section of the Contract. They shall be strictly interchangeable and suitable for use in place of the corresponding parts supplied the Plant and must be suitably marked and numbered for identification and prepared for storage by greasing or painting to prevent deterioration.

All spare apparatus or materials containing electrical insulation shall be packed and delivered in cases suitable for storing such parts or material over a period of years without deterioration. Such cases shall have affixed to both the underside and topside of the lid a list detailing its contents. The case will remain the property of the municipality.

C2.12 FIRE PRECAUTIONS

All apparatus, connections and cabling shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire. When cabling is carried out as part of this Contract the Contractor shall be responsible for sealing all holes in floors, walls, roofs, etc. through which the cabling may pass.

C2.13 ERECTION AT SITE AND ACCOMMODATION

The Contractor shall provide, at his own cost and expense, all labour, plant and material necessary for unloading and erection at the Site and shall be entirely responsible for its efficient and correct operation.

The Contractor shall be responsible for arranging and providing all living accommodation, services and amenities required by his employees.

C2.14 SPANNERS AND SPECIAL TOOLS

A complete set of spanners shall be supplied for each station to fit every nut and bolt head on the apparatus supplied under this Contract, together with all special tools required for the adjustment and maintenance of the equipment. These tools shall be mounted in a lockable cabinet at each station also to be provided under this Contract.

Eye bolts which have to be removed after use shall be accommodated in the cabinets.

Spanners and other maintenance equipment provided under the Contract shall not be used for the purpose of erection of the Contract Works.

Any special devices, slings or tackle necessary for the complete overhaul of the plant shall be handed over to the municipality in working order on completion of the Contract.

Before delivery of any or all of these tools to the municipality, invoices shall be presented and a signature obtained from the Engineer or municipality's representative. Any tools not signed for shall be deemed not to have been delivered.

C2.15 SLINGS, EYE BOLTS AND LIFTING TACKLE

All slings, eye bolts and other lifting tackle provided shall be proof tested to twice the safe working load and suitably marked with embossed labels to show clearly the safe working loads.

C2.16 SUPERVISION AND CHECKING OF WORK ON SITE

The carrying out of all work on Site included in the Contract shall be supervised throughout by a sufficient number of qualified representatives of the Contractor.

Before putting any plant or apparatus into operation, the Contractor shall satisfy himself as to the correctness of all connections between the plant and apparatus supplied under this Contract and plant and apparatus supplied under any other contract and shall give reasonable notice in writing to the Engineer when the plant and apparatus is ready to be energized.

The Contractor shall ascertain from time to time which portion of the work on the Site the Engineer desires to check, but such checking shall not relieve the Contractor of the liability to complete the Contract Works in accordance with the Contract or exonerate him from any of his guarantees.

The Contractor shall be deemed to have allowed for working such hours per week at the Site as are consistent with completing the Contract Works in the time specified whilst maintaining working conditions for his personnel on a level comparable with that for other kindred classes of work being carried out on the Site.

If at any time it appears to the Engineer that the Contractor will be unable to complete any section of the Contract Works in the time stipulated then the Contractor shall, if required by the Engineer, increase the number of personnel or carry on such work outside of normal working hours and shall not make any claims for any extra expense thereby incurred unless in the opinion of the Engineer the delay is due to causes for which the Contractor would be entitled to an extension of time under the Conditions of Contract.

If the Engineer certifies that effects have shown themselves in the Contract Works, the Contractor shall, for the purpose of the maintenance after completion of the Contractor Works provided by the Conditions of contract, send to or keep on Site a supervisory staff of such numbers and for such periods as the Engineer may require.

ANN C.3 TESTS

INDEX

C3.1	INSPECTION AND TESTS
C3.2	DISCONNECTORS AND EARTHING SWITCHES
C3.3	POST INSULATORS
C3.4	BUSBAR CONDUCTORS
C3.5	CURRENT CARRYING CONNECTORS
C3.6	INDICATING AND RECORDING INSTRUMENTS AND METERS
C3.7	MOTORS
C3.8	MOTOR CONTROL EQUIPMENT
C3.9	MATERIAL
C3.10	GALVANISING
C3.11	POWER TRANSFORMERS
C3.12	VOLTAGE CONTROL EQUIPMENT
C3.13	CABLE BOXES AND DISCONNECTOR CHAMBERS
C3.14	BUSHINGS
C3.15	TANK AND ONAN COOLERS
C3.16	COOLING PLANT WITH FORCED OIL CIRCULATION
C3.17	PUMPS, MOTORS, PIPEWORK, OIL SAMPLING DEVICES AND VALVES
C3.18	OIL
C3.19	GAS AND OIL ACTUATED RELAYS
C3.20	SECONDARY WIRING
C3.21	WELDING
C3.22	CURRENT TRANSFORMERS
C3.23	SURGE ARRESTERS
C3.24	MINIMUM ACCEPTABLE SITE TESTS
C3.25	TESTS AT SITE
C3.26	EARTHING AND AUXILIARY TRANSFORMERS

C3.1 INSPECTION AND TESTS

C3.1.1 GENERAL

The plant and equipment are subject to inspection and test by the Engineer during the course and on completion of manufacture and erection to ensure compliance with this Specification and to provide the necessary operating data.

Not less than twenty-one days of notice of all tests shall be given to the Engineer in order that he may be present if he so desires. As many tests as possible shall be arranged together in accordance with a programme to be agreed with the Engineer.

The Contractor or his Sub-Contractor shall supply to the Engineer, as soon as practicable after works tests, site tests and commissioning have been witnessed, six copies of the relevant test certificates which shall contain details of each test performed, and shall be prepared as required by the Engineer; records, results and calculations of all electrical tests shall be provided.

The subsequent sections of this Schedule list specific, works and site tests which the Engineer requires, but this shall not preclude the Engineer's right to call for further tests if he considers these necessary.

After the plant has passed the site tests required under this Contract, and it became available for commercial operation, certain additional tests may be carried out in order to investigate the response and recovery of the system during events such as the switching of various items of plant, system faults and load rejection.

C3.2 DISCONNECTORS AND EARTHING SWITCHES

Each type of disconnector and earthing switch being provided shall be subjected to the type and routine tests specified in IEC 129, and shall comply fully with the following supplementary type and routine tests:

C3.2.1 TYPE TESTS

a) Insulation Co-ordination

In order to demonstrate the insulation co-ordination of the disconnector the critical flash over levels to earth and across the open gap shall be determined. The "up and down" method described by IEC 60 shall be used for these tests.

b) Short Circuit Current Carrying Capability

Disconnectors, earth switches and maintenance earthing devices shall have a rated short time current carrying capacity in accordance with the Schedules of this Specification. The incoming and outgoing connections to the disconnector shall simulate as closely possible those of the particular installation for which it is being supplied.

c) Mechanical Endurance Test

The test shall be made in accordance with the requirements of IEC 129 but the number of operations shall be increased to 2 000 in the case of the disconnector and 1 000 in the case of the earth switches. Operations of all auxiliary switches shall be checked.

d) Radio influence Voltage Tests

A complete single phase of each disconnecting device shall be assembled as in service and subject to radio influence voltage tests in accordance with NEMA 107. The noise level shall not exceed that specified in the Schedules

e) Auxiliary Switch - Type Test

Switches shall withstand the current stated in the Schedules. The current shall be applied five times to each switch and the mechanism operated ten times between each application. The contact resistance measured after the test series shall not exceed the resistance measured at the commencement of the tests.

C3.2.2 ROUTINE TESTS

Routine tests shall be carried out in accordance with IEC 29 with the exception that, where required by the Engineer, the specified tests shall be made on each disconnector and operating mechanism being provided.

When the disconnector is not completely assembled in the manufacturer's works, the operational test specified shall be made on each mechanism being provided, the disconnector loading being simulated in a manner to the approval of the Engineer.

C3.3 POST INSULATORS

Type, sample and routine tests shall be made on post type insulators in accordance with the requirements, IEC 168 as appropriate.

Each type of post insulator shall all be subjected to radio influence voltage tests in accordance with NEMA 107. The post insulators shall be assembled as in service for the tests.

C3.4 BUSBAR CONDUCTORS

The tests shall be in accordance with IEC 207 and 208 and BS 125 or BS 159.

C3.5 CURRENT CARRYING CONNECTORS

C3.5.1 TYPE TESTS

a) General

Where type tests have been carried out on connectors similar in design but not identical in all respects to those to be supplied on the contract, existing test results on the connectors may be submitted for consideration in lieu of testing the actual contract clamp designs.

b) Mechanical

Connectors shall be tested in accordance with the requirements for non-tension joints of BS 3288, Part 1.

c) Electrical

Resistance measurement, short circuit and electrical load cycling tests shall generally be in accordance with BS 4579 and BS 3288.

The number of heating and cooling cycles to be performed shall be as specified in BS 3288.

Tests shall also be performed to prove compliance with corona and radio interference requirements.

C3.5.2 SAMPLE TESTS

Tests shall be in accordance with the requirements for non-tension joints of BS 3288 Part 1.

C3.6 INDICATING AND RECORDING INSTRUMENTS AND METERS

C3.6.1 ROUTINE TESTS

- a) All instruments and meters shall satisfactorily comply with the tests specified in the appropriate BS or IEC Specifications.
- b) Each instrument shall be calibrated, with its associated instrument transformer, to the specified accuracy.
- c) Insulation tests

The windings and electrical connections of each instrument and meter shall be subjected for one minute to an alternating test pressure of 2 000 V rms, 50 Hz, to the case or any other metal which is not intended to be insulated from the case when the instrument or meter is in use.

C3.7 MOTORS

Performance tests shall be in accordance with IEC 34-1.

C3.8 MOTOR CONTROL EQUIPMENT

Type and routine tests shall be carried out in accordance with IEC 158.

C3.9 MATERIAL

Samples selected by the Engineer from metals used in the Contract Works shall be tested to prove compliance with the Specification including the guarantees stated.

C3.10 GALVANISING

All galvanized material shall be subject to visual examination. Samples shall be subjected to tests in accordance with the following procedure:

C3.10.1 WIRES

The sampling and testing procedures laid down in SABS 935.

C3.10.2 MATERIAL OTHER THAN WIRES

Two test samples shall be taken for each batch of similar items, the size of which shall not exceed 100 items. Should either sample fail to pass any of the undermentioned tests, four samples of the actual material shall be taken from each batch. Should any of these further samples fail the batch shall be rejected.

The test samples shall be of a thickness equal to that of the articles galvanized and shall be loosely attached to the articles during galvanizing. The testing procedures specified in SABS 763 shall be extended to cover the thickness of galvanizing specified:

- a) Test for uniformity of Zinc Coating - In accordance with SABS 763.
- a) Test for weight of Zinc Coating - Acid strip test in accordance with SABS 763

C3.11 POWER TRANSFORMERS

Routine, type and special tests shall be carried out in accordance with IEC 76. The tapping connection to be used for the impulse tests shall be the one on which the highest voltage stresses occur. Verification of the correct choice of tapping shall be provided. Impulse tests shall be applied by direct application to each line terminal in turn except where, by agreement with the Engineer, the transferred surge method of test may be adopted for tests on lower voltage windings. The following additional tests shall be made.

C3.11.1 ROUTINE TESTS

- a) The impedance voltage test shall also be carried out on the maximum and minimum tapping positions.
- b) Magnetic circuit insulation (where appropriate)
- (i) A power frequency voltage of 2 kV for 1 minute applied as follows:

Core bolts to core, to yoke clamps and to core leg side plates.

Core to yoke clamps and to core leg side plates.

- (ii) Immediately prior to despatch, 2 kV for 1 minute applied between core and earth. A megger may be used for this test.
- c) No load current at:
 - (i) 90 % rated voltage
 - (ii) 100 % rated voltage
 - (iii) 110 % rated voltage
 - (iv) The maximum voltage equivalent to the value quoted in the Schedules
- d) Noise level: The level of noise shall be measured to NEMA Standards TRI or other approved national standards.
- e) Vibration: Vibration measurements shall be taken and the level recorded shall be subject to approval. This test shall be carried out unless it can be shown to the satisfaction of the Engineer that the level of vibration in the transformer and its auxiliaries is harmless.
- f) Partial discharge: The details of the pd test shall be as far as possible based on IEC 270 subject to the agreement of the Engineer except where otherwise stated. Transformers with a nominal value of 132 kV and below need not be subjected to partial discharge tests unless otherwise advised by the Engineer. In the following specification, wherever possible, reference will be made to the relevant parts of IEC 270. Those aspects of the test not covered by IEC 270 will be specified herein.

Test conditions: The test shall be made under controlled ambient pd conditions; if possible in a large shielded enclosure, using corona free terminals and connections, a filtered power supply and a calibrated test circuit.

The arrangement of the transformer, the supply leads and earth, etc shall simulate installed conditions as closely as possible, except where this may interfere with the achievement of a low ambient pd level.

Test procedure: The pd measurements shall be associated with the induced over potential test. The test voltage shall be applied across the whole winding.

The pd measurements shall be made on each phase in turn and where possible on at least two terminals of the winding under test.

With increasing voltage observe the pd of the transformer, remain at 1.2 x nominal voltage for half-an-hour or longer if necessary to examine, measure and record the pd. As the induced voltage is increased, record pd inception voltage (*1) and the pd level. With reducing voltage record the pd extinction voltage (*1) and the pd level. When 1.2 x nominal voltage is reached it shall be maintained for half-an-hour or longer if necessary to examine, measure and record the pd.

If possible it would be preferable to record continuously the pd level throughout the tests. (1*).

It is required that the transformer is shown to have an internal pd extinction voltage which is greater than 1.2 x nominal voltage ie that the transformer is discharge free (*2) at 1.2 x nominal voltage.

Reasons for any changes in the recorded pd before and after the application of the full induced over-voltage shall be explained.

Test circuit: The test circuit shall be one of those described in IEC 270 Section 4.2 and Appendix 1.

Method of measurement: The method of measurement and instrumentation shall be according to IEC 270 Section 4.3 and 4.3.1.

This is the preferred method, any other method will be subject to the Engineers agreement.

Calibration: The instruments and the test circuits shall be calibrated according to IEC 270 Section 5.1, 5.2, 5.2.1, 5.3 and 5.3.1; any other method will be subject to the Engineers agreement.

C3.11.2 TYPE TESTS

- a) Capacitance: The capacitance between windings and between each winding and earth shall be measured.
- b) Switching surge: Each high voltage terminal of 330 kV and above shall be switching surge tested, with one reduced voltage wave (50 - 70 %), and three full voltage waves, of negative polarity, between line terminal and ground.

The switching surge wave form shall have the following characteristics.

A crest value as specified in the Schedules.

The wave front time (time to crest) shall be 100 microseconds \pm 20 % and the wave tail shall be a minimum of 1 000 microseconds and shall exceed 90 % of its crest value for at least 200 microseconds.

- c) Transferred surge: Where recurrent surge oscillograph tests are required by the Schedules, the transformer shall be designed so that with the test voltage, applied to the other windings, the maximum surge that can be transferred to the unloaded winding(s) does not exceed its specified insulation level. Compliance with this requirement may be achieved by the use of external equipment connected to the unloaded winding and shall be proved by recurrent surge oscillograph measurements.

The test shall be repeated with the unloaded winding(s) connected to earth via a circuit simulating a connected machine and the transferred surge shall not be greater than 50 % of the winding BIL.

(*1) See IEC 270, Section 3.5, 5.1, 3.4.1 and 6.4.2.

(*2) 'Discharge free" means: not greater than the background pd level. See IEC 270, Section 5.4.3.

During the temperature rise test the accuracy of oil and/or winding temperature indicating devices shall be determined.

Where an impulse test is required it shall follow the power frequency tests.

Where impulse, partial discharge, switching and transferred surge and temperature rise tests have previously been carried out on equipment similar in all essential respects to that included in this contract, the Engineer may waive one or all these tests on production of complete test records which they consider satisfactory, and the Purchaser will be credited with the amount state in the Schedules.

C3.12 VOLTAGE CONTROL EQUIPMENT

Route and type tests shall be carried out in accordance with IEC 214.

C3.13 CABLE BOXES AND DISCONNECTING CHAMBERS

Oil tightness - All cable boxes and disconnecting chambers shall be tested with oil, having a viscosity not greater than that of IEC 296 insulating oil when at a temperature of 15 °C, at a pressure of 70 kN/m² for 12 hours, during this time no leakage shall occur nor shall there be any permanent set when the pressure is released.

C3.14 BUSHINGS

Routine, type, sample and special tests shall be carried out in accordance with IEC 137. The following special test shall be made:

- a) Short time current

Each type of bushing being provided shall be subject to a short time current test of 3 seconds at the fault rating specified in the Schedules, the test procedure being in accordance with that of IEC 56.

C3.15 TANK AND ONAN COOLERS

C3.15.1 ROUTINE TESTS

- a) Oil leakage - All tanks and oil filled compartments including all forms of radiator but excluding separate coolers using forced oil circulation, (for which see Section below) shall be tested, before painting, for oil tightness by being completely filled with oil of a viscosity not greater than that of IEC 296 insulating oil at a temperature of 15 °C and subjected to a pressure equal to the normal pressure plus 35 kN/m². This pressure shall be maintained for a period of not less than 24 hours, during which time no leakage shall occur.
- b) The tap changer barrier shall be subjected to normal oil pressure head for 24 hours, during which time there shall be no leakage from the panel or bushings.
- c) Detachable radiators may be tested as separate units.

C3.15.2 TYPE TEST

a) Vacuum

(i) One transformer tank, tap changing compartment, radiator and cooler of each size shall be subjected when empty of oil to that vacuum test level specified in the Schedules. There shall be no permanent deflection of the stiffeners, nor shall the permanent deflection of the panels exceed the value specified in the following table.

Major dimension of panel between stiffeners (meters vertical or horizontal)		Maximum permanent deflection
Up to 1,5 m		3 mm
1,5 m - 3 m		8 mm
Above 3 m		13 mm

(ii) A further test at a vacuum equivalent to 3 m bar absolute pressure for a period of 8 hours shall be made for the purpose of checking the mechanical withstand capability of the tank; during this test no damage or fractures shall occur. This test is only applicable to units to 200 kV and above and may be combined with other tests or made during the processing of the unit.

b) Pressure

One transformer tank of each size shall be subject to a pressure corresponding to the normal pressure plus 35 kN/m² for 12 hours. There shall be not permanent deflection of the stiffeners exceed the value specified in the above table. This test may be combined with a routine oil leakage test.

The tapchanger barrier shall be shown to withstand an over pressure test of normal pressure plus 35 kN/m² for 12 hours.

c) Pressure relief device

When required by the Engineer one pressure relief device of each size shall be subjected to increasing oil pressure and shall operate before reaching normal pressure plus 35 kN/m².

The operating pressure shall be recorded on the test certificate.

C3.16 COOLING PLANT WITH FORCED OIL CIRCULATION

C3.16.1 ROUTINE TEST

- a) Air/oil coolers - All coolers using forced oil circulation shall be filled with oil of a viscosity no greater than that of IEC 296 insulating oil at a temperature of 15 °C and subjected to a pressure equal to twice the maximum working pressure at the inlet to the cooler under service conditions which shall be maintained for a period of not less than 24 hours; during this time no leakage shall occur.
- b) Water/oil coolers - The oil and water compartments of all water cooled oil coolers shall be tested separately to withstand a hydraulic pressure of 350 kN/m² for 15 minutes after which the pressure shall be reduced to twice the

maximum working pressure at the inlet to the cooler under service conditions and shall be maintained for a period of not less than 24 hours during which time no leakage shall occur.

C3.16.2 TYPE TESTS

One force oil cooler of each type shall be subjected, when empty of oil, to that vacuum test level specified in the Schedules. There shall be no permanent deformation or distortion of any part of the cooler.

C3.17 PUMPS, MOTORS, PIPEWORK, OIL SAMPLING DEVICES AND VALVES

C3.17.1 ROUTINE TEST

- a) Oil filled equipment - The bodies of all oil pumps complete with submerged motors, if any, and the oil pipework, oil sampling devices and valves shall withstand a hydraulic pressure of 140 kN/m² for 15 minutes
- b) Water filled equipment - Water pumps, water pipework and valves shall withstand a hydraulic pressure of 700 kN/m² for 15 minutes after which the pressure shall be reduced to twice the maximum working pressure, at the inlet to the cooler under service conditions and shall be maintained for a period of not less than 24 hours during which time no leakage shall occur.
- c) Control gear - All control gear shall be subjected to the tests specified in the appropriate IEC.
- d) Motors - Each machine shall be subjected to the following tests where applicable:
 - (i) Measurement of winding resistance (cold)
 - (ii) No load test at rated voltage for determination of fixed losses.
 - (iii) An overvoltage test at 1.5 times rated voltage applied with the machine running at no load, for a period of 3 minutes, to test interturn insulation.
 - (iv) High voltage in accordance with IEC 3401.

C3.17.2 TYPE TESTS

- a) Motors - Performance tests shall be in accordance with IEC 34-1 however, certificates of type tests in accordance with IEC will be accepted.
- b) Except for non-return valves, all valves and oil sampling devices which are subject in service or during maintenance to oil pressure shall withstand, when empty of oil, absolute pressure not exceeding 350 m bars. In the case of valves this test is to be applied to the body only. This type test shall subsequently be followed by a repeat oil leakage test.

C3.18 OIL

Samples of oil from each consignment shall be tested in accordance with IEC 296 before despatch.

Subject to the agreement of the Engineer a test certificate, confirming that the oil from which the consignment was drawn has been tested in accordance with IEC 296, may be accepted. Before commissioning any transformer, the electric strength of its oil shall be check-tested and the results approved by the Engineer.

C3.19 GAS AND OIL ACTUATED RELAYS

C3.19.1 ROUTINE TESTS

The following tests shall be made on relays when completely assembled. Where oil is referred to it shall have a viscosity not greater than that of IEC 296 insulating oil at 15 °C.

- a) Oil leakage - The relay, when filled with oil shall be subjected to an internal pressure of 140 kN/mm² for 15 minutes. No leakage shall occur either from the casing or into normally oil free spaces, such as floats, within the casing.

b) Gas collection

- (i) With the relay mounted as in service and at a rising angle of 5 degrees (tank to conservator) and full of oil, gas shall be introduced into the relay until the gas collection contacts close. The oil level contacts shall not close when gas is escaping freely from the relay on the conservator side. These contacts shall, however, close when the pipework is empty of oil.
- (ii) The empty relays shall be tilted, as if mounted in pipework rising from tank to conservator, at an increasing angle until the gas collection contacts open. The angle of tilt shall then be reduced and the gas collection contacts shall close before the angle is reduced to less than 13 degrees to the horizontal.
- (iii) With the relay mounted at a falling angle of 16 degrees to the horizontal and full of oil, the gas collection contacts shall be open.
- c) Oil surge - with the relay mounted as in service and full oil at approximately 15 Deg C, the surge contacts shall close within the steady oil flow limits specified in the Schedules. This operation shall not be adversely affected when the gas collection contacts have already closed and gas is escaping freely.
- d) Voltage - with the relay empty of oil, a voltage of 2 kV shall be applied in turn between each of the electrical circuits and the casing for one minute, the remaining circuits being connected to the casing.
- e) Operation - with the transformer assembled with its cooling plant as in service, tests shall be made to demonstrate that the relay does not operate whilst the oil pump motors are being started or stopped.

C3.19.2 SAMPLE TESTS

All discretion of the Engineers, the following tests shall be made:

Variation of performance with mounting angle with the mounting conditions as in service, the mounting angle shall be varied within the rising angle limits 1° and 9° and tests repeated in the manner prescribed for the routine tests.

C3.20 SECONDARY WIRING

All secondary wiring, including panel wiring and control circuits and all apparatus connected thereto shall be subjected to the following test:

C3.20.1 ROUTINE TESTS

- a) Voltage - 2 kV applied for one minute except where this requirements is modified by a SABS, IEC or BS, to which item the appropriate test shall be applied.
- b) Insulation resistance - By megger of not less than 500 volts

C3.21 WELDING

C3.21.1 WELDERS QUALIFICATION TESTS

All welders engaged on fabrication either in the manufacturer's works or on site and on any weld repairs subsequently found necessary shall, before undertaking welding, satisfactorily complete procedure and qualification tests in the presence of the Engineer.

The minimum requirements for the testing of welders engaged on structural steel would be as follows:

- a) Butt welds (manual)

Test plates to be of average thickness for the Contract. Two tests required:

Horizontal/vertical and vertical

From each test weld are to be prepared one forward and one reverse bend test and one macro specimen. The bend tests are to be taken through 180 degrees over a former of diameter equal to three times the thickness of the plate.

b) Fillet welds

The size of fillet weld must be an average of those called for on the Contract. Two tests are required:

Horizontal/vertical and vertical

From each test weld, nick break and macro specimens are to be prepared.

c) Butt welds (machine welding)

On full penetration butt welds, the first two seams welded are to be witnessed with 'run on' and 'run off' plates attached. From these plates are to be prepared a forward bend, a reverse bend and a macro. The bend requirements are as for the manual test.

On partial penetration butt welds the first two seams are to be witnessed and macro specimens are to be prepared from the 'run on' and 'run off' plates in addition to the ends of the actual weld. The extent of penetration is to comply with the approved drawing.

C3.22 CURRENT TRANSFORMERS

The following tests shall be conducted on the current transformers in accordance with the requirements of BS 3938 as follows:

a) Prior to assembly in turrets and neutral cases:

Inter-turn insulation tests - Clause 2.4.4

Polarity test for lead marking - Clause 2.4.1

Accuracy and parameter tests - Clause 4

b) After assembly in turrets and neutral cases:

Insulation tests - Clause 2.4.3

Polarity test - Clause 2.4.1

The turret installation shall be checked for mechanical soundness of installation, freedom from interference with bushings and oil tightness of terminal box.

C3.23 SURGE ARRESTERS (OPTIONAL)

a) Tests on Surge Arresters: Routine, Manufacturer's control and standard acceptance tests in accordance with the latest revision of IEC Publication 99-1 shall be conducted on each arrester assembly.

b) Tests on Surge Counters: The rated minimum operating current stated in the Schedules shall be passed through the surge counter ten times and operation shall be registered on each occasion. The surge counter shall correctly register and withstand the current waves as specified in BS 2914 Clause 14(c) at twice the rated arrester current. The peak voltage across the counter during this test shall not exceed the value stated in the Schedules.

C3.24 MINIMUM ACCEPTABLE SITE TESTS

The site tests, full details of which are to be submitted by the Contractor after the Contract has been placed, shall include those tests described in outline below.

a) Transformers

Insulation resistance of core and windings.

Dielectric strength of oil samples.

Ratio and no-load current at low voltage (eg 400V) on all tapplings.

Vector relation check.

Calibration check of temperature instruments, including secondary current injection and providing contact settings.

Air injection tests of gas/oil-actuated relays

Setting check of oil-level, oil-flow and water-flow

Complete functional tests of cooling equipment and tap change equipment, including manual/automatic sequences, indications, alarms and interlocks, measurement of motor current, adoption of suitable motor protection settings and proof of protection operation for stalled or single phasing conditions.

Operation tests of 'freeze-drier' type breathers

Insulation resistance of all secondary circuits.

Final checks before energising:

Venting, position and locking of valves, earthing of star-point(s) and of tank, state of breathers and of pressure-relief devices, oil levels, absence of oil leakage, operation of kiosk heaters, tap-change counter readings, resetting of maximum temperature indicators, final proving of alarms and trips.

Tests when energised:

On-load tap-changer operation throughout range (subject no exceeding 1.1 pu volts on any windings)

Maintenance of 1.1 pu volts on untapped windings for 15 minutes (but no exceeding this value on tapped winding).

Test on load:

Temperature instrument readings

Measurements of WTI CT secondary current

C3.25 TESTS AT SITE

After the plant and auxiliary equipment have been erected and connected up on site, the Contractor shall carry out to the satisfaction of the Engineer such tests as may be required to prove compliance with the Specification, independently of any tests carried out at the manufacturer's works.

Not less than thirteen weeks before any section of the plant is required to enter commercial service, the Contractor shall submit for the approval of the Engineer his detailed site test proposals for that section of the plant, together with details of the test equipment and methods that he proposes to use. Subject to approval of the tests, these will be written by the Engineer into an overall programme of tests, which will be issued to all directly concerned prior to the starting date for the tests.

The Engineer shall have the right to witness all tests, and the results must be available to him as the tests proceed. He may recommend waiving of some tests, or may add further test if considered necessary to prove compliance with the Specification.

Clear records of all tests necessary before the plant can be regarded as ready to be first connected to the Purchaser's system shall be maintained by the Contractor and submitted to the Engineer in duplicate (one copy being for the Purchaser). Both the Purchaser and the Engineer require this information before the plant will be accepted for initial energising.

Initial energising and all subsequent 'live' tests will be directed by the Engineer, and carried out jointly by the Purchaser, Contractor and Engineer. They will be subject to the Purchaser's standard safety procedures, and all operational switching will be carried out by the Purchaser according to a detailed programme which the Engineer will prepare and which will be agreed in advance between all three parties.

During these 'live' tests the Contractor shall remain responsible for the performance of his plant.
A record of the results of the tests in this category will be made available to the Contractor by the Engineer.

The Contractor shall submit to the Engineer for approval a list of recommended settings for all protection and other types of automatic equipment, not less than thirteen weeks before such equipment is required in commercial service. Where the settings involve discrimination with settings of an existing network or plant supplied under a separate contract, the relevant information will be supplied to the Contractor.

C3.26 EARTHING AND AUXILIARY TRANSFORMERS

The following tests shall be conducted in accordance with the requirements of BS 171 as detailed in Schedule F A.1, as follows:

Routine tests: (a), (b), (e), (f), (g), (j), (l) and BS 171 Clause 38

Type Tests: (q)

Short Circuit Tests: The test shall be conducted at a current equal to the 10 second rated current prior to carrying out test (j)

ANN C.4 DETAIL TECHNICAL SPECIFICATIONS

SCHEDULE	DESCRIPTION
A-1	Scope of Works
A-2	General Particulars of Work
A-3	Commencement Date and Periods of Readiness for Inspection, Access to Site and Completion
B-1	Site Climatological Data
C-1	Manufacturers, Place of Manufacturer, Testing and Inspection
D-1 to D-7	Technical Particulars and Guarantees Required
E-1	Manufacturers Technical Particulars and Guarantees (For Completion by the Tenderer)
F-1	Drawings, Documents, Samples, Operating and Maintenance Instructions

SCHEDULE A-1

1. GENERAL

The Detail Technical Specification (The Schedules) should be read in conjunction with the General Technical Specification (Section ADD C1), the Project Information (Section ADD C2) and the contract drawings. In case of any contradiction between the said specifications, instructions as given in the Detail Specification must be adhered to. Any discrepancy between the contract drawings and the documents must be brought under the attention of the Engineer, who will resolve the matter in writing. All the offered equipment shall comply with the relevant tests as per Section ADD C3.

2. SCOPE OF THE WORKS

All the equipment to be supplied under this contract will be installed outside in open air. This does not include the tap change control panel. The following equipment forms part of this installation:

3. DEFINITE WORK/EQUIPMENT

Two copper winding 10 MVA power transformers with on load tap changers and control and metering panels for De Aar West Substation, Northern Cape Province – Manufactured, transported, installed on site and completely commissioned.

Supply and installation of new 22 kV equipment and the commissioning thereof.

Servicing of existing 22 kV equipment – Two Dog boxes and open air isolators and busbars with associated tests.

Servicing the existing 6.6 kV equipment in the substation – 15 oil circuit breakers with associated tests and calibration of their protection systems.

Integration of the new protection systems with the old and complete testing and calibration.

Provision of a new BTU for the new control and metering panels.

Servicing the 2x BTUs and replace the batteries.

Removal of the old transformers and 22 kV equipment from site and compensating the municipality for the transformers.

4. OPTIONAL WORK/EQUIPMENT

None

5. FACTORY INSPECTION AND TESTS

The tenderer shall allow in his rates in the schedule of prices for the following:

- a) 3 x Copies of operation and maintenance manuals per transformer.
- b) All cost for two (2) delegates of the municipality and to witness the routine tests (test conducted on complete assembled transformer(s)) on the transformers. These should include return airfare costs from Bloemfontein airport to airport closest to factory, vehicle transport from airport to place of test, accommodation in a hotel if so required, equivalent to a City lodge, subsistence costs and other related costs as identified by the contractor.
- c) The contractor must allow at his own discretion for all cost involved for additional factory inspections due to the following matters:
 - transformer(s) failed the routine tests;
 - the transformer(s) does not comply to specification as per a fault list issued by the engineer and require further inspection(s) before the unit(s) leave the factory.

- in the case that factory inspections for more than one transformer are not combined due to bad organisation by the contractor.
- d) In case the transformer design was not yet type tested, the relevant cost to type test one transformer should be quoted in the Schedule of prices. These cost should include the cost for two (2) representatives of the municipality as detailed in (b) and (c) above.

SCHEDULE A-2**GENERAL PARTICULARS OF WORK**

ITEM	DESCRIPTION	PARTICULARS
1.	Location of Site	De Aar, Northern Cape
2.	Altitude above sea level	± 1 280 m
3.	Rated System Voltage	22 kV / 6.6 kV
4.	Rated Short Circuit	See schedule D-1
5.	Current Rating of Busbar Circuits	LV: 900 A (min)
6.	Type of Switching Arrangements	Circuit Breakers
7.	Type of Switchgear	Oil, Vacuum or SF6
8.	Maintenance Equipment to be provided	Yes
9.	Spares	Optional
10.	Quality Assurance Programme Required	Yes
11.	Construction electricity power supply provided on site by Council (Subject to reasonable limit)	Yes
12.	Construction water supply provided on site by Council (Subject to reasonable use)	No
13.	Ablution facilities provided on site by Council	No
14.	Programme Required	Yes – Within 3 weeks

SCHEDULE A-3

COMMENCEMENT DATE AND PERIODS OF READINESS FOR INSPECTION, TESTING, DELIVERY, ACCESS TO SITE AND COMMISSIONING

A detailed program for the manufacture, factory tests, delivery, installation and commissioning should be provided for all the various equipment to be supplied within three weeks from date of official order.

This program should also cater for all the other work as detailed in the specifications and bill of quantities.

SCHEDULE B-1

SITE CLIMATOLOGICAL DATA

ITEM	DESCRIPTION	PARTICULARS
1.	Outdoor temperatures: (°C)	
1.1	Annual mean	38.1
1.2	Maximum	40.2
1.3	Minimum	-7.6
1.4	Highest mean monthly diurnal range	37.2
2.	Wind:	
2.1	Prevailing wind bearing	ESE
2.2	Maximum expected gust speeds:	
2.2.1	50 year return period m/s	50
3.	Maximum solar radiation kW/m ²	1,12
4.	Pollution	Dust storms
5.	Thunderstorm activity:	
5.1	Lightning ground flash density No/km ² /annum	3,9
6.	Mean annual rainfall:	
6.1	July - September mm	12.3
6.2	December - February mm	42.3
7.	Average relative humidity:	
7.1	08h00 %	64
7.2	14h00 %	31

SCHEDULE C-1**MANUFACTURERS AND PLACES OF MANUFACTURE****TESTING & INSPECTION***(Information to be supplied with Tender)*

ITEM	DESCRIPTION	MANUFACTURER	PLACE OF MANUFACTURE	PLACE OF TESTING AND INSPECTION
1.	Main Transformers			
2.	Neutral Earthing Resistors	N/A	N/A	N/A
3.	Core Plates			
4.	Tanks			
5.	Radiators			
6.	Bushing: HV Bushing: LV Bushing: HV Neutral Bushing: LV Neutral			
7.	Current Transformers			
8.	Porcelain for Insulators: HV Porcelain for Insulators: LV			
9.	On-load Tap Changers			
10.	On-Load Tap Changer Control Panel			
11.	Marshalling Kiosk			
12.	Voltage Control Panel	N/A	N/A	N/A
13.	Temperature Indicators			
14.	Oil			
15.	Oil Valves			
16.	Oil Coolers	N/A	N/A	N/A
17.	Air Blowers			
18.	Fan Motors			
19.	Motor Control Gear			
20.	Alarm Devices			
21.	Gas and Oil Actuated Relays			
22.	Tank Over pressure Device			
23.	Surge Arresters (Primary side)			

Indicate N/A where necessary.

Any deviation from this Schedule during the course of the Contract requires the Engineer’s approval.

The Tenderer proposes to employ the following Sub-contractors:

Transport Sub-Contractor	
Erection Sub-Contractor	
Commissioning Sub-Contractor	
Protection Systems Sub-Contractor	

SCHEDULE D-1

GENERAL REQUIREMENTS

NO	DESCRIPTION	UNITS	22 kV SYSTEM
1.	System voltage: Nominal Maximum	kV kV	22 24
2.	System fault levels	kA	20
3.	Short time rating	Sec	3
4.	Frequency	HZ	50
5.	Phase rotation		Non standard
6.	Method of earthing		Effective
7.	Minimum withstand insulation impulse level (at sea level)	kV Crest	150
8.	Dry and wet power frequency voltage	kV min	50
9.	Critical corona voltage	kV	100
10.	Noise level for radio interference voltage test measured at 110 per cent of line to ground operating voltage at 1 000 kHz	uV	<2 500
11.	Pollution design		
11.1	Moderate polluted atmosphere (creepage of 16 mm per kV Um)	mm	N/A
11.2	Moderate polluted atmosphere (creepage of 20 mm per kV Um)	mm	N/A
11.3	Heavily polluted atmosphere (creepage of 25 mm per kV Um)	mm	Yes (600 mm)

SCHEDULE D-2

INFORMATION TO TENDERERS AND SPECIFICATIONS THAT EQUIPMENT MUST COMPLY

THREE PHASE POWER TRANSFORMERS

ITEM	DESCRIPTION	DETAIL
1.	Quantity required	2 x 10MVA
2.	Type of cooling*	100% CMR ONAN
	Alternative design and offer	Forced cooling for 25% overload.
3.	Primary line voltage	22 kV Normal 24 kV Maximum
4.	Secondary voltage	6.6 kV Normal
5.	Fault level of system at transformers operated in parallel	
5.1	Symmetrical RMS current (3 sec)	Primary : 20 kA Secondary : 17 kA
5.2	Asymmetrical peak factor	2.55
6.	Transformer earthing: 6.6kV - Side	Effective (solid)
7.	6.6 kV Earth fault current	10kA
8.	Impulse withstand voltage:	
8.1	Windings: 22 kV windings 6.6 kV windings	150 kV peak 75 kV peak
8.2	Bushings 22 kV 6.6 kV	150 kV peak 75 kV peak
9.	Wet and dry withstand level at power frequency voltage:	
9.1	Windings: 22 kV windings	50 kV
9.2	Bushings 22 kV	50 kV peak
10.	22/6.6kV Impedance (@ 75 Deg C))	10 MVA: 9.4% Minimum on any tap.

11.	<p>Windings:</p> <p>a) insulation HV LV</p> <p>b) Winding connection 22kV 6.6kV</p> <p>c) Vector group and neutral designation</p> <p>d) Tapped winding (HV Neutral)</p> <p>e) Type of tap changer</p>	<p>Fully insulated Fully insulated</p> <p>Delta Star</p> <p>Dyn11 (22/6.6kV)</p> <p>Optional</p> <p>OLTC</p>
12.	On-load tap changer	
12.1	Steps	In 1.25 % steps
12.2	Number of steps	Total of 17 positions
12.3	Minimum Voltage ratio (22kV)	18 700 V to 6 600 V (-15%)
12.4	Maximum Voltage ratio (22kV)	23 100V to 6 600 V (+5%)
12.5	The tap changer must be able to operate as follows	
	Individual (Hand/Auto)	Yes
12.5.1	Automatic and in parallel with each other	Yes
	Remote control	Yes
12.5.2	Complete tap changer control panel	Yes – Should cater for 2 on load tap changers (new and old Ferranti) with circulating current control mechanism
13.	Must transformer and accessories be filled with oil	Yes
14.	Transformer marshalling kiosk: Free standing or transformer mounted	Transformer mounted
15.	Pressure relief valve installed	Yes
16.	Type of breather	Silica Gel
17.	Supply voltage for transformer accessories	230/400 +/- 10% RMS AC
18.	Final paint finish: Transformer Conservator Tap changer control panel	<p>SABS 1091 - G12 (Dark Grey)</p> <p>SABS 1091 - W (White)</p> <p>SABS 1091 -G54 (Light Grey)</p>
19.	Current Transformer on Secondary (6.6kV) neutral	Yes – 300/5; 10VA; 10P10 for use by Standby Earth Fault Relay
20.	Surge arresters required on 22 kV side of transformer	No
21.	Mounting of transformer	Ideally on existing concrete plinth with suitable pitch under-base in open air

22	Optional tests The cost of the following test shall be shown separately in the Schedule of prices. a) Temperature - rise test on one unit b) Impulse test c) Acoustic noise level measurement d) Overload test	Yes Yes Yes Yes
23.	Accessories required	Rating plate Diagram Plate Drain Valves Earthing terminals (LT) 4 x Earthing Terminals (HT Tank) Dehydrating breather Pressure Relief Vent Oil Temperature thermometer Winding temperature thermometer including CT Gas and oil relay - transformer Gas and oil relay - tap changer CT on 6.6kV neutral for standby earth fault relay
24.	Main offer	Transformer with conventional bushing mounted onto transformer top plate.

Please note that the ratings plates and diagram plates (transformer and tap changer) must be metal and engraved/cast solid.

SCHEDULE D-3

POWER TRANSFORMERS: OPERATION, CONTROL, IDENTIFICATION AND ALARM CIRCUITS

NO	DESCRIPTION	FUNCTION	SUPPLY/ CONTROL VOLTAGE	WHERE REQUIRED	TO BE SUPPLIED BY TENDERER
1.	Relay for gas and/or oil activated	a) Alarm b) Trip	30 V DC	HT & LT & TC	Yes
2.	Winding temperature	a) Alarm b) Trip c) Cooler control d) Indication on transformer	30 V DC	On LT & TC	Yes
3.	Oil Temperature	a) Alarm b) Trip c) Indication on transformer	30 V DC	TRF & TC	Yes
4.	Relay for standby earth fault relay	a) Trip			No – Integrate with existing
5.	Fan Fail	a) Alarm	30 V DC		Yes
6.	Tap changer equipment				
6.1	Tap position with corresponding voltage ratio	a) Indication	30 V DC		Yes
6.2	Power supply fail	a) Indication b) Alarm	30 V DC		Yes
6.3	Tap changer fail	a) Indication b) Alarm	30 V DC		Yes
6.4	Tap changer in process	a) Indication b) Alarm	30 V DC		Yes
6.5	Tap changer out of step	a) Indication b) Alarm	30 V DC		Yes
6.6	Voltmeter	a) Indication	± 30 V DC		Yes
7.	Oil level	a) Indication b) Alarm	30 V DC	TRF & TC	Yes

All trip-, alarm, and other indications must be extended to and visible on the tap change control panel. All alarms and trips of the transformer, tap changer, voltage control and cooling apparatus must visible with a flag indication on the tap changer control panel. These contacts must be voltage free and suitable for computer control.

SCHEDULE D-4

COLOUR CODE FOR CONTROL AND INSTRUMENT WIRING

Red White Blue	Phase Connection, whether earthed or unearthed, either directly connected to the primary circuits of CT'S and VT'S
Green	Neutral connections, whether earthed or unearthed insulated earthed wires
Black	Connections in AC circuits other than CT and VT circuits and connections in AC/DC circuits
Grey	All DC circuits

Solid state and electronic equipment:

Required voltage withstand levels for input/output and power supply circuits:

- a) For protection relays: 5 kV impulse to BEMA 219 and 220 VAC for one minute
- b) Other than protection relays: 2 kV impulse to BEMA 219 and 220 VAC for one minute

If approved, the power frequency voltage withstand capability may be achieved by initiating of a protective device requiring resetting or replacement to re-establish the original equipment performance.

SCHEDULE D-5
LABELS AND PLATES

ITEM	DEVICE	LANGUAGES OF INSCRIPTION	COLOURS	PLATE DIMENSIONS mm	LETTER HEIGHT mm	STROKE WIDTH mm
1.	OUTDOOR					
1.1	Circuit/Busbar	English	Black on orange	200 high	150	15
1.2	Phase identification	-	Red/ <u>Yellow</u> /Blue	100 dia	-	-
1.3	Yardgear, items	English	White on black	As required	70	10
1.4	Kiosks, junction boxes	English	Black on white	As required	15	2
2.	INDOOR					
	GIS	English	Black on orange	As required	As required	As required
	Equipment labels	English	Black on orange	As required	15	2
	Panel labels	English	Black on white	As required	25	3
	Panel equipment labels	English	Black on white	As required	5	1
3.	DANGER, CAUTION	English and Afrikaans	Red on white	As required	25	3

SCHEDULE D-6

CLEARANCES FOR OUTDOOR BUSBARS AND CONNECTIONS

RATED SYSTEM VOLTAGE kV											
	12 and below	24	36	72	100	123	145	245	300	362	420
Minimum clearance between live metal and earth (m)	0,20	0,30	0,38	0,70	1,00	1,15	1,30	2,00	2,40	2,80	3,36
Minimum clearance between live metal of different phases (m)	0,25	0,34	0,43	0,82	1,16	1,22	1,50	2,30	2,80	3,40	3,90
Minimum safety clearance between live metal and positions to which access is permissible with other equipment alive (m)	2,60	2,80	2,90	3,00	3,50	3,60	3,80	4,50	4,80	5,30	5,5
Minimum clearance from ground level to base of insulation		2,5 not voltages									

Clearance apply only to equipment not subject to impulse voltage tests.
They apply to conditions of maximum conductor swing and sag

SCHEDULE D-7

EARTH CONDUCTOR SIZES

RATED SHORT CIRCUIT CURRENT kA	8,0	10,0	12,5	16,0	20	25	31,5	40,0
Minimum cross section area for a conductor required to carry full fault current								
3 s rating mm ²	61	76	95	122	153	191	241	306
1 s rating mm ²	35	44	55	71	88	110	139	176
Minimum cross sectional area for a conductor in a mesh system								
3 s rating mm ²	40	51	63	81	102	127	160	204
1 s rating mm ²	23	29	36	47	58	73	92	117

SCHEDULE E-1

MANUFACTURER TECHNICAL PARTICULARS AND GUARANTEES (INFORMATION TO BE SUPPLIED BY THE TENDERER)

22/6.6 kV POWER TRANSFORMER

1.	GUARANTEED PERFORMANCE DATA	10 MVA
1.1	Continuous rating in MVA of windings on any tapping with maximum cooling in service HV MVA LV MVA	
1.2	Continuous rating in MVA of windings on any tapping with ONAN cooling HV MVA LV MVA	
1.3	Maximum current density in windings in A/mm ² HV A/mm ² LV A/mm ²	
1.4	Short-circuit current that transformers is designed to withstand, in per unit of rated current HV p.u. LV p.u.	
1.5	No-load loss on principal tapping in kW at 0.90 Ut kW at 1.00 Ut kW at 1.10 Ut kW	
1.6	Maximum flux density at rate frequency for any voltage ratio specified	
1.7	Magnetising current, at rated frequency, on principal tapping, in percent of rated current at maximum HV rating at 0.90 Ut % at 1.00 Ut % at 1.10 Ut %	
1.8	Load loss (I ² R + stray) at 75°C and at maximum rating in kW a) On principal tapping kW b) On extreme plus tapping kW c) On extreme minus tapping kW	
1.9 Input to coolers with cooling for maximum rated output in service		
1.9a)	Fans in kW kW in A, at rated voltage A	
1.9b)	Oil pumps in kW kW in A, at rated voltage A	
1.10	Ohmic impedance at 75°C and rated frequency based on maximum rated power of HV winding in percent a) On principal tapping % b) On extreme plus tapping % c) On extreme minus tapping %	
1.11	Tolerances applicable to guaranteed impedance, in percent of values a) on principal tapping Max % b) On extreme plus tapping Min% c) On extreme minus tapping %	
1.12	Temperature rises at 1800 m in °C a) Top oil °C b) Windings (by resistance) °C	

1.13	Percentage of total losses that will be supplied for a temperature rise test	%
1.14	Maximum acoustic noise, in dB(A)	
2. GUARANTEED MINIMUM INSULATION		
2.1	Windings	
2.1.1	Impulse withstand test voltage (1.2/50 microsecond full wave) in kV crest HV kV peak LV kV peak	
2.1.2	Sixty second, separate source, withstand test voltage to earth, in kV rms HV kV rms LV kV rms	
2.1.3	Induced ver voltage withstand test between line terminals and, for graded insulation only, between each line terminal and the core, frame and tank connected together and to earth, in kV rms	
2.1.3a)	Between line terminals and earth HV kV rms LV kV rms	
2.1.3b)	Between line terminals HV kV rms LV kV rms	
2.1.3c)	Test frequency Hz	
2.1.3d)	Test duration SEC	
2.2	Main terminal bushings	
2.2.1	Impulse withstand test voltage at sea level, (1,2/50 microsecond full wave) in kV crest HV kV peak LV kV peak HV Neutral kV peak	
2.2.2	Sixty-second, power frequency, wet withstand test voltage at sea level, in kV rms HV kV rms LV kV rms HV Neutral kV rms	
2.2.3	Total creepage distance in mm HV mm LV mm HV Neutral mm	
2.2.4	Protected creepage distance in mm (90° rain) HV mm LV mm HV Neutral mm	
3.	GENERAL INFORMATION	
3.1	Transformer	
3.1.1	Manufacturer	
3.1.1a)	Type of transformer (core or shell)	
3.1.1b)	Number of limbs	
3.1.1c)	Type of cooling (to IEC 76)- see typical load profiles included under Section 4	
3.1.2	Oil quantities in litres:	
3.1.2a)	Transformer tank litre	

3.1.2b)	Coolers and conservator litre	
3.1.2c)	Tap changer litre	
3.1.3	Masses in kg:	
3.1.3a)	Core and windings kg	
3.1.3b)	Core steel kg	
3.1.3c)	Winding copper (insulation excluded) kg	
3.1.3d)	Tank and fittings kg	
3.1.3e)	Coolers kg	
3.1.3f)	Oil kg	
3.1.3g)	Total kg	
3.1.3h)	Largest transportation mass (excl. Oil) kg	
3.1.4	Filling medium of transport	
3.1.5	Overall dimensions in mm:	
3.1.5a)	Complete unit height mm length mm breadth mm	
3.1.5b)	Tank only (if separate cooler bank) height mm length mm breadth mm	
3.1.5c)	Height over HV bushings mm	
3.1.5d)	Wheel gauge mm	
3.1.5e)	Distance between axles mm	
3.1.6	Tank and cooler material thickness in mm	
3.1.6a)	Sides mm	
3.1.6b)	Bottom mm	
3.1.6c)	Top mm	
3.1.6d)	Conservator mm	
3.1.6e)	Cooler tubes mm	
3.1.6f)	Pressed-sheet radiators mm	
3.1.7	Safe withstand vacuum at sea level, absolute internal pressure in kPa of transformer, including tank and cooling apparatus, bushings, conservator and tap changer, including barrier boards kPa	
3.2	Bushings Type (e.g. make and reference number or voltage/current rating) HV LV HV Neutral	

3.3	Motors (forced cooling) Make Type	
3.4	On-load tap changers	
3.4.1	Manufacturer and type designation	
3.4.2	State precise electrical location of tappings	
3.4.3	Diagrammatic arrangement shown on Drawing number	
3.4.4	Tapping range of HV/LV ratio in per unit of the ratio on the principal tapping Maximum p.u. Minimum p.u.	
3.4.5	Number of steps	
3.4.6	Size of steps, in present %	
3.4.7	Number of positions (including transition position)	
3.4.8	Nominal voltage and current rating of tap changer in kV kV in AA	
3.4.9	Nominal voltage and current rating of tap changer	
3.4.9a)	Connectors Selector kV/A Selector switch kV/A Divertor switch kV/A	
3.4.9b)	Resistor kV/A	
3.4.10	Driving motor input in kW kW in AA	
3.4.11	Type of driving motor, i.e. three phase split-phase	
3.4.12	Tap changer over current protection: Have all requirements been met?	
3.5	Contract Drawings Is supply of Contract Drawings guaranteed?	
3.6	Type Test Certificates Type test certificates shall be submitted with the tender for approval, otherwise it will be assumed that no type test certificates for identical units are available.	
3.7	Indicating and Protective Devices Give the make, type and catalogue number for each of the following devices:	
3.7.1	Winding temperature thermometer(s)	
3.7.2	Oil temperature thermometer	
3.7.3	Oil- and gas actuated relay	
3.7.4	Pressure relief device	
3.7.5	Tap changer protective device (detail)	
3.7.6	Dehydrating breathers	
3.7.7	Conservator	
3.7.8	Oil level indicators	

4.	Current transformers Manufacturer Test Certificates	
5.	STATE ANY DEVIATION FROM THIS SPECIFICATION	

SCHEDULE F-1

DRAWINGS, DOCUMENTS, SAMPLES, OPERATING AND MAINTENANCE INSTRUCTIONS

1. The contractor shall supply three (3) copies complete manuals of all the relevant equipment. The manuals shall include drawings, documents, operating and maintenance instructions and any other information that may be deemed necessary by the judgement of the engineer.
2. A sample manual will be submitted to the engineer for approval before the final copies will be compiled.
3. One complete set of as built drawings will be submitted additional with the manuals as well as on electronic format.
4. The manuals will be bind in durable format with suitable plastic covering the protection.
5. No Taking over Certificate will be issued before all the manuals have not yet been received.