



SPECIFICATION FOR PAD-MOUNTED DISTRIBUTION TRANSFORMERS

(RATED AT 1500 KVA AND LESS)

ITEM DESCRIPTION	ON ORDER	NOTE
Transformer - 150 KVA - 22KV - 480Y/277 V, Pad mount Three phase	1	Use will be inland.
TRANSFORMER, 75KVA 22KV, 480Y/277V PADMOUNT Three Phase	1	Use will be inland.

Belize Electricity Limited
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SCOPE

This specification applies to single and three-phase pad-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 volts [three-wire, single point grounded wye] distribution systems.

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.

IMPEDANCES

Pad-mounted transformers of rating 1500 kVA or less shall have impedances less than 4%.

HIGH VOLTAGE BUSHINGS & TERMINALS

All pad-mounted transformers shall have externally clamped high voltage bushing wells for load break inserts. None of the high voltage bushings are connected directly to the ground.

LOW VOLTAGE BUSHINGS & TERMINALS

All pad-mounted transformers shall have spade LV terminals and spade support when the current is 1400 amps or greater.

1. DESIGN REQUIREMENTS

1.1 DESIGN CRITERIA

Without limiting the generality of other requirements of these specifications, all works specified herein shall conform to or exceed the applicable requirements of the most recent edition of the referenced standards, provided that wherever the provisions of said publications are in conflict with the requirements specified herein, the more stringent shall apply. The referenced standards are:

1. ANSI C57.12.00, C57.12.8, C57.12.22, C57.12.26, C57.12.28, C57.12.29, C57.12.70, C57.12.90, C57.91, C57.13 and other applicable ANSI standards.
2. NEMA TR-1 and applicable ASTM, IEEE, AISC, ASME, NEC, NESC and other NEMA standards.

The transformers shall comply with the following design criteria:

Type	Pad-mounted
transformer	
Design	Dead front
Number of windings	2
Continuous ratings on all taps, MVA to be	individually specified.
Number of phases	3 and single (based on specific order)
Frequency, Hz	60
Rated high voltage, kV	to be individually specified.
Rated low voltage, kV	to be individually specified.
Cooling	ONAN
Temperature, °C	
Maximum ambient temperature	40
Maximum temperature rise of any winding at rated capacity	65
Phase displacement HV-LV	Dyn 1
Winding connection	3

	Delta
High voltage	
Low voltage	Grounded Wye- three phase
LV Terminal conductor	Standard NEMA type rotatable tin-plated copper spade per ANSI requirements
Maximum noise level as per NEMA TR1-1980	
Equipment finish	
Type	Coastal finish
Color	Forest green or light
Munsell notation	grey5 BG 7.0/0.4
Tank ground pads	1 in HV, 1 in LV

Instrument casings for oil level gauges and temperature indicators shall be made from corrosion-resistant materials. Aluminum will not be accepted.

2. TRANSFORMER NAMEPLATE

Nameplate shall be stainless steel. Aluminum will not be accepted. 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 in the low voltage side of the transformer tank in accordance with IEEE C57.12.00. Unless otherwise specified, the minimum information shown on the nameplate shall be that specified below.

- a. Serial number
- b. Class (ONAN, ONAF, etc)
- c. Number of Phase
- d. Frequency
- e. KVA rating
- f. Voltage rating
- g. Tap voltages
- h. Temperature rise, degrees C Polarity
- i. (single phase transformer) Phasor
- j. diagram (polyphase transformer)
- k. Percent impedance
- l. Basic lightning impulse insulation levels (BIL)
- m. Approximate total mass in kg (pounds)
- n. Connection diagram
- o. Name of manufacturer
- p. Type of insulating liquid (generic name preferred)

3. FABRICATION AND MANUFACTURE

• Noise Level

The maximum noise level of the transformer shall be in accordance with NEMA TR1-1980.

• Overloads

Transformer and all component parts shall be capable of overload operation in accordance with the referenced standards.

• Short Circuits

Transformer and all component parts shall be capable of withstanding mechanical and thermal stresses caused by short circuits in accordance with ANSI C57.12.90.

• Radio Interference

Maximum radio influence voltage level of transformer shall be in accordance with ANSI standards.

• Insulation

Thermally upgraded insulation shall be used to permit continuous operation of the transformer with an average winding temperature rise of 65°C over a 40°C ambient for a total (average winding) temperature by resistance of 105°C.

• Basic lightning impulse insulation Level (BIL)

BIL is to be provided as per IEEE C57.12.00.

• KVA Ratings

The KVA rating at rated voltage shall be 65, 145 for three-phase.

• Windings

Transformer windings shall be manufactured of aluminum.

• Taps

Provide power transformers with off-circuit taps rated for full capacity.

The taps shall be controlled by an off-circuit tap changer having an *external* operating handle accessible from ground level, tap position indicator and provision for padlocking in each tap position.

The high voltage windings shall have two, 2-1/2% no load taps above and two, 2-1/2% no load taps below. The highest voltage tap shall be tap position „E“. The tap position switch shall be located on the high voltage side of the transformer terminals when viewed from the door opening.

4. ACCESSORIES

⚡ Bushing Wells and Inserts

The single and Three phase pad-mounted units shall be fitted with externally mounted high voltage bushing wells for 25 kV rated load break or non-load break inserts or load break feed thru inserts similar to ELASTIMOLD 2702A1 insert, regardless of the transformer primary voltage rating. It is preferable that a single set of bushing be available for three phase transformer units and that the rating of the HV accessories be suitable for installing loop feed using ELASTIMOLD 2702A1 feed thru inserts and that the dimensions of the HV compartment be suitably sized to house the insert.

⚡ Indicators

The pad-mounted transformer must have

- a. An oil temperature indicator similar to one manufactured by QUALITROL.
- b. An oil level indicator mounted in the LV cabinet.
- c. Tank ground strap and a neutral ground strap.

⚡ Oil

The transformer shall be supplied filled with oil. The oil shall comply with referenced standards and shall contain **no PCBs**. Supply certificates from an independent laboratory showing that oil shipped to site and oil used during in-plant testing has no PCB content.

⚡ Gaskets

Gaskets shall be of cork neoprene, nitrile rubber or approved equivalent. Gasket stops shall be provided to prevent over-compression of the gasket material.

Hardware

Nuts, bolts, etc. 10 mm diameter and below shall be made of a solid corrosion-resistant material such as Everdur or approved equivalent.

Nuts, bolts, etc. above 10 mm diameter shall have a corrosion-resistant finish such as cadmium plating or approved equivalent.

Finish

All external surfaces except non-ferrous metal, galvanized steel, finished or machined surfaces shall be painted with one coat of primer and two finish coats of an approved weatherproof high quality paint. The overall thickness of the dried finish exclusive of metal treatment shall not be less than 0.075 mm (0.003 inches).

The interior of the transformer tank shall be painted with an oil-resistant paint of white or other approved light color.

Tank Materials

The transformer tank materials shall be mild steel. ***The tank material for transformers designated for Coastal Environments shall be painted 304L stainless steel.***

Specific Requirements

The transformer housing shall be designed to be tamper-resistant to prevent unauthorized access in accordance with the latest revision of the Western Underground Committee Guide 2.13, entitled "Security for Pad mounted Equipment Enclosures."

The transformer shall have specific dimensions for Type B transformers for loop-feed systems as defined in the latest revision of ANSI Standard C57.12.26.

The transformer shall be equipped with three externally clamped primary bolted-on bushing wells rated for 200A in accordance with the latest revision of the ANSI/IEEE Standard 386. The bushing wells shall be equipped with 200-A load break bushing inserts to accommodate load break elbows for sectionalizing cables in a loop-feed primary system.

The low-voltage neutral shall have a fully insulated bushing. A removable ground strap sized for the rating of the transformer shall be provided and connected between the neutral bushing terminal and a ground terminal in the compartment on the tank of the transformer.

The high and low voltage compartments shall each have a ground terminal on the transformer tank equipped with an eyebolt connector designed to accept a 1/0 barecopper wire. A ground pad shall be provided on the external surface of the transformer tank.

A metal barrier shall separate the high and low voltage terminals for the transformer windings.

The transformer shall be equipped with RTE Bay-O-Net, or approved equivalent, externally replaceable overload-sensing primary fuses, for coordinated overload and secondary fault protection, coordinated and in series with the applicable partial-range current-limiting fuses. The current-limiting fuses shall not operate on secondary short circuits or transformer overloads. The current-limiting fuses shall be installed under oil inside the transformer tank. Each load-sensing and current-limiting fuse device shall be capable of withstanding line to line system recovery voltage across an open fuse.

The transformer shall be equipped with oil drip shields directly below the Bay-O-Net fuse holders, to prevent oil dripping on the primary elbows or bushings during removal of the fuses.

The transformer tank shall have a removable cover or hand hole of the tamper-resistant design.

A Qualitrol no. 202-032-01 automatic pressure relief device with an operation indication or approved equivalent, shall be supplied on the transformer.

The transformer tank shall be equipped with a 1-in oil drain valve with a built-in oil sampling device.

A fill plug housed in the LV compartment.

- **Materials**

All material is to be new.

5. DRAWINGS

Proposals shall 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.

6. LOSSES EVALUATION

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

follows: The total annual cost of core loss is:

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

where:

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

The total annual cost of copper loss is

$$\text{then: } C_{cu} = (Sr + C_{p-kwh}hf) P^2 kW_{cu}$$

where:

S = system investment per kva of load in dollars per kVA
 r = rate of fixed charge in per unit
 C_{p-kwh} = incremental cost at peak of energy generation per kWh
 f \$/kW_{cu} = number of hours per year
= loss factor in per unit
= 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 input data are required.

These are defined as:

System investment per kVA of load in dollars per kVA	\$1,681.8
Rate of fixed charge in per unit	0
Incremental cost of energy generation per kWh	0.1529
Incremental cost at peak of energy generation per kWh	\$0.126
Number of hours in a year	\$0.3993
Loss factor	8760
Peak load on transformer in per unit	0.49075
Present Worth Factor	1
	5.766

Notes

- All prices are in US dollars.
- The loss factor is the ratio of the average loss to the peak loss and is computed as $0.15 \times LF + 0.85 \times LF^2$. LF is the load factor = 0.66
- Peak load should be coincidence factor but we have assumed this to be 1.
- The cost of peak load energy will change from month to month.

The formula for evaluation:

- Use the formula to compute annual loss.
- Add the core and copper loss.
- Convert to total cost by adding core and copper loss and multiply by a presentworth factor for 15 years at 15.29% - 5.766
- Evaluated price per transformer = Base Price + (Core Loss + Copper Loss) xPWF.

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.

6. TOLERANCES

- **For turn 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 $\sqrt{3}$.

Tolerances for Impedance

The tolerances for impedance shall be as follows:

- e. The impedance of a two-winding transformer with an impedance voltage larger than 2.5% shall have a tolerance of $\pm 7.5\%$ of the specified value and those with an impedance voltage of 2.5% or less shall have a tolerance of $\pm 10\%$ 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.
- f. The impedance of a transformer having three or more windings, or having zigzag windings, shall have a tolerance of $\pm 10\%$ 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.
- g. The impedance of an autotransformer shall have a tolerance of $\pm 10\%$ 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.

- h. Transformers shall be considered suitable for operation in parallel when reactance come within the limitations of the foregoing paragraphs, provided that turns ratios and other controlling characteristics are suitable for such operation.

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. 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 is placed in service, the transformer shall be repaired or replaced by the manufacturer/supplier at no cost to the purchaser.

SCHEMATICS



