Saudi Electricity Company	الشركة السعودية للكهرباء

SEC DISTRIBUTION MATERIALS SPECIFICATION	51-SDMS-02
	DATE: 25-09-2010G

51-SDMS-02

SPECIFICATIONS

FOR

DISTRIBUTION TRANSFORMERS UP TO 36KV 400/230 VOLTS

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1.0 SCOPE

This Saudi Electricity Company (SEC) Distribution Material Specification (SDMS) specifies the minimum technical requirements in respect of design, engineering, manufacturing, inspection, testing and performance of outdoor/indoor mineral oil immersed, three (3) phase distribution transformers intended to be used in 13.8kV and 33kV system of the Saudi Electric Company (SEC), Saudi Arabia.
It is not intended that this specification shall apply to dry type transformers. However, it can be considered as reference for transformers used in package/unit substations.

2.0 CROSS REFERENCES

This SDMS shall always be read in conjunction with the SEC specification 01-SDMS-01 titled "General Requirements for All Equipment/Material" latest revision, which shall be considered as an integral part of this SDMS. This SDMS shall also be read in conjunction with SEC Purchase Order (PO) requirements.

3.0 APPLICABLE CODES AND STANDARDS

The latest revisions of the following Codes and Standards listed shall be applicable for the equipment/material covered in this SDMS. In case of conflict, the vendor/manufacturer may propose equipment/material conforming to one group of Industry Codes and Standards quoted hereunder without jeopardizing the requirements of this SDMS.

3.1	SSA 422	Power Transformers (SASO – Saudi Arabian Standards Organization)
3.2	SSA 421	Testing Methods for Power Transformers
3.3	I E C 60076	Power Transformers
3.4	I E C 60296	Specification for New Insulating Oils for Transformers and Switchgear
3.5	I E C 60551	Measurement of transformer and reactor sound level
3.6	I E C 60137	Bushings for alternating voltages above 1kV
3.7	I E C 60354	Loading guide for oil-immersed Transformers

4.0 DESIGN AND CONSTRUCTION REQUIREMENTS

4.1 **General:**
Transformers shall be suitable for outdoor/indoor usage, three phase, having two separate mineral oil immersed copper windings in hermetically sealed mild steel tanks. It should be suitable for base mounting with MV & LV bushings inside cable boxes for pad mounted, or on overhead line structure

(base or side mounting) with top MV bushings and side LV bushings in cable box.

4.2 **Ratings:**

All transformers shall be designed for secondary voltage of 400/230Volts.
The standard ratings shall be:
Pole mounted: 50, 100, 200, and 300 KVA
Pad mounted: 300, 500, 1000, and 1500 KVA

Transformer rated KVA shall be calculated on the following assumptions:
Constant flux regulation.
Continuous steady load.
Design temperature of 30ºC.
50ºC average winding temperature rise and 45ºC top oil temperature rise limits above ambient.
Maximum winding hot spot temperature of 98ºC.

4.3 **Losses:**

4.3.1 Capitalization Formula:

Transformer vendors/manufacturers shall be evaluated by using the following capitalization formula:

$$T = P + 11000 \times C + 4000 \times W$$

Where T = Total capitalized cost in Saudi Riyals
P = Initial cost of transformer in Saudi Riyals
C = Iron (Core) losses in kW (No-Load Losses)
W = Copper (Winding) losses in kW at rated load (Load Losses)

4.3.2 Maximum Losses:

The indicated figures below are the maximum acceptable values.
Transformers with losses exceeding these values will be rejected.

Transformer Rating	No-Load Losses (Watts)	Load Losses (Watts)
Up to 100KVA	250	1500
200KVA	380	2200
300KVA	520	3200
500KVA	750	4700
1000KVA	1100	9000
1500KVA	1700	14000

4.3.3 Guaranteed Values:
No-load and Load losses submitted in the tender shall be treated as guaranteed values. Any increase in these values at the time of testing shall not be accepted.

4.4 **Emergency Loading:**
After thermal equilibrium has been reached at 75% of rated load, the transformer shall be capable of sustaining the overload conditions listed in the following table without the transformer winding hot spot temperature exceeding 140ºC:

Load Percent of rating (%)	Minimum Duration in Minutes at Ambient Temperature of	
	30ºC	40ºC
133	240	155
150	98	65

The supplier shall demonstrate by test and calculation that these requirements are met.

4.5 **Cooling:**
Cooling shall be by natural circulation of oil internal to the transformer and external air i.e. ONAN.

4.6 **Transformer Oil:**
Transformer shall be supplied initially filled of Class 1 uninhibited transformer Mineral oil complying with IEC 60296.

4.7 **Tap Changer:**
4.7.1 M.V.
Transformer shall be fitted with a lockable 5 positions, manual, off-load Tap Changer having the following taps:

Tap No. 1	+ 5%	of rated voltage
Tap No. 2	+ 2 ½ %	of rated voltage
Tap No. 3	0 %	of rated voltage
Tap No. 4	- 2 ½ %	of rated voltage
Tap No. 5	- 5 %	of rated voltage

4.8 **Vector Group:**
Unless otherwise specified, the transformer shall be connected delta-star in accordance with vector group reference Dyn11.

4.9 **Impedance Voltage:**
The impedance voltage at normal tap shall be 4% for transformers up to 300KVA, 5% for 500 KVA and 6% for transformers greater than 500KVA.

4.10 **Temperature Rise:**
At the rated power the transformer shall comply with the following Maximum temperature rises:

Top oil	45°C Max.
Winding	50°C Max.
Hot Spot	98°C Max.
Avg. temp. due to short circuit	250°C Max.

4.11 **Noise Level:**
The noise level emitted by a transformer, at full load, shall not exceed 48 dB. Measurements shall be in accordance with IEC Standard 60551.

4.12 **Short Circuit Level:**
The short circuit current that transformer should withstand for two seconds is:
25 times full load current for ratings of 50, 100, 200, 300KVA
20 times full load current for rating of 500KVA
17 times full load current for ratings of 1000 & 1500KVA

4.13 **Degree of Protection:**
Transformer and its cable boxes shall be designed to have adequate protection level suitable for outdoor usage.

4.14 **Dimensions:**
The maximum dimensions of the transformer shall be as follows:

For pole mounted transformers:

Rating (KVA)	Width (mm)	Depth (mm)	Height (mm)
50 & 100	1350	900	1450
200 & 300	1450	1100	1700

For pad mounted transformers:

Rating (KVA)	Width (mm)	Depth (mm)	Height (mm)
300 & 500	1700	1400	1600
1000	1900	1600	1900
1500	1920	1700	2000

The above dimensions are not applicable for transformers used in Package/Unit substations.

4.15 **Tanks**

4.15.1 Tank fabrication:

i. Transformer tanks shall be made of mild steel of 3mm thickness, and shall not leak. The criterion of leakage shall be discoloration by oil of white wash applied externally to the suspended part at an oil temperature 90ºC or other method approved by SEC.
ii. All pipes, radiators, fins, or corrugations that are welded to the tank shall be externally welded.
iii. The tank shall be of hermetically sealed construction, and shall withstand an internal pressure of 30kN/m² without permanent deformation.
iv. Top cover shall be bolted type and fitted with neoprene cork seals suitable for temperatures as specified in this specification. The cover shall be in such a design and construction as to prevent the ingress of moisture and accumulation of rainwater.

4.15.2 Tank corrosion protection and finish:

i. The transformer tank and its accessories shall be adequately protected against corrosion.
ii. Hot dip galvanizing followed by painting is the preferred method of base protection. Otherwise tanks shall be shot-blasted and then immediately zinc sprayed to an average weight deposit of not less than 550g/m², followed by zinc or zinc chromate based primary paint, and two coats of durable oil and weather resisting paint. Finish color shall be Cement Grey, RAL 7033. All bolts and fixings shall be suitably protected against corrosion.

Refer to SEC specification for paint (Color, Tests and Maintenance).

4.16 **MV bushings:**

Bushings shall generally comply with the requirements of IEC Standard 60137.

The MV bushings shall be labeled U, V, W by using indelible black color paint. Phase identification by adhesive stickers is not acceptable.

4.17 **Pole-mounted transformer:**

The MV terminals shall be 3 porcelain bushings fitted on the top of the transformer tank. Bushings shall be of the outdoors-weatherproof type and provided with M12 screwed stems and nuts with washers.

4.17.1 Pad-mounted transformer:

The MV terminals shall be 3 bushings fitted on the side of the transformer tank inside a termination box with cable entry coming vertically from bottom. The box shall include cable clamps, grounding connectors, and its size shall be adequate for terminating three single core or one three-core MV cables as per SEC specification 12-SDMS-03, sizes 50mm² to 70mm² Aluminum or Copper with heat/cold/pre-mold termination. It shall be single gasketed removable bolted cover. Bottom plate shall be in two halves with cable entries steel knockouts suitable for above cables. Loose rubber bushings shall be provided inside of this box for these knockouts.

Bushings shall be provided with M12 screwed stems and nuts with washers. Dry type termination is used.

4.18 **LV bushings/terminals:**

The low voltage leads of all transformers shall be brought out of the transformer tank on the opposite side of the HV bushings inside a cable box. The LV bushings shall be connected to conductors/cables by means of cable lugs, (SEC shall provide cable lugs). However, the manufacturer shall supply all bolts, nuts and washers. The LV bushings shall be labeled u, v, w, n by using indelible black color paint. Phase identification by adhesive stickers is not acceptable.

4.18.1 Pole-mounted transformer:

The LV terminals shall be suitable to connect the following Aluminum cables:

Transformer rating KVA	Cables to be connected Up to
50 & 100	one 4cx185mm²
200 & 300	two 4cx185mm²

See Spec. 12-SDMS-02 for details of cable lug.

4.18.2 Pad-mounted transformer:

LV bushings/terminals shall be brought out of the transformer tank inside a cable box on the opposite side of the HV box with cable entry coming vertically from bottom, box shall have removable front and bottom sides.

The LV terminals shall be suitable to connect the following Copper cables:

Transformer rating KVA	Cables per phase to be connected	Cables for neutral to be connected
300 & 500	one 1cx630mm²	one 1cx630mm²
1000	two 1cx630mm²	
1500	three 1cx630mm²	two 1cx630mm²

See Spec. 12-SDMS-02 for details of cable lug.

4.19 **Supplementary Fittings**

4.19.1 Bracket for Surge Arrestor:
For pole mounted transformer surge arrestor mounting bracket should be provided on top cover with distance between mounting points equal or greater than the distance between the center to center of MV bushings. Holes for surge arrestor mounting bracket shall be 14mm. See Fig (3)

4.19.2 Temperature Indicator:
A removable dial type thermometer shall be fitted in a thermometer pocket on the transformer for oil temperature reading with a range 0-120ºC. The indicator shall be visible from ground level.

4.19.3 Pressure Relief Vent:
A vent shall be provided to prevent rupturing of the transformer. This shall be capable of withstanding the variations of pressure in normal service.

4.19.4 Oil Level Indicator:
An oil level indicator shall be fitted with the sight glass or dial type fitted to the same side of the transformer as the tap change control handle. The indicator shall be visible from ground level.

4.19.5 Lifting Lugs:
Lift lugs shall be permanently attached and arranged on the tank to provide a distributed balanced lift in a vertical direction for the completely assembled transformer and shall be designed to provide a safety factor of 3 (assuming that the transformer is filled with oil). The safety factor is the ratio of the ultimate stress of the material used to the working stress. The working stress is the maximum combined stress developed in the lifting provision by the static load of the completely assembled transformer including oil.

4.19.6 Tank Earthing:
Two stainless steel M10 studs with nut and washer shall be provided diagonally opposite on the tank for pole mounted transformer, for pad mounted it shall be at the HV side of the transformer to facilitate tank earthing. If the base assembly is detachable then the earthing facilities shall be located on the tank wall. Suitable precautions shall also be taken to avoid corrosion attack on earthing facility.

4.19.7 Oil Drain Facility:
Facility for oil draining and filling shall be provided. The drainpipe size shall be one inch with opening valve and sealing plug, the filling facility size shall be one inch with sealing plug.

4.19.8 Rollers:
For pad mounted transformer Bi-directional rollers having 12.5cm minimum diameter shall be fitted to facilitate site installation. Rollers should have a locking facility to secure the transformer in its position. See Fig (4).

4.19.9 Cable Clamps:
All HV and LV cable support clamps to the transformer body should be made of a non-ferrous material.

4.19.10 Mounting Channels:
For Pole-mounted transformers, mounting channels shall be designed with slots/holes suitable for transformer platform in Fig (5). For 50KVA and 100KVA support clamps shall be designed as per Fig (6).

4.20 **Name Plate:**
Each transformer shall be fitted with a rating plate of weatherproof material, fitted in a visible position, showing the information listed below. Etching, engraving or stamping shall legibly mark entries on the plate.

Manufacturer's name	-
Manufacturer's serial number	-
Owners serial number (to be applied by SEC)	-
Year of manufacture	-
Specification	- IEC 60076
Number of phases	- 3
Rated power	- KVA
Rated frequency	- Hz
Rated voltages	- kV

Rated currents	- A
Connections symbol (Vector Group)	- Dyn11
Impedance voltage at rated current	- %
Resistance	- ohm
Type of cooling	- ONAN
Total mass	- kg
Total mass of core and windings	- kg
Volume of oil	- Liter
Connection diagram	-
Table giving tapping voltages of the tap positions	-
Ambient temperature	- ^{o}C
Purchase order no.	-
SEC stock number (Customer item code)	-

5.0 TESTING

5.1 Routine Tests:

Routine tests shall be carried out on all transformers, and shall be free of charge.
The manufacturer shall carry out the tests in accordance with IEC-60076 and a test certificate should be provided along with each transformer.
The results of the tests shall be recorded on a routine test certificate, and two copies of this shall be sent to SEC immediately after the tests.

The following routine tests shall be carried out:

Measurement of winding resistance.
Voltage ratio measurement and check of polarity or vector group symbol at all tap positions. Bushing positions must have permanent markings at this stage of production.
Measurement of impedance voltage.
Measurement of load loss.
Measurement of no-load loss and no-load current.
Induced overvoltage withstand test.
Separate source voltage withstand tests on HV and LV windings.
Oil leakage test.

SEC may carry out routine tests in its laboratory on random basis on 20% of each batch delivered to SEC stores. If one transformer fails, SEC can decide to reject the batch, if pass SEC can decide to test any number of transformers of the same batch and the supplier shall replace any failed transformer.

5.2 **Type Tests:**

Type tests shall be carried out on individual transformers at an independent testing laboratory and be witnessed by representative acceptable to SEC.

The transformers offered shall meet any or all (as per SEC option) of the type test requirements of the standards listed below:

Test of temperature rise	IEC 60076 and SSA 421
Impulse voltage withstand tests	IEC 60076 and SSA 421
Noise level measurement	IEC 60551
Radio influence voltage measurement	IEC 60437
Winding insulation requirement	ASTM-D-202
Tests on bushings	IEC 60507

6.0 INSPECTION:

SEC may wish to witness tests or to visit factory during manufacture of any or all items covered in this specification. Accordingly the supplier shall give advance notice to SEC of the manufacturing and test schedule.

7.0 PACKING AND SHIPPING

Packing and shipping shall generally be as per SEC General Requirements 01-SDMS-01 including the following:

i. The transformer shall be delivered ready for service.
ii. Supplier shall contact Materials Department of SEC for additional packing, handling, and shipment instructions as applicable.
iii. Packing crates shall be marked with the following:

- Manufacturer's name
- Country of origin
- SEC purchase order number
- SEC item number
- Gross weight in kilograms
- Handling instructions
- Final destination store

8.0 GUARANTEE

The supplier shall guarantee the transformers against all defects arising out of faulty design or workmanship, or defective material for a period of one year from the date of commissioning or two years from date of delivery. SEC certificates for date of commissioning or delivery shall be accepted.

9.0 SUBMITTALS

Submittals required with tender:

The supplier shall complete and return one copy of Data Schedule given by SEC.

The following drawings shall be provided with quotation for each transformer rating offered:
Outline of transformer showing position of fittings and attachments.
Details of HV and LV terminals.
Mounting arrangements.
Lifting arrangements.
Details of filling and draining valves.
Details of cable clamps.
Type test certificates for transformers of identical design.

10.0 LITERATURE

Maintenance and Operation Booklets shall be provided in English and Arabic languages.

TENDER NO. _____

DATA SCHEDULE

NO	DESCRIPTION	UNIT	SEC REQUIREMENTS	BIDDERS DATA
GENERAL DATA:				
1	Manufacturer			
2	Applicable Standard		IEC – 60076	
3	Type of Designation		Pole/Pad mounted	
4	Number of phases	No.	3	
5	Number of Windings	No.	2	
6	Frequency	Hz	60	
7	Primary voltage	KV	33 (or 34.5)	
		KV	13.8	
		KV	13.8-11 (dual)	
8	Secondary voltage	V	400/230	
INSULATION LEVEL:				
9	Impulse withstand voltages (BIL):			
	a) MV winding	kVp	200, 170, 110, 95	
	b) LV winding	kVp		
10	Separate- source power frequency test voltage:	kVrms	70, 38	
	a) MV winding	kVrms	10, 3	
	b) LV winding			
11	Induced overvoltage withstand test:			
	a) MV winding	kVrms		
	b) LV winding	kVrms		
	c) Test frequency	Hz		
CONSTRUCTIONAL FEATURES:				
12	Flux density at rated voltage and frequency	T		
13	Specific loss in core laminations	Wt/Kg		
14	Insulation of core laminations			
15	Winding conductor material (Cu. or Al.):			
	a) MV winding			
	b) LV winding			
16	Winding conductor shape			
	a) MV winding			
	b) LV winding			
17	Winding resistance at 20°C per phase at principal tap:	Ohm		
	a) MV winding	Ohm		
	b) LV winding			
18	Maximum current densities in windings at normal rating and principal tap:			

TENDER NO. _____

DATA SCHEDULE

	a) MV	A/mm²		
	b) LV	A/mm²		
19	Material of winding insulation:			
20	Grade and type of core			
RATINGS:				
1	Nominal transformer rating at principal tapping	KVA		
2	Normal rated current: a) MV	A		
	b) LV	A		
3	Design continuous ambient temperature	ºC		
LOSSES:				
1	Core loss (No-Load loss)	KW (Max.)		
2	Winding loss (Load loss) at 75º C:			
	a) Principal tapping	KW (Max.)		
	b) Tapping having highest losses	KW (Max.)		
3	Magnetizing current	A		
EMERGENCY LOADING:				
	Maximum duration of overload at 30º C:			
	a) 133%	Minutes		
	b) 150%	Minutes		
COOLING:			ONAN	
O I L:				
1	Producer			
2	Type and trade mark		Class 1 uninhibited mineral oil	
3	Applicable standard specs. (ref. No. & date of issue).			
4	Minimum flashpoint	°C		
5	Pour Point	°C		
6	Viscosity: at 20°C	m²/s		
7	Maximum dielectric strength for 1 min	KV		
8	Dielectric factor			
9	Acidity (neutralization value):			
	- Inorganic	mg/KOH/g		
	- Organic	mg/KOH/g		
	- Sponification value (maximum)	mg/KOH/g		
10	Maximum sludge formation	%		
11	Maximum acidity development in sludge	mg/KOH/g		
12	Moisture content	ppm	Max.30	

TENDER NO. _____

DATA SCHEDULE **Sheet 3 of 5**

NO	DESCRIPTION	UNIT	SEC REQUIREMENTS	BIDDERS DATA
TAP CHANGER:				
1	Type			
2	Make			
3	Rated current			
4	Rated step voltage			
5	Voltage class			
6	Taps (off-load) on MV:			
	a) Total range	±%	5	
	b) Number of taps	No.	5	
	c) Plus steps	%	+ 2.5, + 5	
	d) Minus steps	%	- 2.5, - 5	
VECTOR GROUP SYMBOL			Dyn11	
IMPEDANCE VOLTAGE		%	4 / 5 / 6	
TEMPERATURE RISE:				
1	Max. top oil temperature rise	°C	45	
2	Max. average winding temperature rise	°C	50	
3	Max. hot spot temperature rise	°C	98	
4	Temperature rise due to short circuit current above hottest spot (3 s) after full load.	°C	250	
NOISE LEVEL:		dB	48	
SHORT CIRCUIT LEVEL FOR 2 seconds:		KA		
DEGREE OF PROTECTION:		IP		
DIMENSIONS and MASSES:				
1	Overall dimensions of complete transformer in service:			
	a) Width	mm		
	b) Depth	mm		
	c) Height	mm		
2	Masses:			
	a) Mass of core and winding	Kg		
	b) Mass of tank	Kg		
	c) Mass of oil	Kg		
	d) Total mass of transformer ready for service	Kg		
	e) Shipping mass	Kg		

TENDER NO. _____

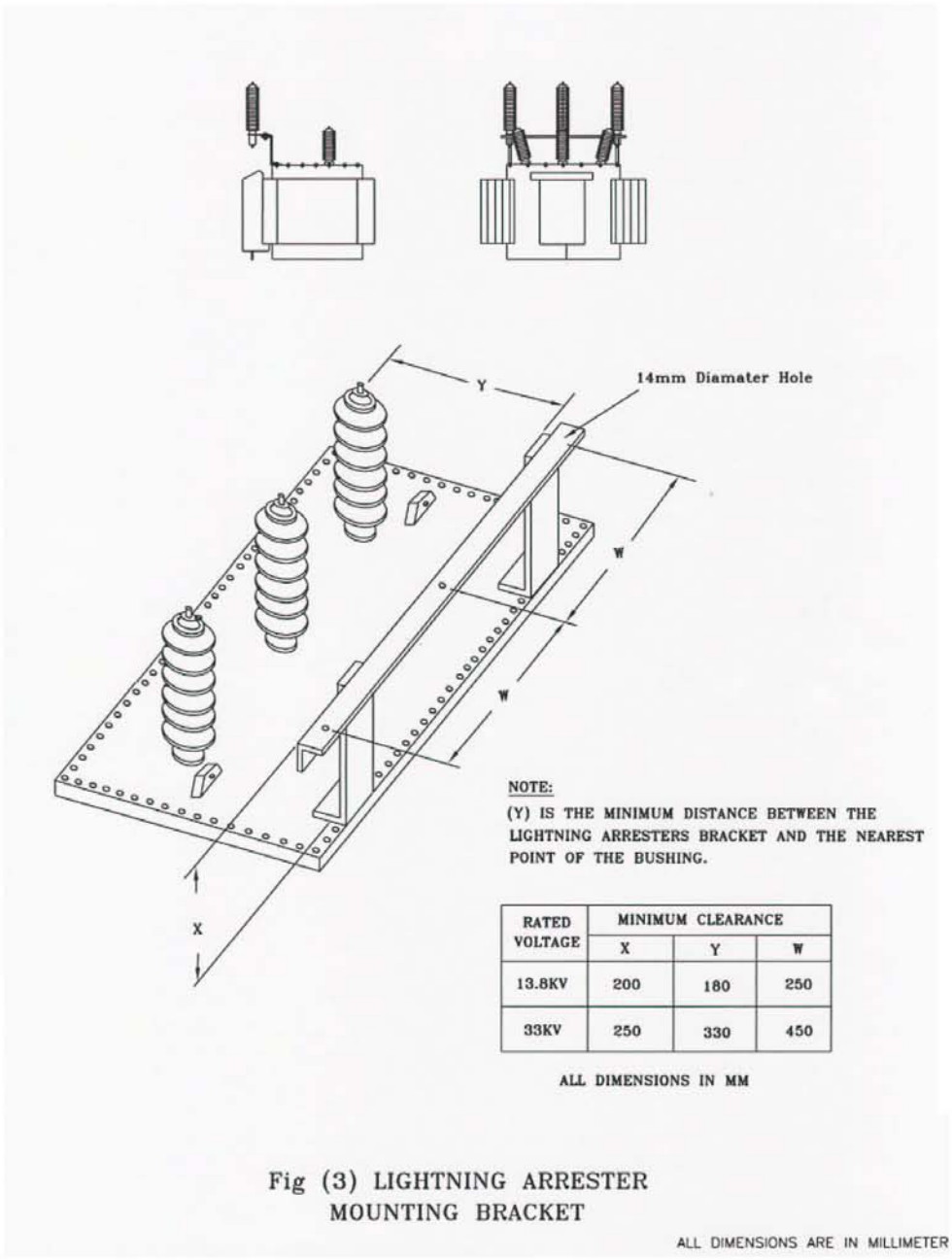
DATA SCHEDULE

NO	DESCRIPTION	UNIT	SEC REQUIREMENTS	BIDDERS DATA
TANKS:				
1	Tank construction			
2	Top oil temperature for internal pressure of 30kN/m²	ºC		
3	Steady load at 40ºC ambient at oil temperature given in 2	KVA		
4	Steady load at 40ºC ambient by considering effect of solar radiation	KVA		
5	Maximum withstand pressure of the tank for 24 hours without leakage	kN/m²		
6	Tank steel thickness	mm		
7	Radiator steel thickness	mm		
MV BUSHING:				
1	Manufacturer			
2	Material / color			
3	Rated current	A		
4	Rated thermal current a) 1 sec	KA		
	b) 3 sec	KA		
5	Impulse withstand voltage	KVp		
6	Impulse flashover voltage	KVp		
7	Power frequency withstand voltage			
	a) Dry	KVrms		
	b) Wet	KVrms		
8	Power frequency flashover voltage			
	a) Dry	KVrms		
	b) Wet	KVrms		
9	Puncture voltage	KV		
10	Maximum withstand salinity	kg/m³		
11	Maximum withstand voltage at 224 kg/m³ salinity at 20ºC	KV		
12	Total creepage distance	mm²		
LV BUSHING:				
1	Manufacturer			
2	Material / color			
3	Rated current	A		
4	Rated thermal current a) 1 sec	KA		
	b) 3 sec	KA		
5	Impulse withstand voltage	KVp		

TENDER NO. _____

DATA SCHEDULE **Sheet 5 of 5**

NO	DESCRIPTION	UNIT	SEC REQUIREMENTS	BIDDERS DATA
6	Power frequency withstand voltage			
	a) Dry	KVrms		
	b) Wet	KVrms		
7	Total creepage distance	mm^2		
SUPPLEMENTARY FITTINGS:				
1	Is transformer fitted with all accessories required in this specification		Yes	
2	Type and make of accessories:			
	a) Temperature indicator			
	b) Pressure relief vent			
	c) Oil level indicator			
LIST OF DEVIATION:				



NOTE:
(Y) IS THE MINIMUM DISTANCE BETWEEN THE LIGHTNING ARRESTERS BRACKET AND THE NEAREST POINT OF THE BUSHING.

RATED VOLTAGE	MINIMUM CLEARANCE		
	X	Y	W
13.8KV	200	180	250
33KV	250	330	450

ALL DIMENSIONS IN MM

Fig (3) LIGHTNING ARRESTER MOUNTING BRACKET

ALL DIMENSIONS ARE IN MILLIMETER

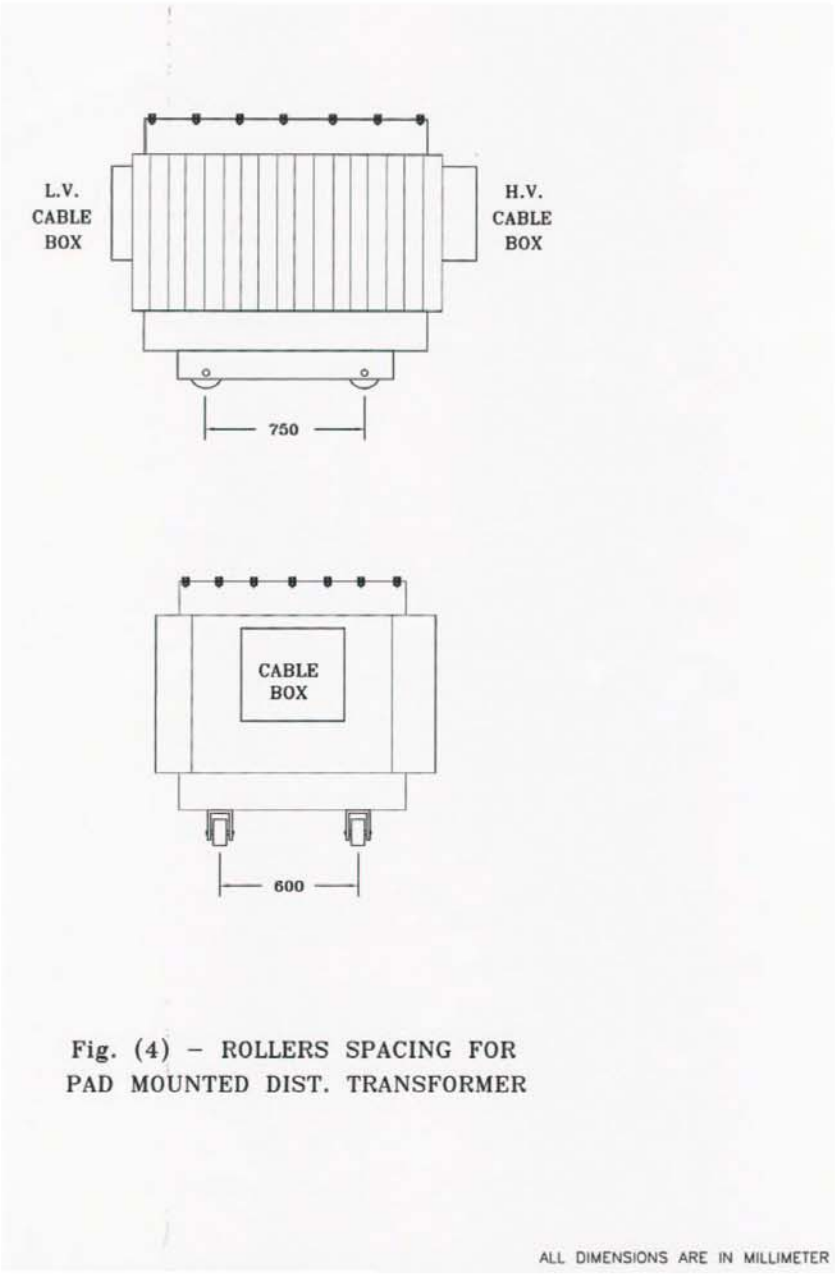


Fig. (4) – ROLLERS SPACING FOR PAD MOUNTED DIST. TRANSFORMER

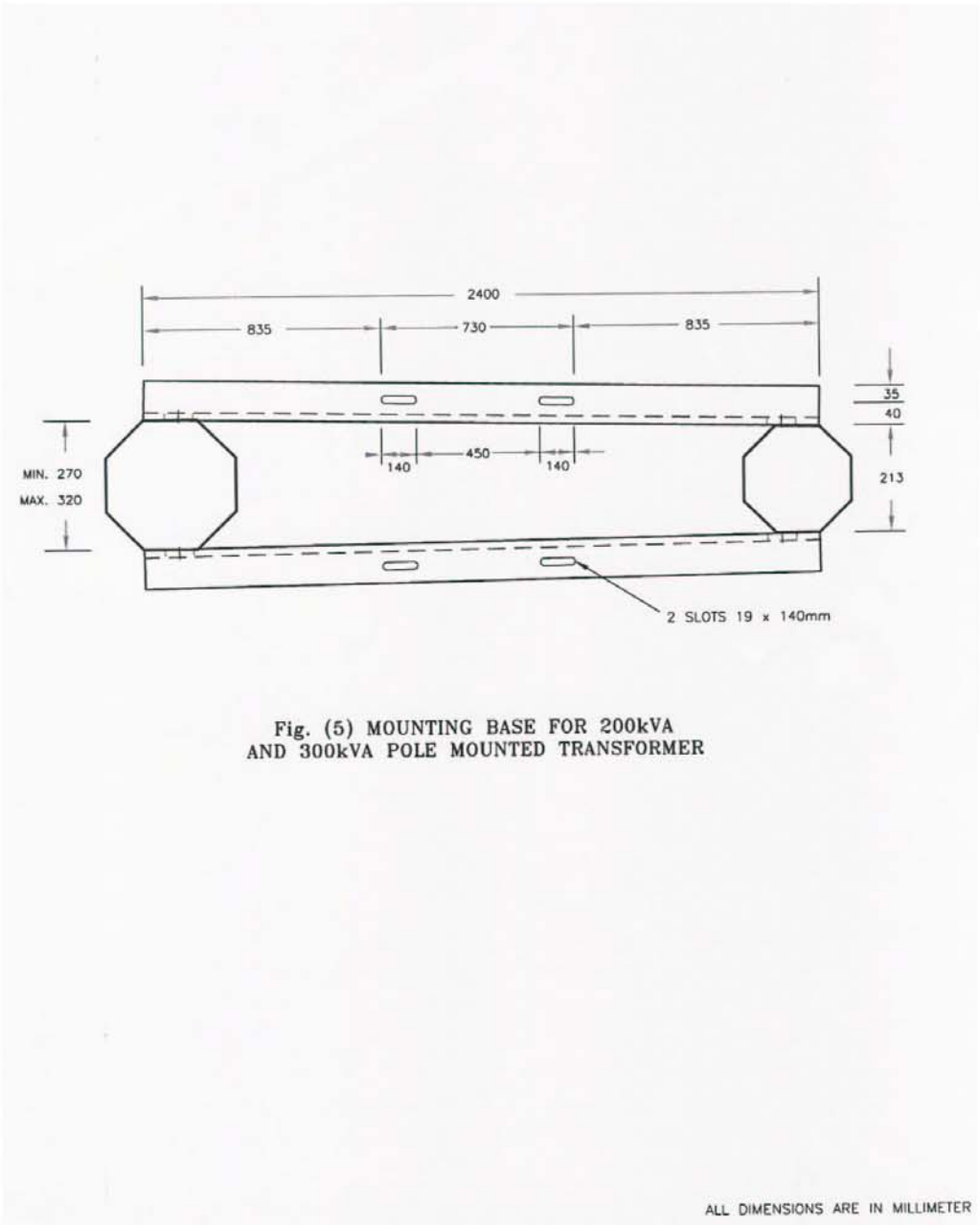


Fig. (5) MOUNTING BASE FOR 200kVA AND 300kVA POLE MOUNTED TRANSFORMER

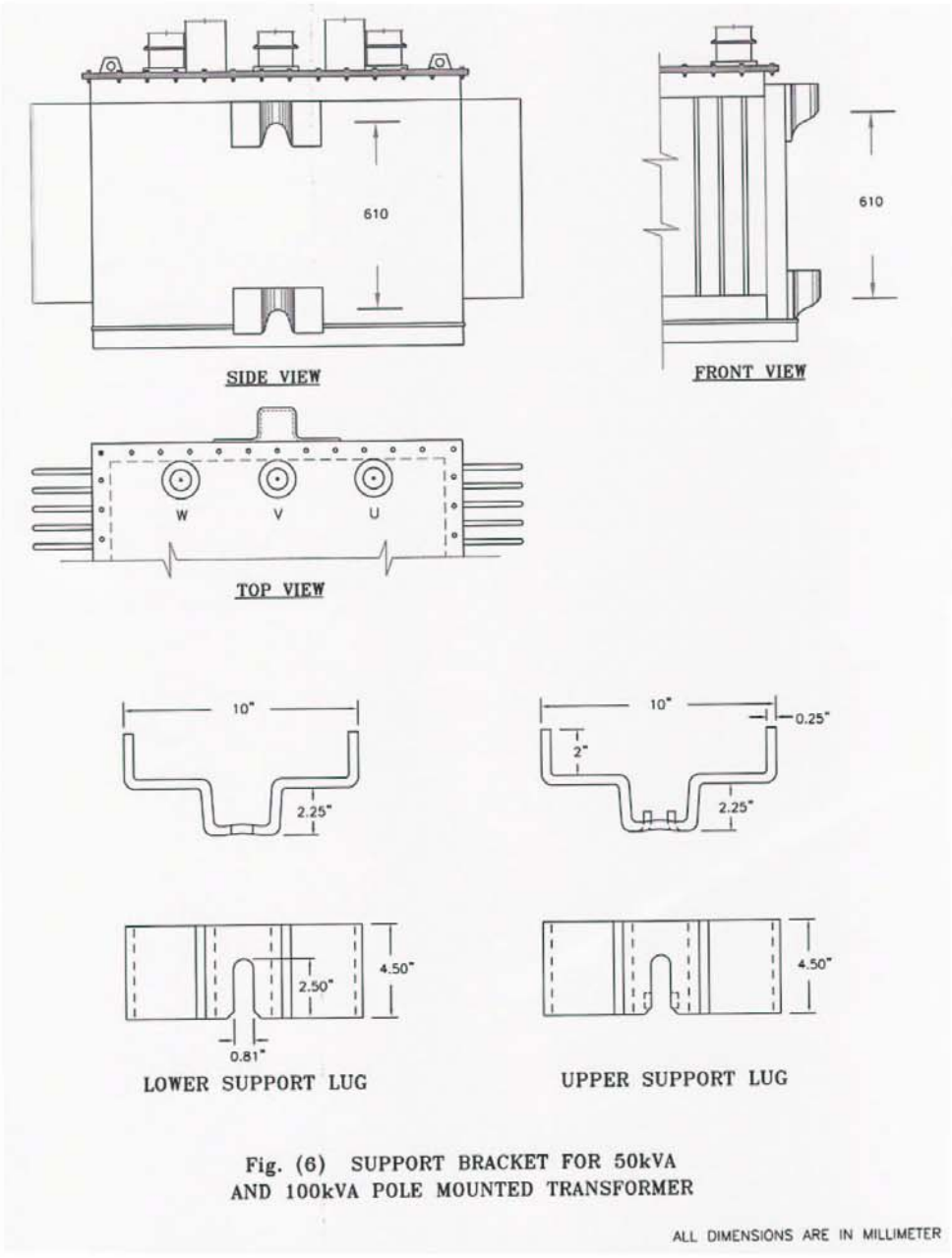


Fig. (6) SUPPORT BRACKET FOR 50kVA AND 100kVA POLE MOUNTED TRANSFORMER

ALL DIMENSIONS ARE IN MILLIMETER