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0.2 Amendment Record

Rev No.	Date (YYYY-MM-DD)	Description of Change	Prepared by (Name & Signature)	Approved by (Name & Signature)

FOREWORD

This specification has been prepared by the Research and Development Department in collaboration with the Technical Services Department both of the Kenya Power & Lighting Company Ltd (KPLC) and it lays down requirements for 2.5MVA 33/11kV Power Transformer. The specification is intended for use by KPLC in purchasing the transformer.

It is expected that manufacturers will provide energy efficient standard design transformers that will provide high level of efficiency and significant initial cost saving. The manufacturer shall also submit information which demonstrates satisfactory service experience with products which fall within the scope of this specification.

1. SCOPE

This specification is for newly manufactured outdoor oil type power transformer as described below:

2.5MVA, 33000/11000 volts, 50 Hz, ONAN three phase power transformer (the **Vector Group** shall be stated on the schedule of requirements in the tender).

The specification also covers inspection and test of the transformer as well as schedule of Guaranteed Technical Particulars to be filled, signed by the manufacturer and submitted for tender evaluation.

The specification stipulates the minimum requirements for 2.5MVA 33kV/11kV power transformer acceptable for use in the company and it shall be the responsibility of the Manufacturer to ensure adequacy of the design, good workmanship and good engineering practice in the manufacture of the transformer for KPLC.

The specification does not purport to include all the necessary provisions of a contract.

2. REFERENCES

The following standards contain provisions which, through reference in this text constitute provisions of this specification. Unless otherwise stated, the latest editions (including amendments) apply.

ISO 1461: Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods.

IEC 60076: Power transformers.

IEC 60044: Instrument transformers.

IEC 60296: Specification for unused mineral insulating oil for transformers and switchgear.

IEC 60354: Loading guide for oil – immersed power transformers.

IEC 60214: Tap-changers - Part 1: Performance requirements and test methods, Part 2: Application guide.

IEC 60512: Connectors for electronic equipment

BS 171: Power transformers

BS 381C: Specification for colours for identification coding and special purposes

3. TERMS AND DEFINITIONS

3.1 The terms and definitions given in the reference standards shall apply.

3.2 The term similar rating where used in this specification shall be for transformer ratings within the range 2.5MVA – 100MVA and primary voltage rating of 33kV – 132kV and secondary voltage of 11kV – 33kV.

4. REQUIREMENTS

4.1 Service Conditions

4.1.1 Operating conditions

The transformer shall be suitable for continuous outdoor operation in tropical areas with the following conditions.

(a) Altitude: Up to 2200 metres above sea level.

(b) Temperature: average of +30°C with a minimum of -1°C and max +40 °C

(c) Humidity: up to 95%,

(d) Pollution: Design pollution level to be taken as "Very *Heavy*" (Pollution level IV: 31mm/kV) according to IEC 815.

(e) Isokeraunic level: 180 thunderstorm days per year

4.1.2 System characteristics

a) The primary HV system is 33,000 volts, 3 phase, 3 wire, 50Hz, with neutral point solidly earthed.

b) The secondary MV system is 11,000 volts, 3 phase, 3 wire, 50Hz, with neutral point solidly earthed.

c) The Transformer shall be operated at a high loading factor.

4.2 General Requirements

4.2.1 The transformer shall be outdoor, oil-immersed, of ONAN (Oil Natural Air Natural) classification and core type (lamination stackings). All offers shall comply with the requirements of IEC 60076. Any deviations/additional requirements shall be as stated in this specification.

4.2.2 The transformer shall be a three-phase integral unit.

4.2.3 The transformer shall be of the free breathing type. A dehydrating cobalt free breather of approved design shall be provided.

4.2.4 The transformer and accessories shall be designed to facilitate operation, inspection, maintenance and repairs. All apparatus shall be designed to ensure satisfactory operation under such sudden variations of load and voltage as may be met with under working conditions on the system, including those due to short circuits.

4.2.5 The design shall incorporate every reasonable precaution and provision for the safety of all those concerned in the operation and maintenance of the equipment keeping in view the regulatory requirements in Kenya.

4.2.6 All material used shall be new and of the best quality and of the class most suitable for working under the conditions specified in clause 4.1 and shall withstand the variations of temperatures and atmospheric conditions arising under working conditions without undue distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

4.2.7 Corresponding parts liable to be replaced shall be interchangeable.

4.2.8 All outdoor apparatus, including bushings insulators with their mountings, shall be designed so as to avoid pockets in which water can collect.

4.2.9 All connections and contacts shall be of ample section and surface for carrying continuously the specified currents without undue heating and fixed connections shall be secured by bolts or set screws of ample size, adequately locked. Lock nuts shall be used on stud connections carrying current. All leads from the winding to the terminals and bushings shall be adequately supported to prevent injury from vibration including a systematical pull under short circuit conditions.

4.2.10 All apparatus shall be designed to minimize the risk or accidental short-circuit caused by animals, birds or vermin.

4.2.11 Galvanizing shall be applied by the hot-dipped process to ISO 1461 and for all parts other than steel wires shall consist of a thickness of zinc coating equivalent to not less than 610g of zinc per square meter of surface. The zinc coating shall be smooth, clean and of uniform thickness and free from defects. The preparation of galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material. The quality will be established by tests as per ISO 1461.

4.2.12 All bolts, nuts, and washers exposed to atmosphere and in contact with non-ferrous parts which carry current shall be of phosphor bronze.

4.2.13 If bolts and nuts are placed so that they are inaccessible by means of ordinary spanners, suitable special spanners shall be provided by the supplier.

4.2.14 Except for hardware, which may have to be removed at site, all external surfaces shall receive at least four coats of paint. The total dry film thickness shall be between 100 and 130 microns.

4.2.15 Descriptive labels for mounting indoors or inside cubicles and kiosks shall be of material that will ensure permanence of the lettering. A matt or satin finish shall be provided to avoid dazzle from reflected light. Labels mounted on dark surface shall have white lettering on a black background. Danger notices shall have red lettering on a white background.

4.2.16 All interior surfaces of chambers or kiosks that are in contact with air shall receive at least three coats of paint, of which the topcoat shall be of a light shade.

4.2.17 The design and all materials and processes used in the manufacture of the transformer, shall be such as to reduce to a minimum the risk of the development of acidity in the oil.

4.2.18 Every care shall be taken to ensure that the design and manufacture of the transformers and auxiliary plant shall be such to have minimum noise and vibration

4.4.2 The transformers shall be capable of operation without danger on any particular tapping at the rated MVA when the voltage may vary by ± 10% of the voltage corresponding to the tapping.

4.4.3 The windings and connections as well as the insulating material shall not soften, ooze, shrink or collapse during service. The materials shall be non-catalytic and chemically inactive in transformer oil during service.

4.4.4 No strip conductor wound on edge shall have a width exceeding six times its thickness. The conductors shall be transposed at sufficient intervals to minimize eddy currents and equalize the current and temperature distribution along the windings.

4.4.5 The windings and connections shall be properly braced to withstand shocks during transportation or due to short circuit and other transient conditions during service.

4.4.6 Adequate pre-shrinkage of the coil assembly using pre-compressed press board material having low moisture content for the radial spacer blocks shall be ensured by the manufacturers so that there is no displacement of the radial spacer blocks due to frequent short circuits on the transformers.

4.4.7 All windings after being wound and all fibrous hygroscopic materials used in the construction of the transformer shall be dried under vacuum and impregnated with hot oil.

4.4.8 The coil clamping rings wherever used shall preferably be of flat insulated steel laminations.

4.4.9 The radial spacer blocks must be made of pre-compressed pressboard material, which will not soften while in contact with oil or fray out into fibers or edges. The slots should be so dimensioned that the blocks will not come out of the slots.

4.4.10 All joints shall be brazed/crimped considering the vibrations due to short circuits and load fluctuations.

4.4.11 KPLC will inspect built-up winding for its quality, weight of copper, insulation and overall weight of coil assembly. The size of conductor used for different windings shall also be checked during stage inspection to check the current density.

4.4.12 The transformer shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth, so as to eliminate wave-form distortion and from any possibility of high frequency disturbances, inductive effects or of circulating currents between the neutral points at different transforming stations reaching such a magnitude as to cause interference with communication circuits.

4.4.13 The windings shall be designed to reduce to a minimum the out-of-balance forces in the transformer at all voltage ratios.

4.5 Tapping

4.5.1 Tapping Range

The high voltage winding shall have tappings at ± 2 x 2.5% operated by an off-circuit switch with marked position indicators. Tapping details shall be included on the transformer name plate.

4.5.2. Tapping Method

Tapping shall be carried out by means of an off-load tap changer.

4.6 Core and Flux Density

a) Core

4.6.1 The core shall be constructed from the laminations of high grade cold rolled non-aging, grain oriented silicon steel known as M4 or superior grade CRGO steels of maximum 0.27mm or less lamination thickness especially suitable for transformer core. The grade of CRGO shall be stated in the bid.

4.6.2 The design of the magnetic circuit shall be such as to avoid static discharges, development of short-circuit paths within itself or to the earthed or to the clamping structure and the production of flux components at right angles to the plane of the laminations which may cause local heating.

4.6.3 Every care shall be exercised in the selection, treatment and handling of core steel to ensure that as far is practicable, the laminations are flat and the finally assembled core is free from distortion.

4.6.4 Adequate oil ducts shall be provided in the core for cooling. Tinned copper strip bridging pieces shall be used for maintaining electrical continuity wherever the magnetic circuit is provided into pockets by such ducts or insulating material thicker than 0.25mm.

4.6.5 There shall be no movement of the core assembly relative to the tank during transport, installation as well as in service due to sudden jerks caused by short circuits and fluctuating loads.

4.6.6 All steel sections used for supporting the core shall be thoroughly sand blasted or shot blasted after cutting, drilling and welding. Any non-magnetic or high resistance alloy shall be of established quality.

4.6.7 Adequate lifting lugs shall be provided to enable core and winding to be lifted.

4.6.8 The supporting framework of the Cores shall be so designed as to avoid the presence of pockets which would prevent complete emptying of the tank through the drain valve, or cause trapping of air during filling.

4.6.9 The insulation structure for the core to bolts and core to clamp plate shall be such as to withstand a voltage of at least 2kV AC for one minute.

(b) Flux Density

4.6.10 The primary voltage variation, which may affect the flux density at every tap, shall be kept in view while designing the transformer.

4.6.11 The transformer shall be so designed that the working flux density shall not exceed 1.6 Tesla at normal voltage, frequency & ratio. Tenders with higher flux density than specified shall not be considered.

4.6.12 Tenderers shall indicate the continuous allowable maximum flux for one minute and five seconds.

4.6.13 The limit of flux density at which core material used saturates shall also be stated in the tender. The name and grade of core material shall be stated in the tender.

4.6.14 The successful tenderer shall be required to furnish magnetization curve of the core material, design calculations and such other data/documents deemed fit by the purchaser for being satisfied that flux density is as desired.

NOTE: The above flux density has been specified to meet with the over fluxing of the core due to temporary over voltage of the orders of 25% for one minute and 40% for five seconds that may appear in abnormal conditions such as the one obtained following sudden loss of large loads.

4.7 Losses, Regulation and Impendence

4.7.1 Losses of the transformer shall be stated and shall be subject to tolerances in accordance with IEC 60076. The fixed losses shall be as low as is consistent with good design, reliability and economical use of materials.

4.7.2 Voltage regulation from no-load to continuous rated output at unity power factor, at 0.8 lagging and 0.8 leading power factor with constant voltage across the higher voltage windings shall be stated in the bid.

4.7.3 The impedance voltage at extreme tappings and at principal tapping shall be stated and shall be subject to tolerances in accordance with IEC 60076. The minimum as per IEC 60076-5 for this size of transformer is 6.0%.

4.8 Terminals: Arrangement & Bushings

4.8.1 The 33kV and 11kV windings shall be brought out separately through open bushings of outdoor, weatherproof design in accordance with IEC.

4.8.2 Bushings for 33kV terminals shall be of the solid porcelain type or condenser type (due to insulation withstand requirements). Bushings for 11kV terminals shall be of the solid porcelain type. Each bushing insulator shall be free from defects and shall be marked indelibly with the manufacturer's name or identification mark and year of manufacture.

4.8.3 The neutral bushing of the transformer shall be identical to the corresponding phase terminal bushings.

4.8.4 Spacing and air clearances shall be so co-ordinated as to render the probability of a flashover from the terminal of one winding to the terminal of another winding negligible.

4.8.5 Leakage distance of bushings shall not be less than 31mm/kV, based on operating phase to phase voltage.

4.8.6 Bushing terminals shall be clamp type suitable for both copper and aluminium Busbars of sizes upto 76mm diameter.

4.8.7 Each bushing of the 33kV windings shall be mounted on a turret. Each turret shall be suitable for accommodating at least two sets of current transformers.

4.8.8 Each bushing of the 11kV windings shall be mounted on a turret. Each turret shall be suitable for accommodating at least three sets of current transformers.

4.8.9 Terminal arrangement on the HV and LV sides shall be **N, A, B, C** and **n, a, b, c** respectively (this shall be indicated on drawings submitted for approval before manufacture).

4.9 Current Transformers

Current transformers of suitable rating and class for winding temperature indicators shall be installed to adequately cover the transformer (HV & LV).

4.10 AIR CLEARANCE

4.10.1 When totally assembled, as in service, electrical clearances in air shall be adequate to withstand the assigned impulse withstand test voltages.

4.10.2 Care shall be taken to ensure that all fittings are suitably positioned so as not to interfere with the external connection to the bushing terminals.

4.10.3 Minimum external air clearances shall be as shown under.

Nominal System Voltage between Phases		11kV	33kV
Minimum clearance phase-to-earth and phase-to-neutral	mm	300	485
Minimum clearance phase-to-phase between phases of the same winding	mm	300	485
Minimum clearance between a line terminal of the high voltage winding and a line terminal of a lower voltage winding	mm	300	485
Minimum clearance from live metal to oil pipe-work including conservator and pressure relief device	mm	300	485

4.11. INSULATION LEVELS

The complete transformer arranged for service, shall be capable of withstanding the following voltages and shall comply fully with the requirements of IEC 60076 Part 3, including the latest amendments.

Nominal system voltage **(kV, rms)**	Highest system voltage **(kV, rms)**	Lightning Impulse withstand voltage, dry **(kV, peak)**	Power frequency withstand voltage, wet **(kV, rms)**
33	36	200	95
11	12	95	38

4.12. MARSHALLING KIOSK (Control Box)

4.12.1 The marshalling kiosk shall be of outdoor, IP 55, weatherproof, vermin-proof type with a hinged, lockable door fitted with a glass panel to facilitate reading of oil and winding temperature gauges without opening the door. The kiosk shall be mounted so that its window is approximately 1600mm above ground level; and shall accommodate at least the following items:-

a) Winding temperature indicator for both HV and MV with a maximum pointer drag hand type with a resetting knob and three separately adjustable mercury contacts for alarm and trip.

b) Oil temperature indicator with a maximum pointer drag hand type with a resetting knob and two separately adjustable mercury contacts for alarm and trip.

d) Mechanical isolating switch for the incoming 3 phase, 4 wire, 415V 50Hz supply to the marshalling kiosk. 415 volts and 240 volts socket outlets (square pins) shall also be provided in the kiosk.

e) An internal standard screw type illumination lamp and heater for the kiosk with respective switches. The lamp shall be door switch operated.

f) Wiring, fuses, links, terminal boards and cable glands for bottom entry of multicore cables.

g) Anti-condensation heater with a switch.

h) Thermostat & hygrostat for anti-condensation heater control.

i) MCB control for each of the circuits.

Detailed technical details, drawings, and schematics shall be submitted with the tender documents for evaluation.

4.13. TRANSFORMER TANK AND TANK COVER

4.13.1 The tank shall be of top cover design and shall be constructed of mild steel plates of sufficient thickness and strength and shall be complete with all accessories. It shall be designed so as to allow the complete transformer when filled with oil to be lifted by crane or jacks, transported by road, rail or on water without overstraining any joints and without causing subsequent leakage of oil. The minimum thickness for sides, bottom and top cover shall be 8mm, 20mm and 20mm respectively

4.13.2 The base of the tank shall be so designed that it shall be possible to move the complete transformer unit in any direction without injury when using rollers, and/or plates

4.13.3 The tank and its accessories shall be so designed as to prevent collecting or trapping of gases. Where this cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe. The vent shall have a minimum outside diameter of 19mm except for short pipes which may be 6.35mm minimum inside diameter.

4.13.4 All joints, other than those that may have to be broken shall be welded. Caulking of unsatisfactorily welded joints is forbidden.

4.13.5. The main tank body shall be pressure tested and a certificate issued by the national standards and testing laboratory ascertaining the soundness of all welded joints. A certified copy of the certificate shall be submitted with the tender for evaluation.

4.13.6 Tank shall be provided with lifting lugs suitable for lifting the complete transformer with oil. Further more, a minimum of four accessible jacking positions shall be provided to enable the complete transformer to be raised or lowered using jacks.

4.13.7 The transformer tank and all attachments normally under oil shall be capable of withstanding full vacuum. The oil conservator shall withstand at least 35% full Vacuum.

4.13.8 Tank cover shall be of such a design and construction as to prevent accumulation of water and shall be bolted to the flange on the tank top to form a weatherproof joint.

4.13.9 Inspection openings shall be provided as necessary to give easy access to bushings, tapping switch and for testing or general inspection.

4.13.10 Tank cover and inspection covers shall be provided with suitable lifting arrangements. Inspection covers shall not weigh more than 25 kg apiece.

4.13.11 The tank cover shall be fitted with isolated pockets for oil and winding temperature instrument bulbs. Protection shall be provided where necessary for each capillary tube. The pocket shall be fitted with a captive screwed cap to prevent the ingress of water. Detailed drawings shall be provided.

4.13.12 The pocket shall be located in a position of maximum oil temperature at continuous maximum rating and it shall be possible to insert and remove the instrument bulbs without lowering the oil in the tank.

Gaskets for weather and oil-tight joint faces shall be of synthetic rubber-and-cork composition and shall have a minimum thickness of 5mm, except that where jointing faces are precision-machined thinner gaskets may be used.

4.14. PAINT WORK

Cleaning and painting shall be in accordance with the following requirements. Any deviations in methodology shall be stated and may only be those that will produce demonstrably superior results.

A test report issued by the national standards and testing laboratory shall be produced at the time of acceptance testing of the transformer.

4.14.1 Tanks and Accessories

(a) External and internal surfaces of all transformer tanks and chambers and other fabricated steel items shall be cleaned of scale, rust and surface dirt by blast cleaning or other suitable approved method. After cleaning, these surfaces should be immediately covered with paint.

(b) The exterior shall be thoroughly cleaned by shot blasting or other approved method and given priming coat followed by two coats of contrasting colours of durable weather-resisting paint. The final coat shall be high gloss of shade No. 632 (Admiralty Grey) according to BS 381C.

(c) The interior of all transformer tanks and other oil-filled chambers shall be cleaned of all scale and rust by shot blasting or other approved method. Hot oil resistant varnish on white synthetic enamel paint is to be used for painting the inside of all oil filled chambers, including transformer tanks and CT chambers & covers. The final coat shall be of a light-coloured anti-condensation finish.

4.14.2 Radiators

(a) Radiators shall be thoroughly degreased and treated externally by phospating and/or other rust-inhibiting process.

(b) Radiators shall be flood-painted with a primer and two coats of durable weather and oil resisting paint. The final external coat shall be high gloss of shade No. 632 (Admiralty Grey) according to BS 381C. The total paint thickness shall not be less than 85µm at any point.

4.15. COOLING SYSTEM

4.15.1 Radiators shall be supplied in banks as suitable. Each bank shall be fitted with gate valves with legible labelling for OPEN/CLOSED positions and used for full isolation from the main tank. Each radiator shall have a top and bottom isolating butterfly valve. The radiator design shall exclude accumulation of rainwater.