B.4.2 Specification Document- LOT 3

Specification for Pole-mounted Distribution Transformers (rated at 100 KVA and less).

	ITEM #	DESCRIPTION	QTY ORDER
1	6931615	TRANSFORMER, 25KVA 22KV, 120/240V POLE MOUNT	55

Belize Electricity Limited Revised February 2024

1. SCOPE

This specification applies to single-phase pole-mounted, type ONAN distribution transformers required by the Belize Electricity Limited (referred to as the Owner). These transformers are for use on 60 Hz, 22,000-volt, 13,200-volt, 11,000-volt, delta, and 6, 600 volt three-wire, single point grounded distribution systems.

2. REFERENCE STANDARDS

The provisions of the following standards, the latest revisions, shall apply unless otherwise stated herein. These specifications shall take precedence over any standard quoted herein in case of any conflict.

(a) C57.12.00 IEEE Standard General Requirements for Liquid-Immersed Distribution Power and Regulating Transformers.
(b) ANSI 57.12.20 Standard for Overhead Type Distribution Transformers, 500kVA and smaller.
(c) C57.12.35 Standard for Distribution Transformer Bar Code Labels C57.12.90
(d) Test Code for Liquid-Immersed Distribution, Power and Regulating Transformer and Guide for Short Circuit Testing of Distribution and Power Transformers.
(e) C57.91 IEEE Guide for Loading Mineral Oil-Immersed Transformers.

3. PRODUCT QUALIFICATION

Transformers shall be manufactured in accordance with quality program, approved by a certified registrar to ISO 9001. The design function of the manufacturer shall be approved to ISO 9000, and the production facility shall be similarly approved to ISO 9001.

4. TECHNICAL REQUIREMENTS

4.1 Mechanical Construction

The cores, framework, clamping arrangements and general structure of the transformers shall be capable of withstanding any shocks to which they may be subjected during transport, lifting installation and service. The internal part shall be prevented from moving relative to the tank. Transformer tanks shall be of sealed construction with no breather or conservator. Fittings shall be provided to enable:

1. The core and windings to be lifted.
2. The complete transformer when filled with oil to be lifted without over-straining any joints.
3. Transformer mounting brackets should be capable of withstanding hurricane force winds of 140 mph.

4.2 High Voltage Bushings & Terminals

All pole-mounted transformers shall have two high voltage bushings for connection to over headlines. The high voltage bushing shall be cover-mounted. All parts of the bushing shall be contained within the projected perimeter of the transformer tank in the vicinity of the hanger brackets.

The high voltage bushing shall be of glazed porcelain with eyebolt terminals. The high voltage bushings shall be equipped with clamp type tin coated copper or bronze alloy terminals suitable

for accepting a #6 to #2 AWG stranded or solid copper lead or stranded aluminum lead. The design of the clamp-type terminal shall take into account the cold-flow characteristics of aluminum conductors.

All high voltage bushings shall have a minimum leakage distance of 20mm/kV of rated voltage of the nominal system (line to line) voltage.

Transformers requested for coastal environments shall have high voltage bushings with a minimum creepage distance of 31 mm/kV of the nominal system (line to line) voltage.

4.3 Low Voltage Bushings & Terminals

Low voltage terminals shall be mounted on the tank wall. All terminals shall be clamp type, which are suitable for stranded or solid copper and stranded aluminum conductor. The design of the clamp-type terminal shall take into consideration the cold flow characteristics of aluminum conductor.

The low voltage neutral bushing shall be equipped with clamp-type terminals. The neutral terminal shall be grounded to transformer tank using cooper tape. Both ends of connection shall be bolted using stainless steel hardware.

4.4 Transformer Taps

All pole mounted transformers shall be provided with off-circuit tap changer on the high voltage windings covering a range of 10 percent, comprising 2 x 2 1/2 percent steps (total 5 percent) above and below the principal (normal) tapping. Off circuit tap changer shall be externally operable lever handle type and made of corrosion resistant material. The highest voltage tap shall be tap position 'A'. The tap position switch shall be located on the right side of the low-voltage terminals when viewed from the low voltage terminal side.

4.5 Impedances

Pole-mounted transformers less than 100 kVA shall have impedances less than 2.5%.

4.6 kVA Ratings

The kVA Ratings at rated voltages shall be 5, 10, 25, 50, 75 and 100 for single phase transformers and 15, 30, 45, 75 for three phase transformers.

4.7 Temperature Rise

The maximum temperature rise of oil for sealed transformers shall be 65 degrees centigrade when measured near the top of the main tank and at rated kVA. The maximum average winding temperature rise shall be 65 degrees centigrade. Each transformer shall be capable ofsupplying its specified rated output on site.

4.8 Operating Parameters

Transformers are to be built to withstand the mechanical and thermal stresses caused by the short circuit currents and their corresponding durations as per ANSI/IEEE C57.12.90. Single-phase transformers shall have polarity specified by ANSI and IEEE. A test certificate shall be supplied along with the transformer defining the parameter such as impedance, losses (no load and full load) insulation, rating, vector diagram and contain the data specified by the relevant ANSI standard. (ANSI C57.1200 5.7.1)

4.9 Material

All transformer material is to be new.

4.10 Cover Bands

Cover bands, if supplied, are to be 304L stainless steel. The Cover Clamp design must have a protective barrier between the clamp and the cover to protect the paint finish.

4.11 Lightning Arrestors & Mounting Provisions

All transformers shall be fitted with lightning arrestors with ratings as specified in Table 2. Surge arrester mounting bosses shall be provided on the transformer tank wall in the same sector as the High Voltage bushings. 'Heavy Duty' surge arresters shall be provided on all transformers as per ratings on Table 2. Creepage distance specified for transformer bushing under Section 4.2 shall also be applicable for the provision of lightning arrestors.

4.12 Hardware

All fastening hardware used to secure the cover and external connections is to be 304L stainless steel.

4.13 Tank Material

The transformer tank material shall be mild steel. ***The tank material for transformers designated for Coastal Environment shall be unpainted 304L stainless steel.***

4.14 Cooling

Transformers are to be supplied without additional exterior cooling (no fins, cooling tubes or radiators)

4.15 Drawings

Proposals ***must*** include two copies of the detailed engineering drawing for each size unit tendered, identifying dimensions, weight, and type of material.

Proposals shall also include, for each unit:

a. No load losses, in watts, at 100% rated voltage

b. Load losses and impedance at rated current and on the rated voltage.

4.16 Welding

All welds shall extend around the complete perimeter of the part to be welded in order to ensure there are no hidden areas that cannot be properly painted. This includes the transformer's support for securing the cover and the brackets.

4.17 Pressure Relief

A pull-ring type automatic self-resealing pressure relief shall be provided. The opening pressure of the pressure relief means shall be less than the withstand pressure of the tank structure. If a valve is used, it shall have a minimum flow rate of 16 l/s at a gauge pressure of 100 kPa. It shall be located on the right side of the transformer when viewed from the secondary terminals. It shall not be located in the vicinity of the hanger brackets.

4.18 Exterior Finish

The exterior finish shall confirm to ANSI C57.12.28 and the salt spray test acceptance criteria shall be 1,500 hrs. The color of the tank and bushings shall be light grey number 70, Munsell notation 5BG7.0/.04. ***Stainless steel transformer tanks designated for coastal environments shall not be painted.***

4.19 Liquid Insulant

The liquid insulant shall be mineral oil. The mineral oil shall be Class B Type I as minimum; Class A Type II is acceptable. When the transformer is shipped, the dielectric strength shall not be less than 40 kV, when tested in accordance with ASTM D1816 using a 2mm electrode spacing.

4.20 Tank Grounding

A one-half inch diameter, 13NC 91/2-13 NC0 tapped hole or boss, in either case with unpainted thread, shall be provided at the centre of the left side lower mounting bracket, as viewed from the low voltage side, for tank grounds connection. One bronze clamp-type terminal suitable to accommodate conductor sizes from #6 to #2 AWG, shall be provided and secured to the transformer at the tapped hole or boss.

4.21 Gaskets

Gasket material shall not be affected by the insulating liquid. The design of the cover and gaskets shall be retained in position so that they will not be damaged when the cover is removed or replaced.

4.22 Transformer Nameplate

Transformers will be provided with a nameplate and connection diagram that shall be legible for the life of the transformer under normal usage. The nameplate shall be mounted on the top mounting bracket on the right side of the tank when looked at from the low voltage terminal side.

The following information shall be shown on the nameplate:

a. POLE-MOUNT TYPE ONAN 60 Hz, 65°C.
b. Rating in kilovolt amperes.

c. Identification number (e.g. serial number).
d. Percent impedance at 85°C (one decimal minimum).
e. Oil volume in Gallons.
f. BIL (Basic Insulation Level)
g. Total mass (including liquid)
h. Rated high and low voltages.
i. Tap voltages in percent of rated voltage and corresponding position of tap switch.
j. Terminal markings including physical position of switch.
k. Terminal markings including physical identification and diagram of connection.
l. Year and month of manufacture.
m. Name of manufacturer and address.

5. Loss Evaluations and Penalty Formula

The total annual loss for core and copper losses are defined as follows:

The total annual cost of core loss is:

$$C_{cl} = (Sr + C_{kwh}h)\ kW_{ci}$$

where:

C_{cl}	= annual cost of core loss in dollars
S	= system investment per kVA of load
r	= fixed charge rate on capital investment in per unit
C_{kwh}	= incremental cost of energy generation per kWh
h	= number of hours per year the transformer is energized
kW_{cl}	= transformer core loss in kilowatts

The total annual cost of copper loss is then:

$$C_{\mathrm{cu}} = (Sr + C_{p\text{-}kwh}hf)\ P^2\mathrm{kW}_{\mathrm{cu}}$$

where:

S	= system investment per KVA of load in dollars per kVA
r	= rate of fixed charge in per unit
$C_{p\text{-}kwh}$	= incremental cost at peak of energy generation per kWh
h	= number of hours per year
fP	= loss factor in per unit
kW_{cu}	= peak load on the transformer in per unit
	= transformer copper loss at rated load and kW

If copper losses of a group of distribution transformers were being evaluated, the fact that the peak loads on the individual transformers do not occur simultaneously must be considered. Hence, the peak system demand due to copper losses will not be equal to the sum of the individual transformer peak losses, but it will be the peak loss times a "coincidence factor".

To use the above formula some data input data are

required. These are defined as:

System Investment per kVA of load in BZD$ per kVA	$1,681.80
Rate of fixed charge in per unit	0.1529
Incremental cost of Energy generation per kWh Incremental	$0.126
cost at peak of Energy generation per kWh Number of	$0.3993
hours in a year	8760
Loss factor	0.49075
Peak load on transformer in per unit	1
Present Worth Factor	5.766

Notes:

a. The loss factor is the ratio of the average loss to the peak loss and is computed as **$0.15xLF+0.85xLF^2$**. LF is the load factor = 0.66
b. Coincidence factor is assumed to be

1. The formula for evaluation:

a. Transformer annual losses to be computed based on the Westinghouse formula as stated above.
b. Add the core and copper loss together.
c. Convert to total cost by adding core and copper loss and multiply by a Present Worth Factor for 15 years at 0.1529% - 5.766.
d. Evaluated price per transformer = Base Price + (Core Loss + Copper Loss) x PWF.

6. Loss Evaluation Penalty

If the final measured loss contained in the certified test certificate exceeds those contained in the tender a penalty will be applied to the item in the payment to the Supplier by subtracting from the contract price the difference between the quoted loss and the certified loss according to the above formula. There shall be no extra payment should the loss be less than the quoted value.

7. Quality Assurance

The manufacturer shall provide the utility with evidence that the quality assurance program in accordance with Item 3, has been established and is being maintained. The purchaser reserves the right to appoint an outside inspector to verify the Manufacturer's quality assurance program, at the expense of the Manufacturer, when, in the opinion of the utility, experience indicates questionable quality control.

8. Tolerances

8.1 Tolerances for Ratio

The turns ratios between windings shall be such that, with the transformer at no load and with rated voltage on the winding with the least number of turns, the voltages of all other windings and all tap connections shall be within 0.5% of the nameplate voltages. However, when the volts per turn of the winding exceeds 0.5% of the nameplate voltage, the turns ratio of the winding on all tap connections shall be to the nearest turn.

For three-phase Y-connected windings, this tolerance applies to the phase-to-neutral voltage. When the phase-to-neutral voltage is not explicitly marked on the nameplate, the rated phase-to- neutral voltage shall be calculated by dividing the phase-to-phase voltage markings by $\sqrt{3}$.

8.2 Tolerances for Impedance

The tolerances for impedance shall be as follows:

a. The impedance of a two-winding transformer with an impedance voltage larger than 2.5% shall have a tolerance of ±7.5% of the specified value and those with an impedance voltage of 2.5% or less shall have a tolerance of ±10% of the specified value. Differences of impedance between duplicate two-winding transformers, when two or more units of a given rating are produced by one manufacturer at the same time, shall not exceed 7.5% of the specified value.
b. The impedance of a transformer having three or more windings, or having zigzag windings, shall have a tolerance of ±10% of the specified value. Differences of impedance between duplicate three-winding or zigzag transformers, when two or more units of a given rating are produced by one manufacturer at the same time, shall not exceed 10% of the specified value.
c. The impedance of an autotransformer shall have a tolerance of ±10% of the specified value. Differences of impedance between duplicate autotransformers, when two or more units of a given rating are produced by one manufacturer at the same time, shall not exceed 10% of the specified value.
d. Transformers shall be considered suitable for operation in parallel when reactance comes within the limitations of the foregoing paragraphs, provided that turns ratios and other controlling characteristics are suitable for such operation.

9. Packaging

Each completed transformer shall be placed on an individual pallet and secured with tie down straps.

10. Guarantee

The manufacturer shall guarantee the transformer supplied to be in accordance with the requirements of this specification and shall supply factory test data in support thereof. If any part of the transformer fails or becomes defective due to faulty workmanship, material or design within a period of one year after the transformer 9 is placed in service, the transformer shall be repaired or manufacturer/supplier at no cost to the Purchaser. replaced by the

11. Shipment

Transformers should be delivered on heat-treated wood pallets.

Table 1: Ratings for Single-phase and three-phase transformers

Transformer high voltage rating (V)	Minimum BIL (KV)	Minimum KVA rating (single-phase) 120/240V	Minimum KVA rating (three-phase) 120/208V	Minimum KVA rating (three-phase) 277/480V
6,600	75	10	45	45
11,000	95	10	45	45
13,200	95	10	45	45
22,000	125	10	45	45
34,500	200	10	45	45

Table 2. Arrester ratings for transformers

Transformer High voltage rating (V)	Lightning arrester rating (KV)	MCOV rating (KV)	IEEE class	IEC class	Material
6,600	9	7.65	Normal duty	Distribution medium	Polymer
11,000	12	12.7	Normal duty	Distribution medium	Polymer
13,200	15	15.3	Normal duty	Distribution medium	Polymer
22,000	24	24.4	Normal duty	Distribution medium	Polymer
34,500	36	39	Heavy duty	Distribution high	Polymer