



Technical Description

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THREE-PHASE DISTRIBUTION TRANSFORMERS



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THREE-PHASE DISTRIBUTION TRANSFORMERS

1. SCOPE

This Technical Specification covers the requirements for construction and testing of oil-immersed three-phase Distribution Transformers.

2. KEYWORDS

Distribution Transformer, MV, LV

3. OPERATING CONDITIONS

3.1. Environmental conditions

These transformers shall be suitable for indoor or outdoor installation, depending on their rated power, under the following environmental conditions:

- Maximum ambient temperature outdoor installation: +40° C.
- Maximum ambient temperature indoor installation: +45° C
- Maximum average daily (24 hours) ambient temperature: +35° C.
- Maximum average annual ambient air temperature: +20° C.
- Minimum ambient temperature: -20° C.
- Altitude: up to 1000 meters above sea level

3.2. System Characteristics

3.2.1. MV system characteristics

Three phases, three (3) wires distribution network with grounded neutral, only at the sending end (without distributed neutral), either directly or through resistance for limiting earth faults current to 1000 A, with the following characteristics:

- Nominal system voltage Ur	:	6.6 kV	15kV	20kV
- Maximum system voltage Um	:	7.2 kV	17.5kV	24kV
- Frequency	:	50 Hz	50 Hz	50 Hz
- System short-circuit power	:	160MVA	250MVA	250 MVA
- Impulse withstand voltage 1,2/50 µs :		60kV	95kV	125 kV

3.2.2. LV system characteristics

Three phases, four (4) wires (three phases plus neutral) distribution network of 230 V nominal voltage (400 V between phases), 50 Hz frequency with multiple grounded neutral.

4. STANDARDS - SPECIFICATIONS

The transformers shall be manufactured according to the recommendations of the present Technical

Specification and the following European Norms and Harmonization Documents:

Regulation N.548/2014 :	EU Commission regulation N. 548/2014 ON "Eco-design" for small, medium and large power transformers.
Directive 2009/125/EC	Directive of the European Parliament and the Council of 21 October 2009 establishing a framework for the setting of Eco design requirements for energy-related products
EN 50588-1: 2015:	Three phase oil immersed distribution transformers, 50 Hz, from 50 kVA to 2500 kVA with highest voltage for equipment not exceeding 36 kV - Part 1: General requirements.
EN 50464-3: 2007:	Three phase oil immersed distribution transformers, 50 Hz, from 50 kVA to 2500 kVA with highest voltage for equipment not exceeding 36 kV - Part 3: Determination of the power rating of a transformer loaded with non-sinusoidal currents.
EN 50464-4: 2007:	Three phase oil immersed distribution transformers, 50 Hz, from 50 kVA to 2500 kVA with highest voltage for equipment not exceeding 36 kV - Part 4: Requirements and tests concerning pressurized corrugated tanks.
EN 60076-1 : 1997 A1/2000, A2/2002:	Power transformers - Part 1: General.
EN 60076-2:2011:	Power transformers - Part 2: Temperature rise.
EN 60076-3:2013:	Power transformers - Part 3: Insulation levels, dielectric tests and clearances in air.
EN 60076-4: 2002:	Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing - Power transformer and reactors.
EN 60076-5: 2006:	Power transformers - Part 5: Ability to withstand short-circuit.
EN 60076-10: 2001:	Power transformers - Part 10: Determination of sound level.
EN 60437: 1997 : EN 62155: 2003:	Radio interference test on high-voltage insulators. Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V.
EN 50180: 1997:	Bushings above 1 kV to 36 kV and from 250 A to 3,15 kA for liquid filled transformers.
IEC 60137:2003 : EN 50386: 2002 :	Insulated bushings for alternating voltages above 1000 V. Bushings up to 1 kV and from 250 A to 5 kA, for liquid filled transformers .
EN 60507: 1993 :	Artificial pollution tests on high-voltage insulators to be used on a.c. systems.
EN 60672-2: 2000:	Ceramic and glass insulating materials - Part 2: Methods of test.
EN 60317-0-1:2008:	Specifications for particular types of winding wires - Part 0 - 1 : General requirements, Enameled round copper wire.
EN 60317-0-2:1998 A1:2000, A2:2005:	Specifications for particular types of winding wires - Part 0 -2 : General requirements, Enameled rectangular copper wire.
EN 60317 - 8: 2010:	Specifications for particular types of winding wires - Part 8: Polyesterimide enameled round copper wire, class 180.
EN 60317-27:1998 A1/2000:	Specifications for particular types of winding wires - Part 27: Paper tape covered rectangular copper wire.
EN 60317-28:1996 A1/1998, A2/2007:	Specifications for particular types of winding wires - Part 28: Polyesterimide rectangular copper wire, class 180.

EN 50216-1: 2002 :	Power transformer and reactor fittings - Part 1: General.
EN 50216-2:2002 A1/2002 :	Power transformer and reactor fittings - Part 2: Gas and oil activated relay for liquid immersed transformers and reactors with conservator.
EN 60216-3: 2006 :	Electrical insulating materials - Thermal endurance properties - Part 3: Instructions for calculating thermal endurance characteristics.
EN 50216-4: 2002 :	Power transformer and reactor fittings - Part 4: Basic accessories (earthling terminal, drain and filling devices, thermometer pocket, wheel assembly).
EN 50216-5: 2002 A2:2005, A3:2006 :	Power transformer and reactor fittings - Part 5: Liquid level, pressure and flow indicators, pressure relief devices and dehydrating breathers.
EN 50216-6: 2002 :	Power transformer and reactor fittings - Part 6: Cooling equipment - Removable radiators for oil immersed transformers.
IEC 60296: 2012 :	Fluids for electro technical applications - Unused mineral insulating oils for transformers and switchgear.
EN 61065: 1993 :	Method for evaluating the low temperature flow properties of mineral insulating oils after ageing
EN 60599: 1999 A1/2007 :	Mineral oil-impregnated electrical equipment in service - Guide to the interpretation of dissolved and free gas analysis.
EN 60567: 2005 :	Oil filled electrical equipment - Sampling of gases and of oil for analysis of free and dissolved gases - Guidance.
EN 61181: 2007	Mineral oil-filled electrical equipment - Application of dissolved gas analysis (DGA) to factory tests on electrical equipment.
ISO 9717/2010(en) :	Metallic and other inorganic coatings - Phosphate conversion coating of metals
IEC 60068-2-11:1981	Environmental testing - Part 2: Tests - Test Ka: Salt mist.
ISO 2409:2007 (ELOT405):	Paints and varnishes. - Cross cut test.
GR-88 : 1983 :	Split bolt connector for copper conductors.
T.Π. ΔΜΚΛΔ182/94:	Underground and overhead twisted cable 12/20 kV with XLPE insulation.
T.Π. ΔΕΗ ΧΚ 11.01:87:	Galvanization of items made from iron or steel. Hot dip
T.Π. ΔΕΗ ΧΚ 11.02:88:	galvanization of items made from iron or steel.
T.Π. ΔΕΗ ΧΚ 11.04.92:	Electrolytical tin-plate procedure.
TK 11.01: 91 :	Code of anchorage/ connection / joining fittings for overhead conductor networks and power cables.

Note: The requirements of this specification prevail over the requirements of the standards and specifications to which it refers. Regarding the standards, their most recent version shall be valid.

5. DESCRIPTION

5.1. General construction requirements

- All transformers provided under the same contract and with same rating values shall be manufactured in a way that enables the interchangeability of their components and parts.
During the validity of the contract, no modification to the study, planning and construction of the Transformers is permitted without prior approval by the Corporation.
All material used for the Transformers construction shall be non - toxic and environmental friendly.
- The Transformers shall be manufactured in such a way as to ensure their easy transportation (on road, by train or ships), so that after their arrival at their destination they can be immediately put in permanent operation with no assembly work required.

5.2. General characteristics

The Transformers shall have the characteristics specified in the Specification herein. The manufacturer's warranty regarding the operation of the Transformers, shall be based on these characteristics :

- Phases: 3
- Cooling: ONAN
- Maximum temperature rise according to EN 60076-2: 2011
 - Oil (measured with a thermometer at its highest level): 60° K for outdoor type transformers and 55° K for indoor installed transformers (bushings instead of insulators).
 - Windings (measured by the resistance method): 65° K for outdoor type transformers and 60° K for indoor installed transformers.

Note: The temperature rise is measured in Kelvin degrees (K).

5.3. Connections, Transformation ratio

The Transformers shall be of Single or Double ratio, with ratings as mentioned below. For the double ratio transformers the below mentioned rated power shall be available regardless of the combination of voltages. The tolerances in ratio at the principal as well as at the rest taps, shall be according to what is mentioned in EN 60076-1:1997 (A1:2000, A2:2002) for the principal tap.

5.3.1. Single ratio transformers: 20/0.4 kV.

5.3.1.1. Rated power in kVA:

50, 100, 160, 250, 400, 630, 1000, 1600, 2500.

5.3.1.2. Nominal Voltage

- Primary: Medium Voltage : 20000 V (MV)
- Secondary: Low Voltage : 400 V (LV)

5.3.1.3. Tapping at the MV side

The following tapping shall be provided at the MV side: -5%, -2,5%, 0%, +2,5%, +5%, that is per 500 V.

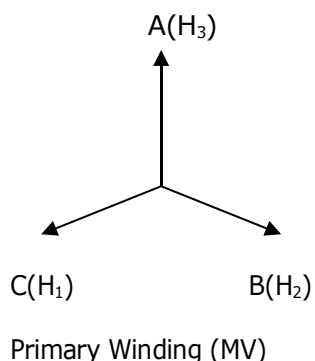
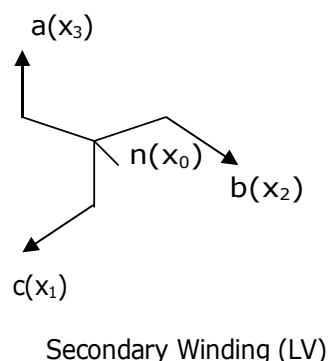
Tap changing shall be performed with the transformer out of voltage, by means of a Tap Changer, which is described in paragraph 5.10.

5.3.1.4. Short-circuit impedance (at 75 °C)

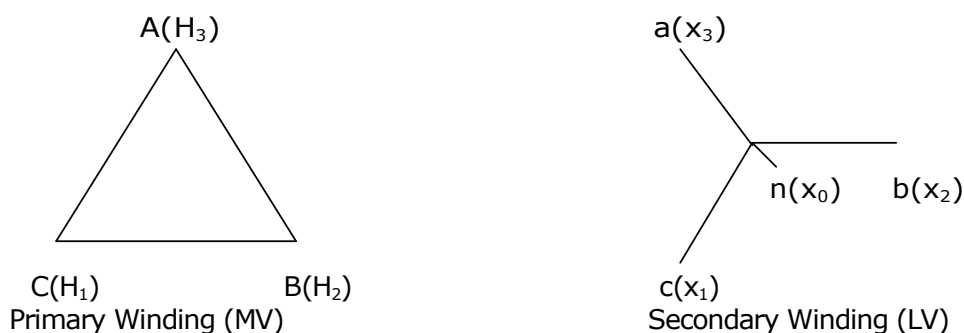
For Transformers with rated power up to and including 630 kVA, the short-circuit impedance shall be 4%, and for Transformers rated at 1000 kVA and up, it shall be 6%. The tolerance for the short-circuit impedance shall be $\pm 10\%$ in both cases.

5.3.1.5. Connection group

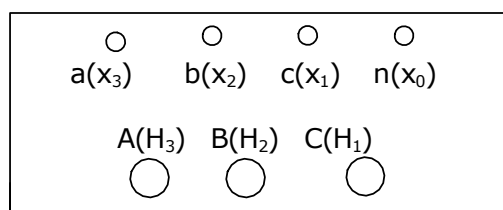
Connection group of Transformers with rated power 50 and 100 kVA: Yzn11 (Yzn1)



Connection group of Transformers with rated power 160 up to 2500 kVA: Dyn11(Dyn1)



5.3.1.6. Bushing arrangement on the cover and phase identifications



$A(H_3)$, $B(H_2)$, $C(H_1)$: MV Bushings
 $a(x_3)$, $b(x_2)$, $c(x_1)$: LV Bushings
 $n(x_0)$: LV Neutral Bushing

Note: Symbols A, B, C correspond to Medium voltage (MV), and symbols a, b, c, n correspond to Low voltage (LV) for connection groups Dyn11 and Yzn11. Connection groups Dyn1 and Yzn1 result if the phases of the MV and LV network respectively are connected to the Transformer terminals according to the symbols provided in brackets, i.e. H_1 , H_2 , H_3 for the MV and x_1 , x_2 , x_3 , x_0 for the LV, i.e. by interchanging the first (1st) with the (3rd) phase for both MV and LV.

5.3.2. Double ratio transformers: 20-15 / 0.4 kV

5.3.2.1. Rated power in kVA

50, 100, 160, 250, 400, 630, 1000

5.3.2.2. Nominal voltages

- Primary: Medium Voltage (MV) : 20000 V 15000 V
- Secondary: Low Voltage (LV) : 400 V 400 V

5.3.2.3. Tapping at the MV side

The following tapping shall be provided at the MV side:

At the 20000V voltage: -5%, -2.5%, 0%, +2.5%, +5%.

At the 15000V voltage: -6.66%, -3.33%, 0%, +3.33%, +6.66%.

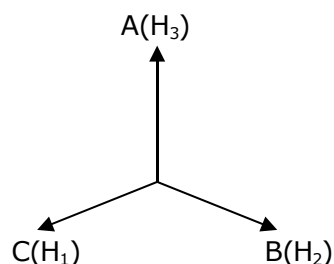
Tap changing shall be performed with the transformer out of voltage by means of a Tap Changer. Voltage change shall also be performed with the transformer out of voltage by means of a Voltage Selector. Both devices are described in paragraph 5.10.

5.3.2.4. Short-circuit impedance (at 75 ° C)

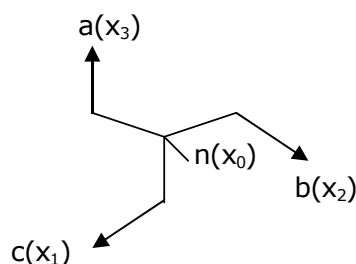
For Transformers with rated power up to and including 630 kVA the short-circuit impedance shall be 4%, and for Transformers rated at 1000 kVA and up, it shall be 6%. The tolerance of the short-circuit impedance shall be $\pm 10\%$ in both cases.

5.3.2.5. Connection group

Connection group of Transformers with rated power 50 and 100 kVA: Yzn11 (Yzn1)

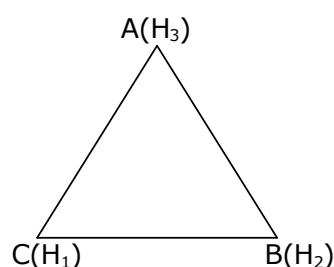


Primary Winding (MV)

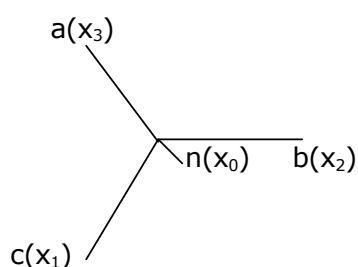


Secondary Winding (LV)

Connection group of Transformers with rated power 160 up to 1000 kVA: Dyn11(Dyn1)

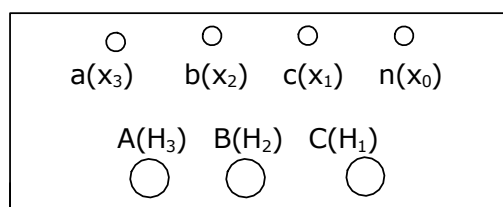


Primary Winding (MV)



Secondary Winding (LV)

5.3.2.6. Bushing arrangement on the cover and phase identifications



$A(H_3), B(H_2), C(H_1)$	:	MV Bushings
$a(x_3), b(x_2), c(x_1)$	:	LV Bushings
$n(x_0)$	:	LV Neutral Bushing

Note: Symbols A, B, C correspond to Medium voltage (MV), and symbols a, b, c, n correspond to the Low voltage (LV) for connection groups Dyn11 and Yzn11. Connection groups Dyn1 and Yzn1 result if the phases of the MV and LV networks respectively are connected to the Transformer terminals according to the symbols provided in brackets, as in the case of the single ratio transformers, that is, by interchanging the 1st with the 3rd phase for both MV and LV.

5.3.3. Double ratio transformers: 20-6.6 / 0.4 kV

5.3.3.1. Rated power in kVA

250, 400, 630

5.3.3.2. Nominal voltages

- Primary: Medium Voltage (MV) : 20000 V 6600 V

- Secondary: Low Voltage (LV) : 400 V/400 V

5.3.3.3. Tapping at the MV side

The following tapping shall be provided at the MV side:

At the 20000V voltage: -2.5%, 0%, +2.5% (19500, 20000, 20500 V) At the 6600V voltage: 0%, -2.5%, -5% (6600, 6435, 6270 V)

Tap changing shall be performed with the transformer out of voltage by means of a Tap Changer, which is described in paragraph 5.10.

That Tap Changer shall have two separate regions, one for 6600V tapping and one for 20000V tapping.

When the transformer operates at 6600V it shall not be permitted to move the Tap Changer to 20000V tapping region and vice versa.

5.3.3.4. Short-circuit impedance (at 75 ° C)

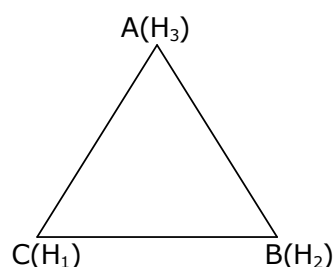
At 20 kV Voltage: 4%

At 6.6 kV Voltage: 4%

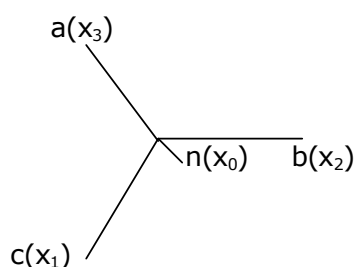
The tolerance of the short-circuit impedance shall be $\pm 10\%$ in both cases.

5.3.3.5. Connection group

Connection group of Transformers with rated power 250 up to 630 kVA: Dyn11 (Dyn1)

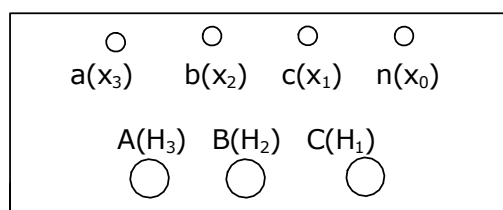


Primary Winding (MV)



Secondary Winding (LV)

5.3.3.6. Bushing arrangement on the cover and phase identifications



A(H ₃), B(H ₂), C(H ₁)	:	MV Bushings
a(x ₃), b(x ₂), c(x ₁)	:	LV Bushings
n(x ₀)	:	LV Neutral Bushing

5.4. Guaranteed losses at nominal voltage

The load losses and the no-load losses shall comply to EU Commission regulation N. 548/2014 of 21 May 2014. Especially the guaranteed load losses shall correspond to column C_k of Table 3 of the standard EN 50588-1:2015 for Transformers rated up to and including 400 kVA, while for Transformers of 630 kVA and up they shall correspond to Column B_k of Table 3 of this standard. The losses of no-load operation shall correspond

to column A₀ of Table 2 of the standard EN 50588-1:2015. That means that the Transformers rated at 50 and up to 400 kVA shall have an C_k - A₀ pair of values and the Transformers rated at 630 and up to 2500 kVA shall have a B_k - A₀ pair of values. For the double ratio Transformers an increase to the guaranteed losses values of the below table is not permitted.

Trasnformer Rated Power	No load losses (iron (Fe) losses)	Load losses (copper (Cu) losses)
50 kVA	0,090 kW	1,100 kW
100 kVA	0,145 kW	1,750 kW
160 kVA	0,210 kW	2,350 kW
250 kVA	0,300 kW	3,250 kW
400 kVA	0,430 kW	4,600 kW
630 kVA	0,600 kW	5,400 kW
1000 kVA	0,770 kW	9,000 kW

5.5. Sound level

The sound level of the Transformers shall not exceed the values specified in column A₀ of Table 2 of EN 50588-1:2015 standard for each rated power. The measurement shall be carried-out according to standard EN 60076-10: 2001.

5.6. Radio interference voltage

The radio interference voltage, measured on the bushings according to EN 60437: 1997, shall not exceed in any Transformer the value of 250 µV at the frequency of one (1) MHz

5.7. Windings

The Transformers shall have two windings (the number of coils of each winding is given by the manufacturer). Both the MV and the LV windings shall be made of copper. The cross-sections of the circular conductors shall be according to EN 60317-0-1: 2008, grade 2, EN 60317-8: 2010, class 180, and the cross-sections of the rectangular conductors shall be according to EN 60317-27:1998, A1:2000 with 0.45 mm thick insulation or according to EN 60317-0-2: 1998, A1:2000, A2:2005 and EN 60317-28: 1996, A1:1998, A2:2007, grade 2. Copper foil may be used for the LV windings.

5.7.1. Insulation level of MV windings

	<u>6.6 kV</u>	<u>15 kV</u>	<u>20 kV</u>
- Power frequency withstand voltage for 1 min of r.m.s. value :	20 kV	38 kV	50 kV
- Full wave impulse withstand voltage, of shape 1,2/50 µs, peak value:	60 kV	95 kV	125 kV
- Chopped wave impulse withstand voltage with a peak value at least equal to that of the full wave for nominal voltages 6.6 kV and 15 kV. `For the 20 kV it shall be equal to 138 kV according to EN 60076-3: 2013.			

5.7.2. Insulation level of LV windings

Power frequency withstand voltage for 1 min, r.m.s. value : 10 kV.

5.7.3. Dielectric distances

The 20 kV winding parts that are under voltage shall have a minimum distance from the tank equal to 30 mm. The minimum distance of the LV winding from the core shall be 2.5 mm with intermediate insulation. No insulation material between windings and tank as well as between tap changer and tank is allowed.

5.8. Bushings

The LV bushings (porcelain insulator + stud, nuts, washers and cover) shall be according to EN 50386: 2002 and the MV shall be according to EN 50180: 1997. The LV and MV studs for up to 250 A shall be made of brass and the studs for higher currents shall be made of copper.

The distances between the centers of the LV bushings shall be 150 mm at least for currents up to 2000 A, and 165 mm at least for currents higher than 2000 A. The corresponding distances for the MV bushings shall be 270 mm at least.

For the 20 kV operating voltage, the minimum distance between bushing points under voltage from any earthed metallic parts shall be at least 22 cm. In the case of pole-mounted Transformers (50 and 100 kVA), the pole is considered to be earthed.

The bushings shall be installed on the cover of the Transformer's tank in vertical position and shall be sealed with suitable gaskets.

5.8.1. Insulators

The MV and LV insulators of the Transformers shall be made of high quality porcelain manufactured with the wet method without pores, and they shall have brown color glazing.

The MV insulators shall be according to EN 50180:1997, type 2, with four sheds, in order to be always interchangeable. They shall deviate from this standard on the diameter of the sheds, which shall be 165 mm instead of 150 mm as provided in this standard, in order to have a resulting creeping distance of 53 cm. Moreover, for the 50 and 100 kVA transformers, the length of the insulator's neck shall be 160 mm instead of 80 mm.

The LV insulators shall be according to EN 50386: 2002.

5.8.2. Plugs at the MV side

Transformers with rated power 630 up to 2500 kVA, shall be equipped with special plugs reception at the MV side of the tank cover instead of bushings. In particular, the 630 kVA Transformers shall be also manufactured with bushings when they are to be used in overhead networks.

A full set of plugs for MV side connection shall be an integral part of the procurement of the transformers intended to be used indoors which shall be in accordance with HD 629.1S1:1996+A12001 and EN 61442:2005.

5.8.3. Electrical characteristics

5.8.3.1. MV Insulators

- | | |
|---|--------|
| a) Full wave impulse, with an 1.2/50 μ s shape, withstand voltage peak value: | 170 kV |
| b) Power frequency withstand voltage, wet , 1 min, r.m.s. value: | 70 kV |
| c) Minimum creeping distance: | 53 cm |

5.8.3.2. LV Insulators

- | | |
|---|-------|
| a) Full wave impulse, with an 1.2/50 μ s shape, withstand voltage peak value: | 30 kV |
| b) Power frequency withstand voltage, wet 1 min - r.m.s value: | 10 kV |

Especially for the insulators intended to be used on Transformers 50 and 100 kVA an impulse withstand voltage of 22,5 kV with an 1,2 / 50 μ s shape, is acceptable due to the fact that they are not fully immersed into the oil.

5.8.3.3. MV Plugs

- | | |
|---|--------|
| a) Full wave impulse, with an 1.2/50 μ s shape, withstand voltage peak value: | 125 kV |
| b) Power frequency withstand voltage, wet, 1 min, r.m.s. value: | 55 kV |

5.9. Bushing terminals

- The MV bushings shall be equipped with split bolt connectors suitable for stranded copper conductors with cross-section from 16 and up to 35 mm², according to drawing N° 430020560.

- The LV bushings (3 for the phases + 1 for the neutral) shall be equipped with clamp connectors suitable for stranded copper conductors with cross-sections as specified below, according to the rated power of each Transformer. Split bolt connector type terminals shall only be used for the 50 kVA Transformers.

Rated power of Transformer in kVA	Cross-section of conductor (cable) in mm ²	
	<u>Phases</u>	<u>Neutral</u>
50	35 and 50	35 and 50
100	95 and 150	95 and 150
160	95 and 150	95 and 150
250	150 and 300	150 and 300
400	300	300
630	2x300	2x300
1000	4x300	4x300
1600		
2500		

- For the 50 kVA Transformers split bolt connectors shall be used according to drawing N° 430020572.
- For the 100 and 160 kVA Transformers, one terminal size (clamp type) suitable for the 95 mm² and 150 mm² cross-sections shall be used, according to drawing 430000057. The part of the terminals that will be adapted to the stud of the bushings shall have a M12x1,75 diameter and shall be manufactured with jointing tolerance (stud + terminal).
- For the 250 kVA Transformers, one terminal size suitable for the 150 mm² and 300 mm² cross-sections shall be used according to drawing N° 430015394, while for the 400 kVA Transformers a terminal suitable for the 300 mm² cross-section shall be used. The part of the terminal that will be adapted to the stud of the bushing shall have a M20x2,5 diameter and shall be manufactured with jointing tolerance (stud + terminal).
- For the 630 kVA Transformers, clamp type terminals suitable for stranded conductors with 2x300 mm² cross-section shall be used for the phases and neutral according to drawing N° 430015400. The part of the terminal that will be adapted to the stud of the bushings shall have a M30x3,5 diameter and shall be manufactured with jointing tolerance (stud + terminal).
- For the 1000 kVA Transformers, clamp type terminals suitable for stranded conductors with 4x300 mm² cross-section shall be used for the phases and neutral according to drawing N° 430021758. The part of the terminals that will be adapted to the stud of the bushings shall have a M42x4,5 diameter and shall be manufactured with jointing tolerance (stud + terminal).

The split bolt type connectors shall be manufactured according to PPC specification GR-88.

The non split bolt type connectors terminals shall be made of copper alloy G-CuZn33Pb2-B and shall be electrolytically tin plated with a thickness 30 µm, according to ТП XK 11.04/92

The terminals shall have an embossed or engraved marking of their manufacturer.

The terminal bolts shall be made of stainless steel (18Cr8Ni).

The terminals shall be properly constructed so that the stud of the bushings does not rotate when the conductors are being connected. Joining shall be performed according to ISO 262:1998.

The terminals suitability shall be checked with tests as specified in paragraph 6.1.5.

5.10. Tap changers - Voltage Selectors

All Transformers shall be equipped with tap changer for tapping at the MV side. The double ratio Transformers (i.e. those with two voltages), shall also be equipped with a voltage selector, for changing the ratio of the nominal voltages. Both the tap changer and the voltage selector shall be of robust construction and shall have a manually operated mechanism for changing taps and voltage. Their transmission mechanism shall be metallic.

The operation levers shall be installed on the cover of the Transformers' tank in a position that enables their use by the technicians and shall have a latching mechanism in every position, step by step.

The levers shall be made of metal and they must ensure a perfect tightness with the tank.

Each step of the lever shall be properly marked with the corresponding taps for the tap changer and the corresponding voltages for the selector in the case of double ratio Transformers. For the taps marking, a metallic disk with numbers corresponding to taps, as they appear on the nameplate, shall be mounted under the lever of the tap changer, or as an alternative the numbers shall be printed on the lever itself. For the voltages marking, another metallic disk shall also be mounted under the lever of the selector.

Both the tap changer and the selector shall be operated with the Transformer out of voltage. The lever of the tap changer shall be operating clockwise, moving from position 1 to positions 2, 3 etc. The axis of the levers and the disks of the tap changers and voltage selectors shall be made of stainless steel (18Cr8Ni).

5.11. Transformer tank and its accessories

5.11.1.Construction

The construction of the tank shall be robust and shall not permit oil leaks. The Transformer tanks shall be manufactured with folded sheets. The folded sheet shall be at least of 1.2 mm thick.

The tank shall be equipped with suitable lugs for lifting when it is empty.

In particular, for the 50 and 100 kVA Transformers, pole supporting lugs are required, according to drawing No 1, at the longer side of the tank on which the MV bushings are installed.

The tank cover shall be removable (by screws) with suitable gasket. The connections of all components that are screwed on the cover or on the tank shall also be made through suitable gaskets.

The gasket material shall be weather-proof and oil-proof at temperatures up to 110 °C.

All nuts and bolts of the tank cover shall have normal metric threads, according to ISO 4017 and ISO 898 respectively, withstand class 8.8.

5.11.2.Wheels - Hanging Lugs - Jack bosses

For the movement of the Transformers the following shall be provided:

- The 50 and 100 kVA Transformers shall have shaped steel feet at the tank base, with minimum height 50 mm.
- The tanks of the 630 kVA indoor Transformers and the tanks of transformers with higher rated power shall be equipped at their longitudinal sides with four suitable jack bosses enabling the use of a lifting jack in order to place rollers under the tank or to remove the wheels.
- The power transformers rated at 630 kVA and above that are to be installed indoors shall be equipped with four (4) double-direction wheels, according to EN 50216-4:2002. The distance between the centers of the wheels shall be 670 mm for the 630 kVA Transformers, 820 mm for the 1000 kVA up to 2000 kVA Transformers, and 1070 mm for the 2500 kVA Transformers.
- The covers of the Transformer tanks shall be equipped with suitable lifting lugs where it shall be possible to attach a steel wire rope in order to lift the whole Transformer without any warping of the cover.
- The lifting lugs shall be properly placed in order to ensure sufficient distance between the steel wire rope and bushings to avoid breaking of the insulators.

For the installation of the Transformers the following shall be provided:

- The 50 kVA Transformers shall be equipped with hanging lugs for single-pole mounting, according to drawing No 1.
- The 100 kVA power Transformers shall be equipped with both single-pole mounting hanging lugs according to drawing No 1 and with a suitable base for installation on a two-pole structure, according to drawing No 2.

- The 160, 250, 400 kVA Transformers, and the 630 kVA Transformers that are to be provided for outdoor installation, shall be equipped with a suitable base for installation on a two-pole structure according to drawing No 2.

5.11.3. Earthing terminals of the tank

The Transformer tank shall be equipped with two, split bolt type, earthing terminals according to drawing 430020559. These shall be installed diagonally on the external surface of the tank wall, close to its bottom and they shall be suitable for copper conductors of 16 to 35 mm² cross-section.

The split bolt type connectors shall be tin plated and shall be screwed to the tank by a nut welded on the tank. The nut shall have round shape, M12 size, and be copper plated or made of stainless steel.

5.11.4. Removable earthing link of the tank (LV neutral connection)

The Transformers shall be equipped with a removable and flexible link made of tin plated copper sheets of at least 35 mm² total cross-section, which shall bridge the stud of the neutral bushing with the cover and the side wall of the tank. For this purpose, bolts of suitable cross-section shall be welded, one on the cover and one on the tank. The copper sheets shall be tightened with a screw made of stainless steel or brass, using two washers made of stainless steel or brass or copper.

5.11.5. Expansion tank

- The Transformers of 160 kVA and above are required to have a detachable expansion tank. The expansion tank shall have suitable height so that the oil level at 20 °C is at least 3 cm higher than the higher exhaust level of the MV bushing, and at 100 °C no oil overflow from the expansion tank is observed. At -20 °C the oil level shall be 35 mm higher from the bottom of the expansion tank.

5.11.6. MV Lightning arresters' mounting bases and earthing terminals

On the cover of every transformer of 50 up to 630 kVA for external use, three (3) bases shall be fastened for the mounting of MV lightning arresters independently from the bolts that tighten the cover on the tank, each for one MV Lightning arrester.

Analytical drawing of the two types of bases are given in the drawings 4 and 5.

The tightening of the bases shall be carried out in the manner foreseen for each type of the transformers by the method and the means shown in the drawings 3.1, 3.2, 3.3, 3.4, 4 and 5.

As the female thread an welded tube on the cover that will be internally threaded shall be used.

More specifically the following 3 Arrester support solutions shall be applied:

- On the 50 kVA T/S 6 base support female threads shall be provided according to the drawing 3.1. Bases for phases 1 and 3 shall be installed on the cover with all their bolts, While the base of phase 2 shall be fastened on one of the previous bases without the bolts. In all cases the bolts for mounting the arresters shall be also tightened on the bases, when delivered. The final installation of the bases on the cover shall be made on the suitable female threads provided that the safety clearances are kept. The base of the 2nd phase shall be installed on the pole as shown in the drawing 3.2.
- On the 100 kVA T/S two methods of installing the bases are provided depending on whether is to be installed on a single pole or two-pole construction. 8 female threads are provided on the cover as shown in drawing 3.4. The bases shall be delivered with all their bolts installed parallel to the MV side. The final installation of thywe bases shall be carried out on any of the provided positions (see above paragraph for 50 kVA T/S or next for T/S 160 kVA and above), depending if the T/S is to be installed on a single pole or on a two-pole construction, provided that safety clearances are kept.
- On 160 kVA and above T/S the female threads shall be 6 (No additional threads required, see drawing 3.3) and the bases shall be installed during delivery with all their bolts tightened on them.

Mounting bases shall be made from S235 (EN 10025) or St 37-2 (DIN 17100) steel, zinc coated with an average thickness of at least 86 µm, according to XK 11.02/88 PPC's technical specification. Two layers of environmental friendly, non - toxic paint with total thickness of 80 µm in dry state and a RAL 7033 color shall be applied on the outer side of the bases, according to what is mentioned in paragraph 5.14.3. The screws and the nuts of the plates shall be made from steel, zinc coated with an average thickness of at least 54 µm, while lock washers and circular washers shall be made from steel, zinc coated with an average thickness of at least 43 µm, according to XK 11.02/88 PPC's technical specification.

For the transformer to be installed on a two pole construction the tightening arresters' mounting bases shall be delivered fixed on the transformer in a way that $\Phi 13$ hole of the middle base is placed, as far as this is possible, at the opposite corner of the MV bushing of phase B of the transformer, while the distance of following $\Phi 13$ holes of the three (3) bases shall be equal to 300 mm at least.

In order to ensure the electrical connection of MV lightning arresters' earthing conductor to the main grounding system, a plug of steel made plate must be welded, prior to the final processing or the paint that is mentioned on paragraph 5.14, on the tank or the folded sheets of the transformer (drawings 3.2 & 3.3). A nut, proper for 4 copper conductors of 16 mm² diameter, with a zinc coated split - bolt connector type earthing terminal screwed on it shall be welded on the previous mentioned plug (the 3 copper conductors concern the earthing of the lighting arresters and the fourth one concerns the connection of this split-bolt connector to the earthing at the base of the TS). That nut shall have a M12 circular shape and be zinc coated or made from stainless steel as well and the split-bolt connector shall be placed in a maximum distance of 25 cm from the top of the transformer cover.

5.11.7. Supplementary accessories

The Transformer tank shall be equipped with the following supplementary accessories:

- Oil drain plug, with filtering and sampling device according to EN 50216-4: 2002.
- Oil filling plug according to EN 50216-4: 2002.
For Transformers with expansion tank, the filling plug shall be installed on this tank. The plug shall be of the breathing type.
For seal type Transformers of 50 and 100 kVA, the filling plug shall ensure perfect tightness and shall be installed on the Transformer's cover at a suitable position, not directly above the windings.
The filling and drain plugs shall be installed diagonally on the Transformer's tank (at the first and the second end, respectively).
- Dial type thermometer, according to EN 50216-4: 2002, with scale from 0 °C to 120 °C, of minimum diameter 100 mm and max value indicator, for measuring the oil temperature. This thermometer is required only for the Transformers of rated power 630 kVA and above. Furthermore for the indoor installed Transformers the thermometer shall be equipped with two electrical contacts, normal open, electrically independent, manually adjusted by the technician on the field e.g. alarm contact, trip contact.
- Oil level indicator according to EN 50216-5: 2002 (A2:2005, A3:2006).
The oil level indicator for Transformers without expansion tank shall be made of a metallic base with suitable slit, covered with a glass plate, resistant to high temperatures, externally marked with readings for - 20 °C, 20 °C and additionally 90 °C. This indicator shall be mounted on the larger side of the container with screws through a suitable gasket, so that it can be easily disassembled from the outside of the tank.
At the Transformers with expansion tank and rated power up to 630 kVA the oil level indicator shall be a glass tube protected by two metallic ears and marked with readings for -20 °C, 20 °C and 90 °C.
Magnetic type indicators shall be used for the indoor installed Transformers.

5.11.8. Sealed type construction of 50 and 100 kVA Transformers

The 50 and 100 kVA Transformers shall be of sealed type construction without expansion tank and without overpressure safety valve. However, the Transformer tank shall be able to withstand an average overpressure of 0,45 bar according to paragraph 6.1.6. Under the tank cover and up to the oil level, a 120 mm high air layer shall be provided. It is not permitted to use inert gas. For this purpose, the porcelain insulators shall have long neck, of a 160 mm length, so that their lower end shall remain immersed in the oil by 25 mm (at least) at a temperature of 20 °C. The last point of the tap changer under voltage shall be immersed in the oil by 30 mm at least.

5.12. Overall dimensions of the Transformers

The overall dimensions of the Transformers shall not exceed the following limits:

- Dimensions for Transformers with rated power up to 400 kVA:
Length: 160 cm
Width: 130 cm
Height: 200 cm
- Dimensions for Transformers with rated power 630 and 1000 kVA:
Length: 190 cm
Width: 130 cm
Height: 200 cm, for Transformers for indoor installation
Height: 230 cm, for Transformers with rated power 630 kVA for overhead networks

Note: A number of transformers, having a rated power of 630 and 1000 kVA intended to be installed indoors, that will be defined in each tender issued, shall have a maximum height of 175 cm, to be suitable for installation to rooms of limited dimensions.

5.13. Transformer oil

The Transformers shall be filled with Transformer oil, which shall meet the requirements of IEC 60296: 2012, EN 61065: 1993 and shall have minimum dielectric strength 70 kV. That oil shall be free of polychlorinated biphenyls and tetra phenyls (PCBs / PCTs). A declaration of the manufacturer that certifies that the delivered oil for filling the transformers of a certain lot is free of polychlorinated biphenyls and tetra phenyls (PCBs / PCTs) shall be submitted to the Corporation's inspector in charge. A certificate of oil analysis issued by a recognized test laboratory shall be attached to the above declaration.

5.14. Finishing and painting

5.14.1.Surface preparation and cleaning

Any surface anomalies and sharp edges shall be removed by grinding from all inner and outer surfaces of the Transformer tank and cover before paint is applied on them. Then the ferrous oxides and welding residues shall be removed from them with the sandblasting method.

Following this work, all the above surfaces shall be degreased - phosphate with a minimum phosphate thickness at least 5 µm, according to ISO 9717/2010(EN) and become free of all impurities.

5.14.2.Priming

Priming for protection against corrosion is required only at the external surfaces of the Transformer tank and cover. It shall be performed by two layers at an anticorrosive primer, which shall be a varnish made of nontoxic and environmentally friendly materials. Each layer shall be dried in a dust-free environment at a temperature of 20 °C to 25 °C, or in a furnace at 80 °C.

Each layer shall have a different color (e.g. the first shall be gray and the second green or yellow) and minimum thickness 40 µm.

5.14.3.Final painting

- The inner surface of the Transformers' tank and cover shall be painted with one layer of white colored, environmentally friendly, special oil-resistant paint without toxic materials, with minimum thickness 40 µm.
- The tank and cover shall be externally painted with two layer of environmentally friendly, non-toxic paint, with total thickness 80 µm (measured at dry condition) and shade per RAL 7033. This paint can be applied either by spraying or by immersing the whole Transformer in the varnish, after having isolated the component surfaces that do not require any painting.
- In general, the paints shall be anti-corrosive and the metallic parts shall be painted in a proper way with an approved and modern method. The painting shall be tested according to paragraph 6.1.3.

5.15. Zinc coating of steel materials, bolts, nuts, etc

All steel bolts, threaded parts, nuts, studs (if they are made of steel) that will be used in the assembly of the Transformers, must be zinc coated according to specification XK 11.02/88 if their diameter is greater than or equal to 10 mm. If their diameter is smaller, the zinc coating can be performed according to specification XK 11.01/87.

5.16. Drawings and Instructions

The manufacturer, shall submit together with his offer, the following :

- A general layout drawing (front view, plan view and side view) for each offered type of Transformer, which shall indicate its outer dimensions and shall show the positions of all components outside the tank with which the Transformer shall be equipped. This drawing shall indicate the total weight of the transformer, the weight of its live part (core + windings), the weight of oil and the free height required for

the extraction of the live part from the tank.

- Drawings of terminals for all types of the offered LV and MV terminals and earthing split-bolt connectors, which shall indicate the material used and the tin-coating thickness.
- Drawings for the nameplates of paragraph 7. These nameplates shall be made of stainless steel.
- The manufacturer, prior to the commencement of the first partial delivery for each contract shall provide the following to the Corporation in six (6) photocopies:
 - Drawing of the interconnections of the MV and LV windings for creation of the vector group.
 - Constructional drawings of the MV and LV windings indicating the coil dimensions, the cross-sections of the conductors used, their weight, the number of turns, the type and dimensions of the insulating materials and their quality.
 - Drawings of the tap changers and voltage selectors and of their levers and accessories.
 - All drawings shall be in their final form and shall be signed by the manufacturer.
 - The maintenance and operating instructions of the Transformers shall be delivered in twenty (20) copies.

5.17. Calculation of thermal ability of windings under short-circuit conditions

The thermal ability of the transformers to withstand short-circuits shall be proved with calculations at the nominal voltage, according to EN 60076-5: 2006. These shall be submitted together with the offer.

It is clarified that the calculations shall be performed for both, the MV and LV windings and for both voltages in case the transformer is of double-ratio type.

6. TESTS

6.1. Type Tests

The Type tests shall be carried out on finished Transformers (complete) at the manufacturer's factory or at the Corporation's laboratories. The time and the number of Transformers that shall undergo the type tests are mentioned in paragraph 6.4. (Acceptance procedure).

Note 1: For the double ratio Transformers the tests mentioned in paragraphs 6.1.1 and 6.1.2 shall be performed at both voltages.

Note 2: Prior to the performance of the tests of paragraphs 6.1.1 and 6.1.2, the voltage selector shall undergo 200 full operating cycles.

6.1.1. Temperature rise test

The temperature rise test shall be performed at the nominal voltage, according to EN 60076-2: 2011.

6.1.2. Impulse voltage withstand test

The test shall be performed with a full and a chopped impulse wave according to EN 60076-3: 2001, at the tap with the lower number of turns.

Further to the criteria specified in the above standard, for the verification of the results, the Transformer passed the impulse voltage test shall then be subjected to induced (0.8 kV rms - 1 min, 100 Hz for LV, or equivalent) and power frequency (50 Hz) voltage withstand test with 100% of the value specified in the same standard for the routine tests (50 kV rms - 1 min, 50 Hz).

Should the Transformer fails to withstand the above tests, the impulse voltage test shall be considered as failed.

6.1.3. Paint tests

These tests shall be frequently performed during the tank painting stage, except of the corrosion test, which shall be performed once on each type of Transformer.

- Corrosion withstand test

This test shall be performed by the salt fog method, according to standard EN ISO 9227:2012, for a period of 240 hours on a 20x20 cm sample of steel surface.

- Adhesion test of the paint

This test shall be performed according to ISO 2409: 2007 (ELOT 405) and the classification shall be 0 or 1.

6.1.4. Tests on the MV, LV insulators and MV plugs.

Insulators and plugs prior to their installation on the Transformers, shall be tested by a representative of the Corporation. The manufacturer is obliged to submit the test reports on the basis of which the LV and MV insulators and MV plugs were accepted from their manufacturer.

The test reports shall comply with the requirements of paragraph 5.8.2 and 5.8.3.

- Impulse voltage withstand test
- Power frequency voltage withstand test under rain.
- Thermal stability test
- Porosity test

The first two tests shall be performed according to EN 60137: 2008.

The thermal stability test and the porosity test shall be performed according to EN 62155:2003.

The Corporation reserves the right to repeat all or some of the above tests at its discretion. In case of tests failure, the insulators shall be rejected.

6.1.5. Tests on the MV and LV terminals

On one of the terminals (except the split bolt type), typical for each type of connectors with which the MV and LV bushings shall be equipped, and randomly selected from one of the transformers of the first lot, the following tests shall be performed:

6.1.5.1. Clamping test

Clamping of the cable conductor or of the bare copper conductor of the same cross-section shall be performed by applying a tightening moment $M=2xd$ [Nm], where d is the diameter of the terminal bolt in mm. This test shall be considered as successful if:

- No retreat of the nut is observed with the above tightening moment.
- No slipping of the conductor from the terminal is observed, if the cable is pulled with a force of 300 N.

6.1.5.2. Alloy chemical analysis

The alloy composition of the terminals shall be tested with a mutually agreed between the Corporation and the Supplier method.

6.1.6. Tightness test for the sealed type Transformers

a) Determination of the maximum pressure inside the tank

To determine the maximum pressure which is developed inside the tank of a 50 or 100 kVA sealed type Transformer when it operates at the nominal load, one Transformer shall be randomly selected from each type with the same nominal power and voltage ratio. This Transformer shall be filled with oil up to the normal level and its tank is sealed in such a way that the same pressure exists both inside and outside under conditions similar with the following:

- Temperature 20 °C.
- Atmospheric pressure 760 mm Hg.

After sealing the Transformer, the oil temperature is increased by placing the transformer inside an oven and after stabilizing the temperature 80 °C, the internal pressure P_m is measured. Alternatively, the pressure P_m can be measured during the thermal test, at the maximum temperature.

b) Test

The tightness test for the tank is performed on the above mentioned Transformers of 50 or 100 kVA in cold state, with overpressure equal to 0,45 bar. The pressure inside the tank is increased up to $P_m + 0,45$ bar within a period of about 1 min with dry air or nitrogen. That pressure shall be maintained stable for one hour.

The test is considered successful if during the one hour period no oil leakage, warping or deformation of the tank is observed. A leakage may be observed by several ways (change of the manometer indication).

6.2. Routine tests according to EN 60076-1:2011

- For the double ratio Transformers, 20-15/0.4 kV or 20-6.6/0.4 kV, the tests mentioned in paragraphs 6.2.1 to 6.2.4 shall be performed at both voltages. The tests of paragraphs 6.2.5, 6.2.7 and 6.2.8 shall be performed only at the 20 kV voltage level. Test mentioned in paragraph 6.2.6 shall be performed only at 20 kV voltage level, while in the other voltage (15 or 6.6 kV) shall be performed as Type test for each lot, after the impulse wave withstand test (par. 6.1.2) and shall be successful. If it fails, it shall also be performed at this voltage as Routine test.
- The tests 6.2.1 to 6.2.5 shall be performed according to EN 60076-1: 2011 and the tests of paragraphs 6.2.6 and 6.2.7 according to EN 60076-3: 2013.

6.2.1. Measurement of the windings resistances.

6.2.2. Measurement of the transformation ratio, polarity check, angular and phase sequence.

6.2.3. Measurement of the short-circuit impedance.

6.2.4. Measurement of load losses.

6.2.5. Measurement of no-load losses and exciting current at the nominal voltage.

6.2.6. Induced voltage test.

6.2.7. Power frequency voltage withstand test (separate source voltage withstand test).

6.2.8. Tightness test for the sealed type Transformers

a) Determination of the maximum pressure inside the tank

To determine the maximum pressure which is developed inside the tank of a 50 or 100 kVA sealed type Transformer when it operates at the nominal load, one Transformer shall be randomly selected from each type with the same nominal power and voltage ratio. This Transformer shall be filled with oil up to the normal level and its tank is sealed in such a way that the same pressure exists both inside and outside under conditions similar with the following:

- Temperature 20 °C.
- Atmospheric pressure 760 mm Hg.

After sealing the Transformer, the oil temperature is increased by placing the transformer inside an oven and after stabilizing the temperature 80 °C, the internal pressure P_m is measured. Alternatively, the pressure P_m can be measured during the thermal test, at the maximum temperature.

b) Test

The tightness test for the tank is performed on each Transformer of the same type in cold state, with pressure $1.2 \times P_m$ in the following manner:

The pressure inside the tank is increased up to $1.2 \times P_m$ within a period of about 1 min with dry air or nitrogen. That pressure shall be maintained stable for one hour.

The test is considered successful if during the one hour period no oil leakage, warping or deformation of the tank is observed. A leakage may be observed by several ways (change of the manometer indication).

6.2.9. Measuring of dry paint thickness

Measurement of the dry paint thickness. This measurement may be performed by any method jointly accepted by the Corporation and the Supplier. The thicknesses of the layers of the primer and final paint shall be measured both at the inner and outer surface of the tank. These thicknesses shall not be less than the specified values.

6.3. Special tests

The number of Transformers that shall be subjected to these tests is mentioned in paragraph 6.4.

Note: For the Transformers of double ratio, the sound level and radio interference tests shall be performed only at the 20 kV voltage.

The tests of paragraphs 6.3.2 to 6.3.5 shall be performed only once, at the delivery of the first lot.

6.3.1. Short-circuit withstand test

The dynamic short-circuit withstand test shall be performed according to EN 60076-5: 2006, but the reference value for the symmetrical short-circuit current shall not exceed in any case 25 times the value of the nominal current. This concerns Transformers with rated short-circuit impedance less than 4%. If the difference in Reactance measured after and before the test, exceeds the limits specified in the above standard for the corresponding type of winding (cylindrical or not cylindrical), the Transformer shall be rejected.

On the tested Transformer it is permitted to exceed the short-circuit impedance voltage above the 10% tolerance limit and up to the permitted limit for the difference of the reactance as provided in EN 60076-5: 2006.

For the Transformers of double ratio the test shall be performed at the voltage at which the tested Transformer has the lowest short-circuit impedance.

6.3.2. Sound level test

It shall be performed according to EN 60076-10: 2001

6.3.3. Radio interference level test

This test is regarded as successfully performed on the T/S if it has been successfully done on the insulators, according to EN 60437: 1997.

6.3.4. Measurement of the no-load current harmonics

It shall be performed according to EN 60076-1:2011

6.3.5. Measurement of the zero sequence impedance

It shall be performed according to EN 60076-1:2011

6.4. Inspection and acceptance procedure

- The Transformers purchased by the Corporation under this specification are subject to inspection by their qualified inspectors. These inspectors shall have access to all departments of the factory during the working hours and they shall be provided with all available accommodation for the inspection of the material.

The manufacture is required to provide to the inspectors advance notification periods for all tests, thus enabling them to attend the tests.

The supplier is required to submit certified copies of the reports of the final Routine, Type and special tests. These shall include information and test results regarding all the specified values.

Type tests shall be performed only at the first lot except for the impulse wave withstand test, which shall be performed on every lot. Special tests shall be performed only once at the first lot.

- In particular, for the impulse tests the supplier is required to:

a) Keep a complete record of all impulse voltages that were applied to the Transformer terminals. The record shall include all preliminary and calibrating tests as well as the final tests. This record shall include oscillographs with their evaluation, the winding connections for the test, atmospheric conditions, etc., as well as any disruption or failure of the test, either inside or outside the Transformer. This impulse tests record and the drawings for the test circuits must be always available to the Corporation.

b) Take oscillographs of the impulse voltages applied to the Transformer terminals for all tests, preliminary, calibrating and final.

- All Transformers of the same type shall be delivered by partial deliveries in lots. The quantity of each lot shall be defined in each contract. In special cases, the lot quantity may be determined by the inspector.
- The Routine tests for each lot can be performed in the absence of the inspector at his discretion. In this case, the manufacturer shall submit to the inspector the tests reports, although the reliability of the measurements shall be verified by him by repeating 10% of the tests. In case of discrepancy between one test and the test reports, the tests shall be repeated on the whole lot.
- In case the results of the Routine tests for the first, or any other, lot are acceptable, the inspector shall proceed to the performance of the Type and Special tests as follows:

First lot: For the execution of type and special tests, two (2) pieces in the case of single ratio Transformers, or three (3) pieces in the case of double ratio Transformers shall be randomly selected. The following tests shall be performed on them:

- On the first one (single or double ratio) a short circuit withstand test shall be performed (paragraph 6.3.1)
- On the second one, if it is of single ratio type, the temperature rise test shall be performed at the nominal voltage (paragraph 6.1.1), followed by the impulse voltage withstand test (paragraph 6.1.2), and the radio interference test (paragraph 6.3.3).
If it is of double ratio type Transformer, the second one shall undergo all the above tests, in the ratio with the highest losses.
- On the third Transformer, the impulse voltage withstand test (paragraph 6.1.2) shall be performed at the voltage ratio that was not used for the tests of the second sample.
- If all these tests are successful, the first lot shall be accepted.

Every other lot except for the first: In order to perform the type tests one (1) piece in case of single ratio transformers or two (2) in case of double ratio transformers shall be randomly selected. The following tests shall be performed on them:

- On the first Transformer, if it is of single ratio, the impulse voltage withstand test (paragraph 6.1.2) shall be performed.
In case of a double ratio transformer the impulse withstand test (paragraph 6.1.2) shall be performed in the ratio with the highest losses.
- On the second Transformer, the impulse voltage withstand test (paragraph 6.1.2) shall be performed at the voltage ratio that was not used for the tests of the first sample.
- If all these tests are successful, the lot shall be accepted.

If at least one of the above mentioned transformers (one, two or three) fails to pass any of the test that correspond to it, then its lot (first or next) shall be rejected, unless it is obvious that the failure was due to an accidental constructional defect.

In the last case, three more Transformers (of single or double ratio) shall be randomly selected from the same lot, which shall be subjected to the tests that the previous transformers failed. If the failed test is the short-circuit withstand test, it shall be repeated only on one Transformer instead of three. The lot shall be accepted on condition that all tests performed on the three (or the one) new Transformers shall be successful, otherwise the lot shall not be accepted. Therefore, its Transformers shall not be accepted.

According to what is mentioned above, following the first lot acceptable the Special tests and the Type tests, except for the impulse voltage withstand test, shall not be repeated on the rest of the lots.

The Corporation, however, reserves the right to repeat these tests at its discretion on one more lot and these shall be successful. If even one of these tests fails, the tests shall be repeated on a new transformer according to the above mentioned procedure for the case of failure in a Type or Special test. In case of failure the Transformer lot shall not be accepted. The Corporation reserves the right to perform these tests on one of the following lots.

It is understood that if certain tests for the acceptance procedure are not performed on a lot, these tests shall be considered as successful.

6.5. Sample

The manufacturer, before the start of the mass production of the Transformers is obliged to supply one (1) Transformer for each rated power and ratio for visual inspection and to comply with the comments of the sample inspection committee.

7. NAMEPLATES AND MARKING

The transformers shall be equipped with the following nameplates. All the nameplates shall be made from stainless steel. Their thickness shall be at least 1mm.

7.1. Transformer characteristics nameplate

This name plate shall contain the main characteristics of the Transformer and shall be mounted at the tank side, where the LV bushings of the Transformer are mounted. The dimensions of the plate shall be 230x160 mm and the arrangement of its data shall be in accordance with the drawings 4, 5 and 6.

The sign shall be marked with CE according to the instruction 2009/125/EU.

The connection diagram shall show the internal connections and the marking of the terminals. The Transformer's serial number shall be printed on the plate, on the cover and on its live part (core + windings).

7.2. Operating nameplates for tap-changer and selector

Each lever of tap-changer or Voltage Selector must be equipped with a nameplate on which the followings must be written in Greek capital letters:

Ο ΧΕΙΡΙΣΜΟΣ ΘΑ ΓΙΝΕΤΑΙ ΜΕ ΤΟ ΜΕΤΑΣΧΗΜΑΤΙΣΤΗ ΕΚΤΟΣ ΤΑΣΗΣ
(that is: "Handling shall be done when the transformer is not live")

Apart from this nameplate, each tap-changer shall be equipped with a circular shaped plate having the same axis with that of the lever, with the tapping markings (1, 2, 3, 4, 5), while on every tap of voltage selector the following voltage markings shall exist: 1 for 20 kV and 2 for 15 kV or 1 for 20kV and 2 for 6,6 kV. As an alternative the numbers corresponding to the taps can marked on the levers themselves.

7.3. Phase marking

A print of reliefs or engraving type for each phase shall be provided on the cover of the Transformer near the base of the MV and LV bushings. It is not permitted to use welded plates. The symbols for the phases are provided in paragraphs 5.3.1.6, 5.3.2.6 and 5.3.3.6.

8. PACKING

The Transformers, before they are loaded for shipment, shall be placed on a wooden base made of suitable beams. The base shall be properly screwed on the Transformer's base.

All three MV bushings shall be surrounded together by a protective cover made of foamy material. If the Transformer is to be transported overseas, special packing is required.

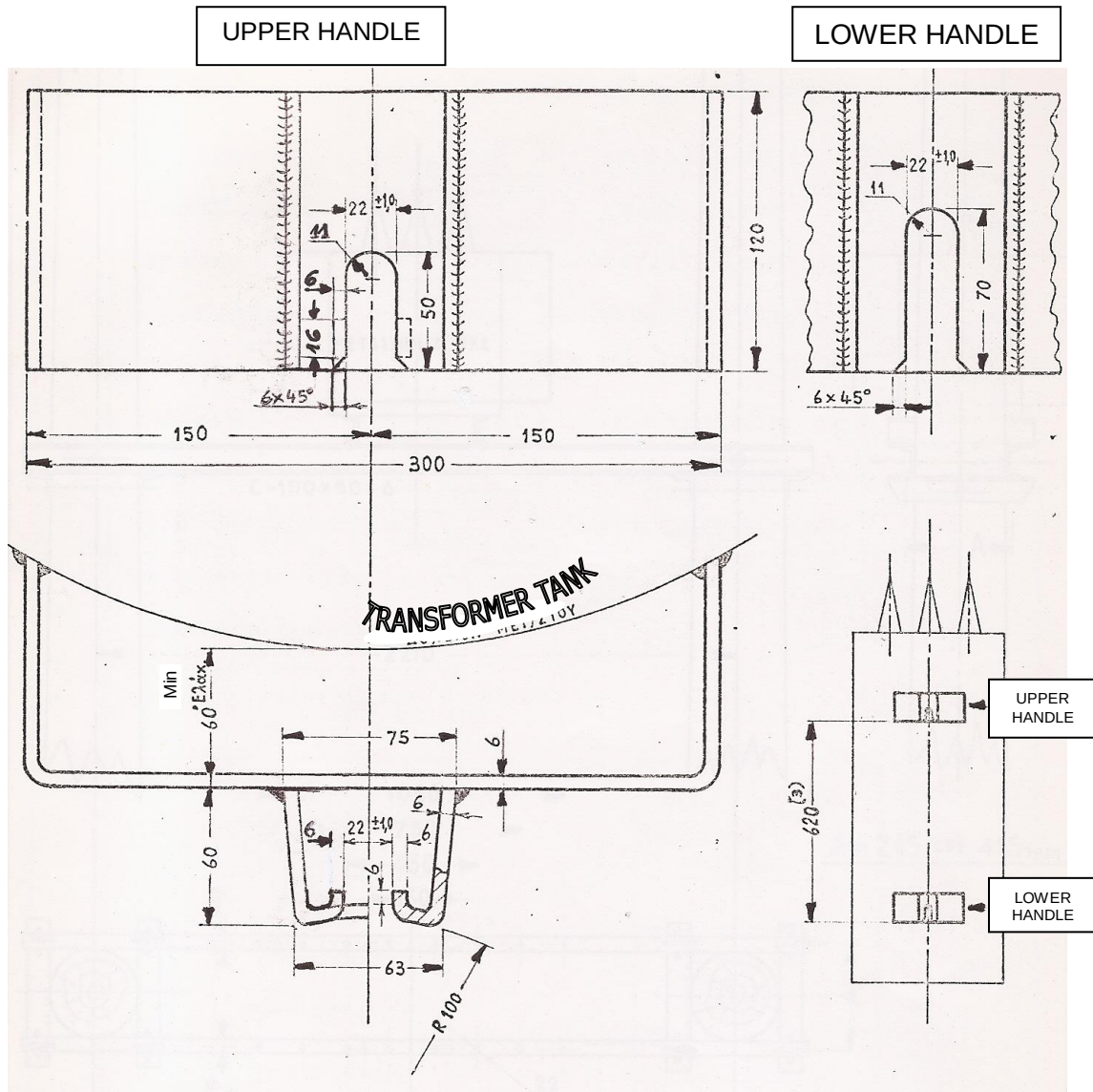
The manufacturer shall be responsible for the design of this special packing and shall be approved by the Corporation.

9. DRAWINGS LIST

- Drawing 1: Hanging lugs of 50 and 100 kVA Transformers
 - Drawing 2: Installation of 100 to 630 kVA Transformers on platform.
 - Drawing 3: Position of the bolts for mounting the MV arrester bases on the cover of 50 and 100 kVA T/S.
 - Drawing 4: Mounting base of MV arresters of the 2nd Phase of 50 and 100 kVA T/S.
 - Drawing 5: Mounting base of MV arresters of 160 kVA and up and for the 1st and 3rd Phase of 50 and 100 kVA T/S.
 - Drawing 6: Indicative nameplate of 20/0.4 kV Transformers.
 - Drawing 7: Indicative nameplate of 20-15/0.4 kV Transformers.
-
- Drawing 8: Indicative nameplate of 20-6.6/0.4 kV Transformers.
 - Drawing N° 430020560: M12 split bolt connector (16-35 mm²).
 - Drawing N° 430020572: M12 LV split bolt connector (35-50 mm²).
 - Drawing N° 430000057: Terminal 95-150 mm², M12.
 - Drawing N° 430015394: Terminal 150 - 300 mm², M20.
 - Drawing N° 430015400: Terminal 2x300 mm², M30.
 - Drawing N° 430021758: Terminal 4x300 mm², M42
 - Drawing N° 430020559: M12 Earthing split bolt connector.

HEDNO TECHNICAL SPECIFICATION

9.2.1 of ND 01.48



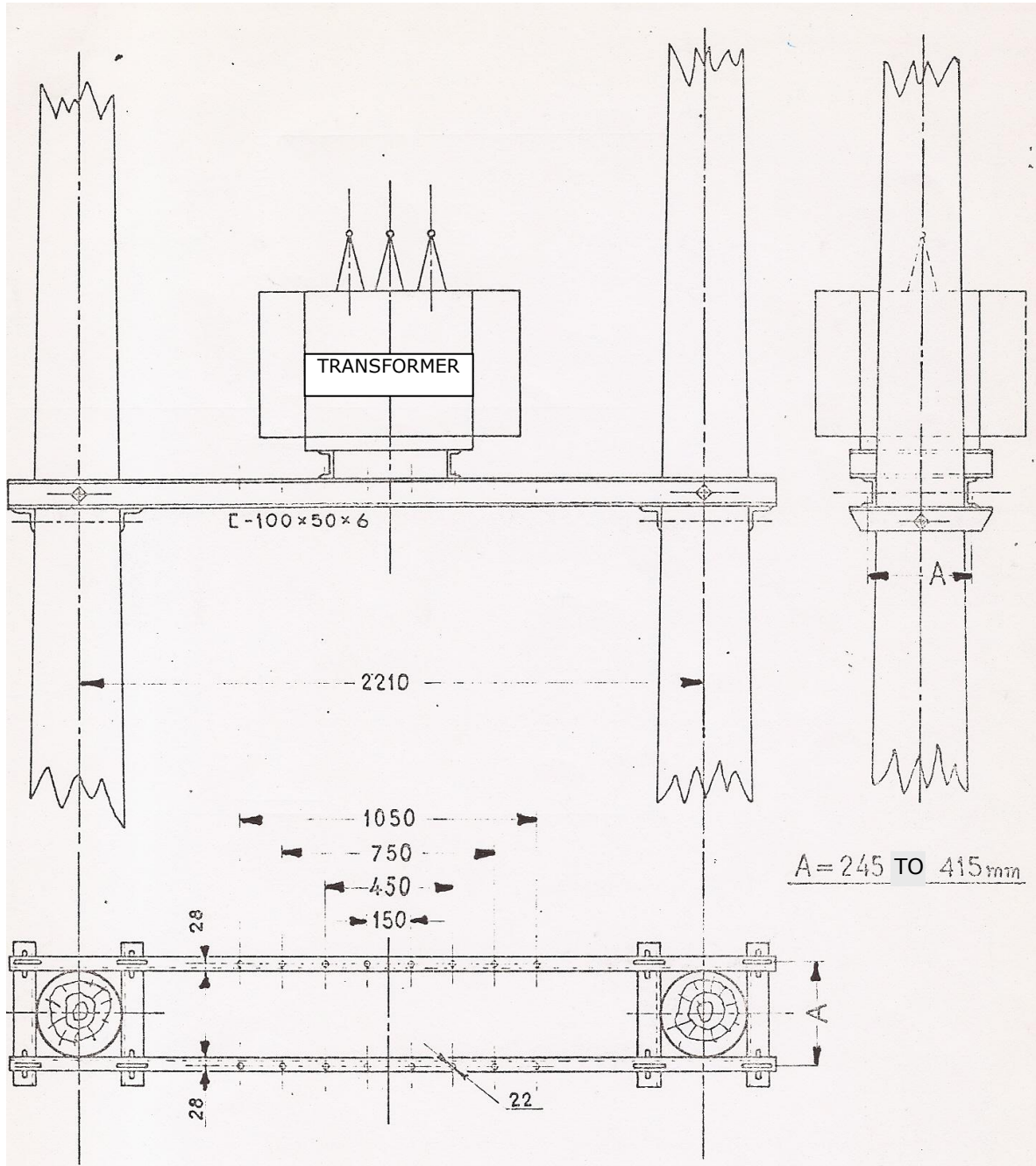
NOTES:

1. Dimension tolerances $\pm 1,5$ mm, unless specified otherwise in the drawing
2. The method of mounting the handles on the container is indicative
3. This distance may become 320 mm if the transformer container dimensions do not permit the 620 mm distance to be maintained

DRAWING TITLE	DRAWING No.
Suspension handles for 50 and 100 kVA transformers	1

HEDNO TECHNICAL SPECIFICATION

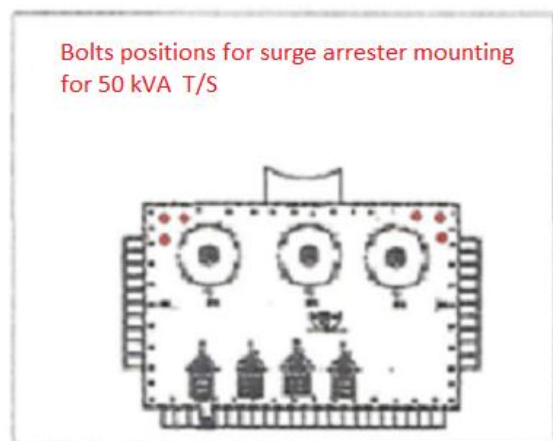
9.2.2 of ND 1.48



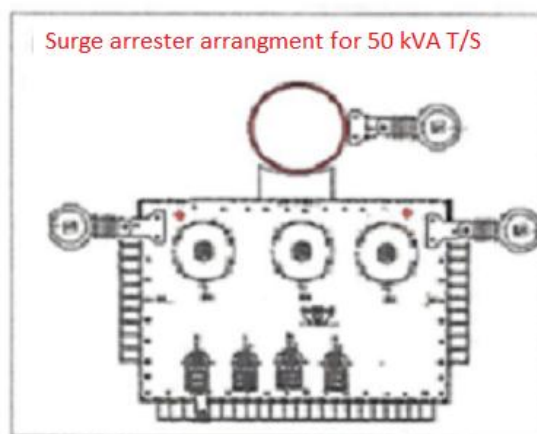
DRAWING TITLE	DRAWING No.
Mounting of 100 to 630 kVA power transformers on a platform	2

HEDNO TECHNICAL SPECIFICATION

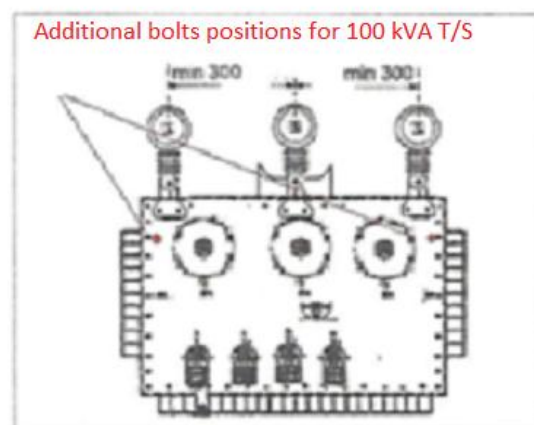
9.2.3 of ND 1.48



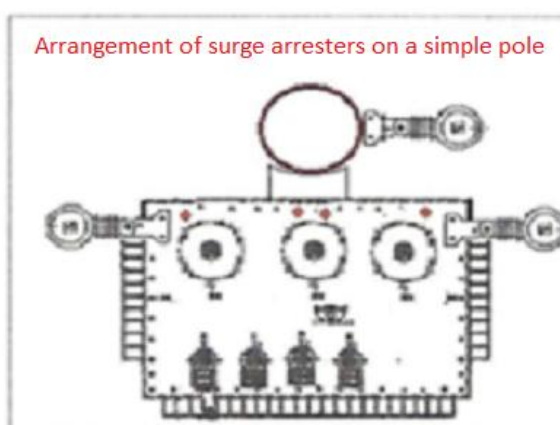
3.1



3.2



3.3

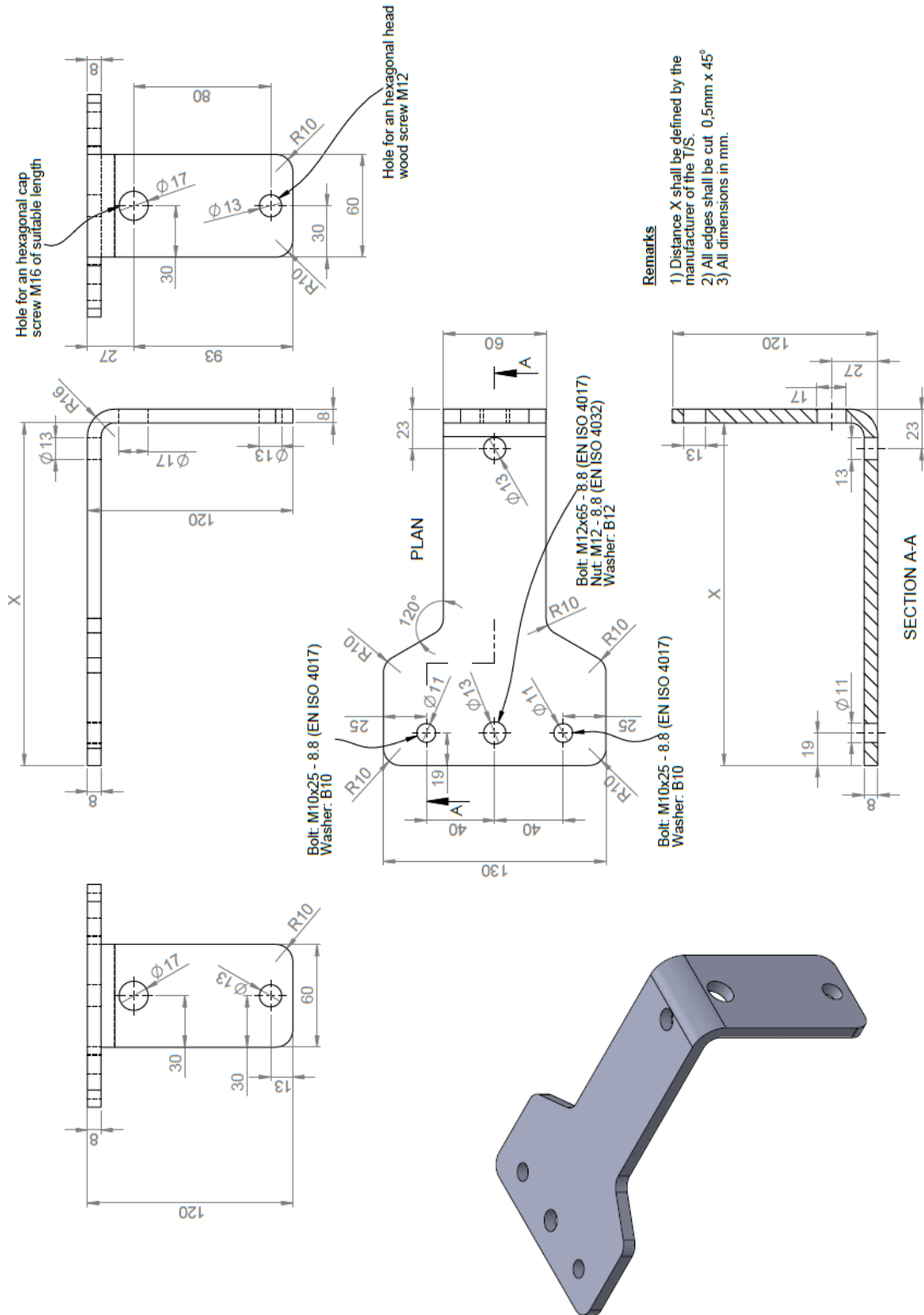


3.4

DRAWING TITLE	DRAWING No.
Position of the bolts for mounting the surge arresters on the cover of T/S of a rated power 50 kVA and 100 kVA	3

HEDNO TECHNICAL SPECIFICATION

9.2.4 of ND 1.48



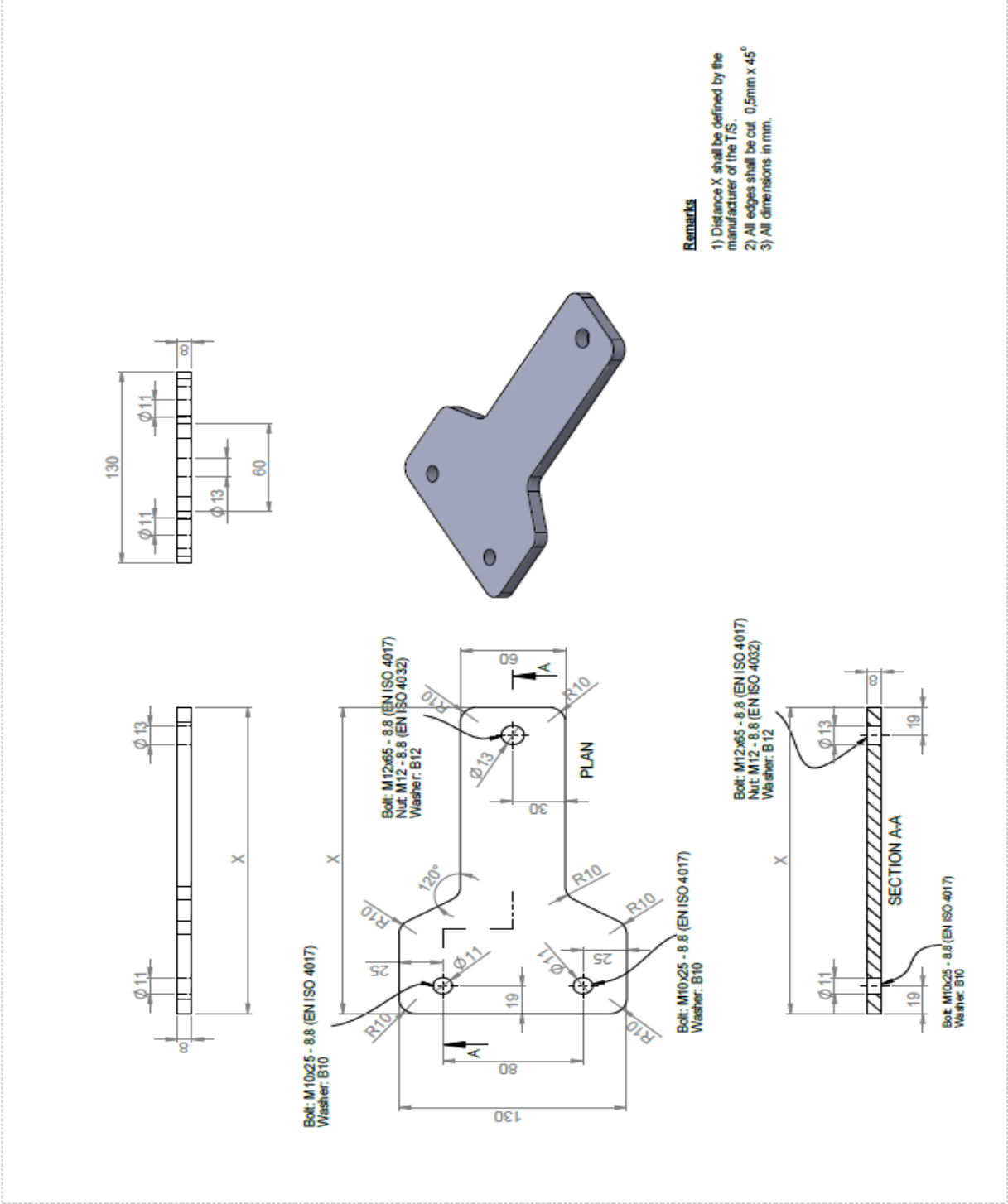
DRAWING TITLE	DRAWING No.
Mounting base of surge arrester of the 2 nd phase of 50 and 100 Kva transformers	4

HEDNO TECHNICAL SPECIFICATION

9.2.5 of ND 1.48

HEDNO TECHNICAL SPECIFICATION

9.2.5 of ND 1.48



DRAWING TITLE	DRAWING No.
Mounting base of surge arrester of a rated power equal or greater than 160 kVA and of the phases 1 and 3 of 50 and 160 kVA	5

HEDNO TECHNICAL SPECIFICATION

9.2.4 of ND 01.48



MANUFACTURER'S NAME

DISTRIBUTION TRANSFORMER



OWNER: Δ.Ε.Η.

SERIAL NUMBER:

POWER: kVA

COOLING TYPE: ONAN

PHASES: 3

FREQUENCY: 50 HZ

LINK:

MANUFACTURED IN:

CONTRACT No.:

TOTAL WEIGHT: kg

OIL WEIGHT: kg

H.V. WINDING MATERIAL:

H.V. WINDING WEIGHT: kg

L.V. WINDING MATERIAL:

L.V. WINDING WEIGHT: kg

WINDING DRAWING No.:

RATED VOLTAGE:

IMPEDANCE VOLTAGE AT 75 °C: %

20.000/400 V

SPACE FOR L.V. WINDINGS

a(x₀)
A(x₀)



b(x₀)
B(x₀)



c(x₀)
C(x₀)



n(x₀)



SPACE FOR
H.V. WINDINGS
WITH TAPS

SWITCH POSITION	H.V. CONNECTIONS	H.V. TAPS %
1		-5
2		-2.5
3		0
4		+2.5
5		+5

230

160

DRAWING TITLE	DRAWING No.
Nameplate of 20/0.4 kV distribution transformers	6

HEDNO TECHNICAL SPECIFICATION

9.2.5 of ND 01.48



MANUFACTURER'S NAME

DISTRIBUTION TRANSFORMER



OWNER

SERIAL NUMBER

POWER

COOLING TYPE

PHASES

FREQUENCY

LINK

MANUFACTURED IN

Δ.Ε.Η.

kVA

ONAN

3

50 HZ

CONTRACT No.

TOTAL WEIGHT

OIL WEIGHT

H.V. WINDING MATERIAL

H.V. WINDING WEIGHT

L.V. WINDING MATERIAL

L.V. WINDING WEIGHT

WINDING DRAWING No.

kg

kg

kg

kg

RATED VOLTAGE

IMPEDANCE VOLTAGE AT 75 °C

15.000/400 V

%

10.000/400 V

%

SPACE FOR L.V. WINDINGS

a(x₁)
A(H₁)



b(x₂)
B(H₂)



c(x₃)
C(H₃)



n(x₀)



SPACE FOR
H.V. WINDINGS
WITH TAPS

SWITCH POSITION	H.V. CONNECTIONS	TAPS %	
		15 kV	20 kV
1		-6.6	-5
2		-3.3	-2.5
3		0	0
4		+3.3	+2.5
5		+6.6	+5



160



230

DRAWING TITLE	DRAWING No.
Nameplate of 20-15/0.4 kV distribution transformers	7

HEDNO TECHNICAL SPECIFICATION

9.2.6 of ND 01.48



MANUFACTURER'S NAME
DISTRIBUTION TRANSFORMER



OWNER

SERIAL NUMBER

POWER

COOLING TYPE

PHASES

FREQUENCY

LINK

MANUFACTURED IN

Δ.E.H.

kVA

ONAN

3

50 HZ

CONTRACT No.

TOTAL WEIGHT

OIL WEIGHT

H.V. WINDING MATERIAL

H.V. WINDING WEIGHT

L.V. WINDING MATERIAL

L.V. WINDING WEIGHT

WINDING DRAWING No.

kg

kg

kg

kg

RATED VOLTAGE

IMPEDANCE VOLTAGE AT 75 °C

6600 / 400 V

%

20000 / 400 V

%

SPACE FOR L.V. WINDINGS

a

A

b

B

c

C

SPACE FOR
H.V. WINDINGS
WITH TAPS
AT 6600 V

SPACE FOR L.V. WINDINGS

a

A

b

B

c

C

SPACE FOR
H.V. WINDINGS
WITH TAPS
AT 20000 V

SWITCH POSITION	H.V. CON-NECTIONS - 6600 V	TAPS %
		0
		- 2.5
		- 5

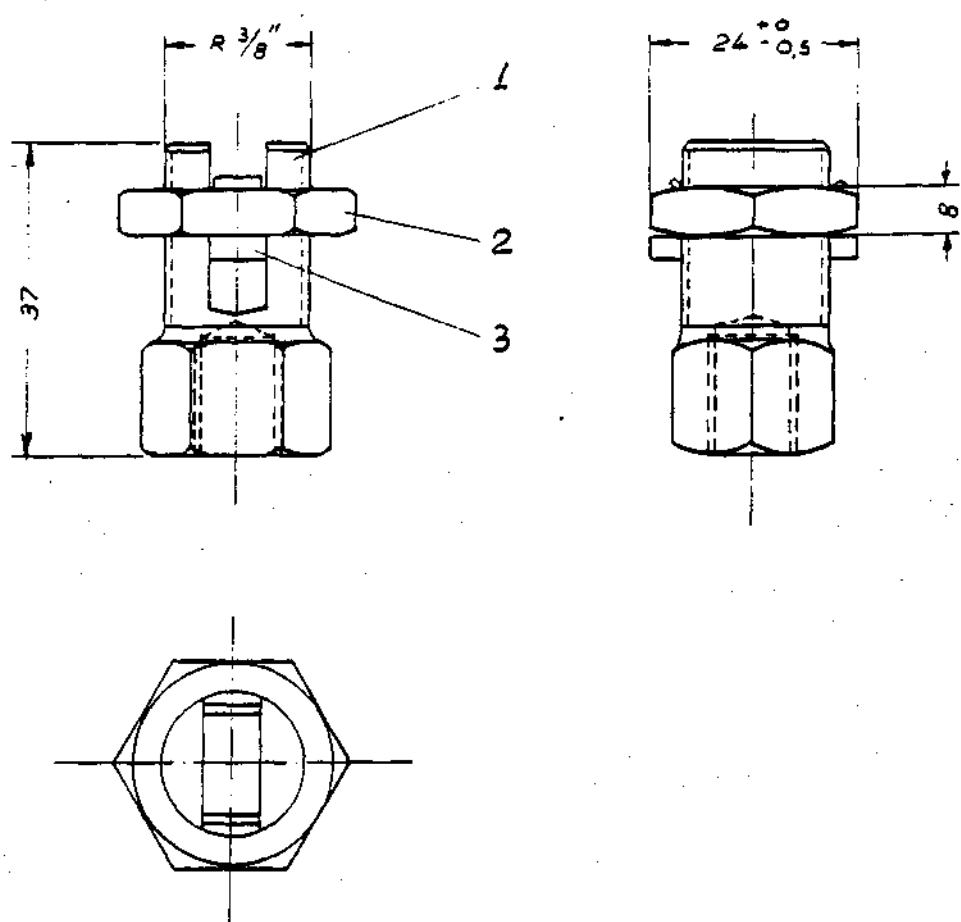
SWITCH POSITION	H.V. CON-NECTIONS - 20000 V	TAPS %
		+ 2.5
		0
		- 2.5

160

230

DRAWING TITLE	DRAWING No.
Nameplate of 20-6.6/0.4 kV distribution transformers	8

Note: After the assembly, the ends of item No. 3 shall be opened, thus enabling it to be moved along by the nut



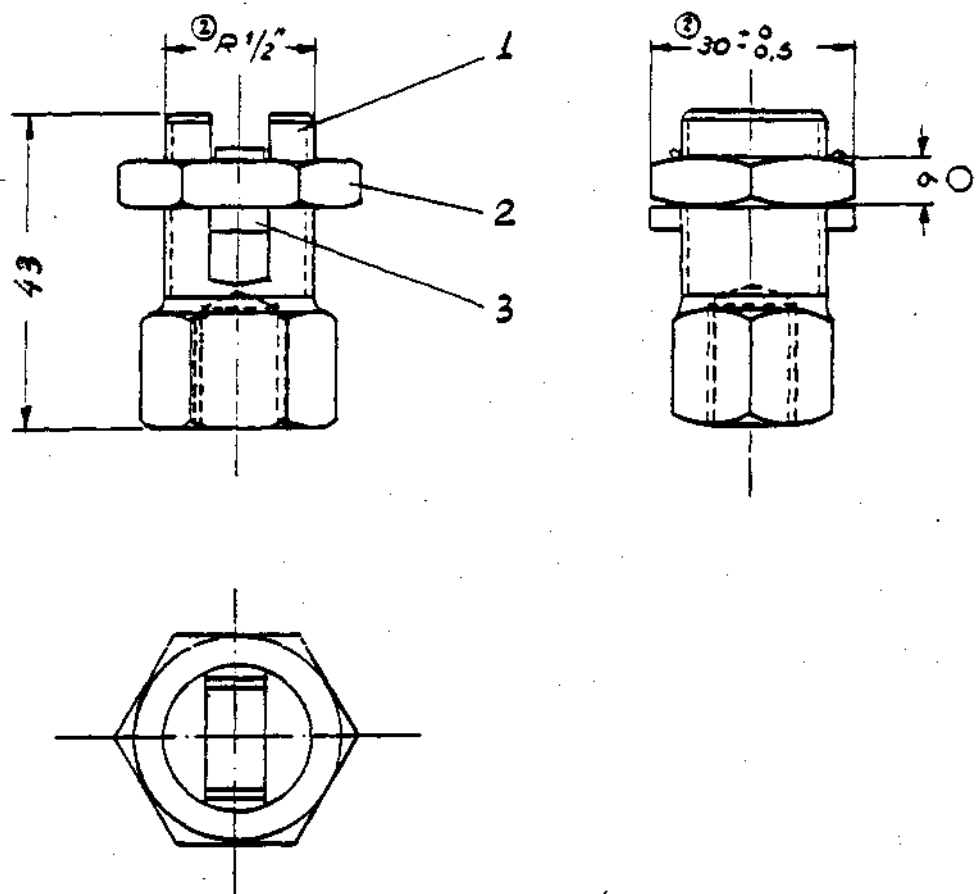
KAV: 430020560 for 50 ÷ 1000 kVA
transformers at M.V.

Weight kg

1	CONDUCTOR TIGHTENER		3			
		412959				
1	NUT R 3/8"		2	Tinning 13μ		
1	BOLTED CONNECTOR		1			
		412958				
ITEM	NAME		MATERIAL	IDX.	SEMI-TREATED MATERIAL	
					SPAC. SEMI- TR.	
	SPECIFICATION		CODE		ORDER RECOMMENDATION	

BOLTED CONNECTOR M12
(16-35 mm²)
430020560

Note: After the assembly, the ends of item No. 3 shall be opened, thus enabling it to be moved along by the nut

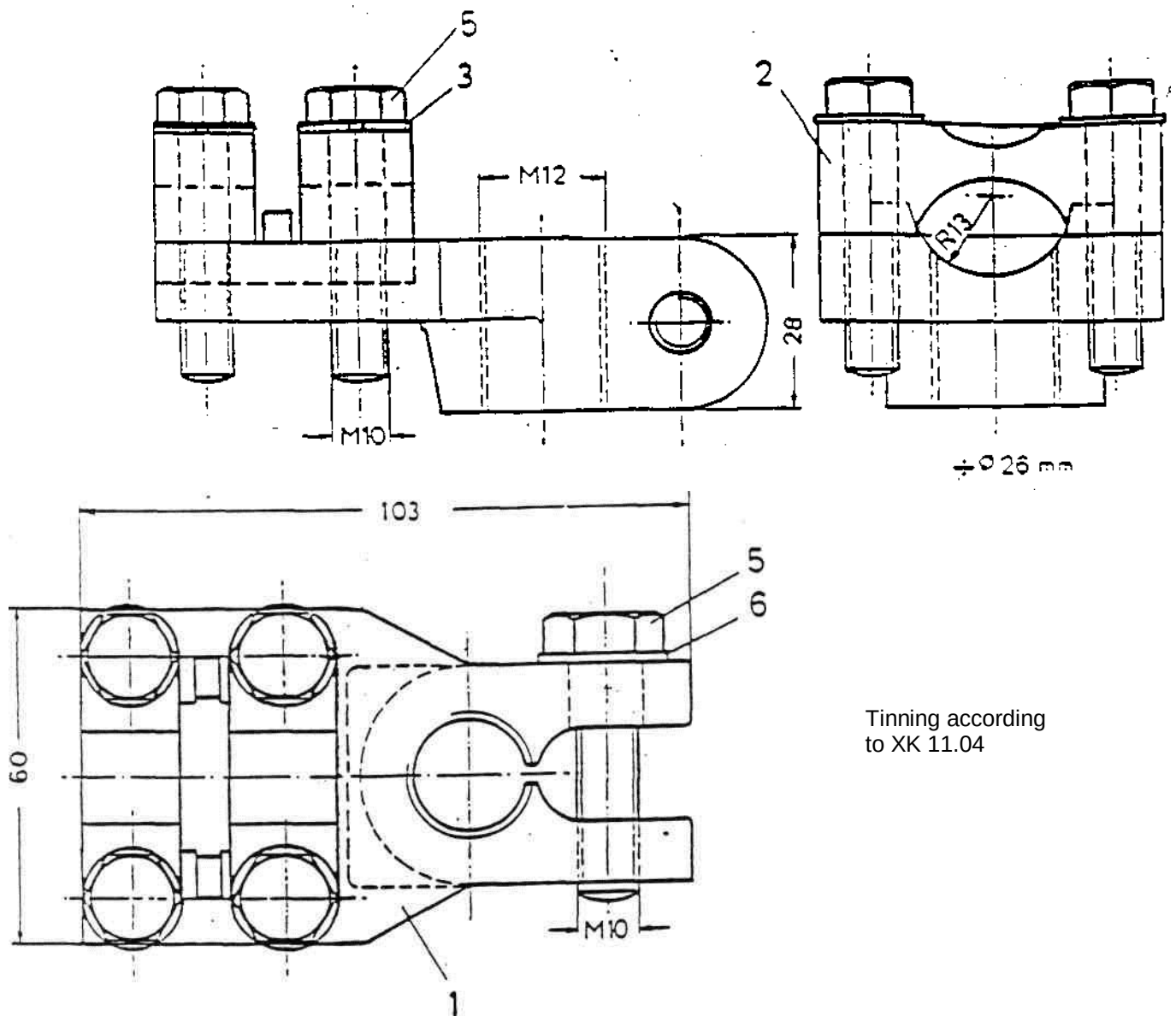


KAY: 430020572 for 50 kVA
transformers at L.V.

Weight 0.118 kg

1	CONDUCTOR TIGHTENER		3			
		400076				
1	NUT R 1/2"		2	Tinning 13μ		
		acc. to PPC GR88				
1	BOLTED CONNECTOR		1			
		400075				
ITEM	NAME	MATERIAL	IDX.	SEMI-TREATED MATERIAL SPAC. SEMI- TR.		
	SPECIFICATION	CODE		ORDER RECOMMENDATION		

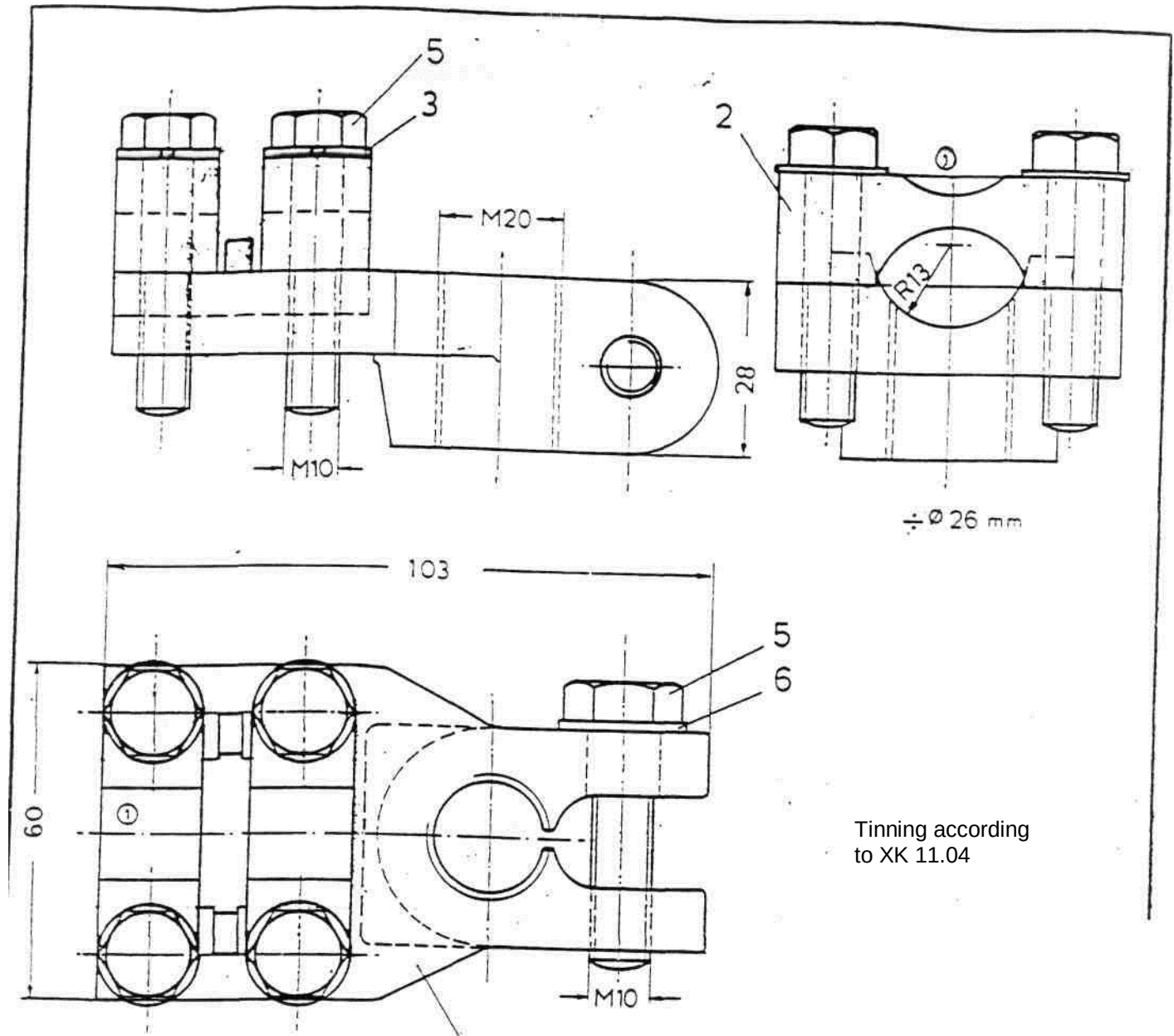
BOLTED CONNECTOR M12
(35-50 mm²)
430020572



Weight ~ 0.94 kg

1	WASHER B10		F St.	6	YZK + bichr.	0.009
	DIN 6796	010537				
5	HEXAGONAL SCREW M10 X 40		8.8	5	STAINLESS STEEL	
	DIN 933	010582				
-	HEXAGONAL SCREW M X 45		5.6	4	TINNED	
	DIN 933					
4	GROVER B40		St	3	YZK + bichr.	0.01
	DIN 127					
2	TIGHTENER COLLAR			2	UNTREATED 010845	0.22
		408734				
1	TIGHTENER BODY			1	UNTREATED 010845	0.52
		412520				
ITEM	NAME		MATERIAL	IDX		WEIGHT
	SPECIFICATION	DRAWING NO.	CODE			kg

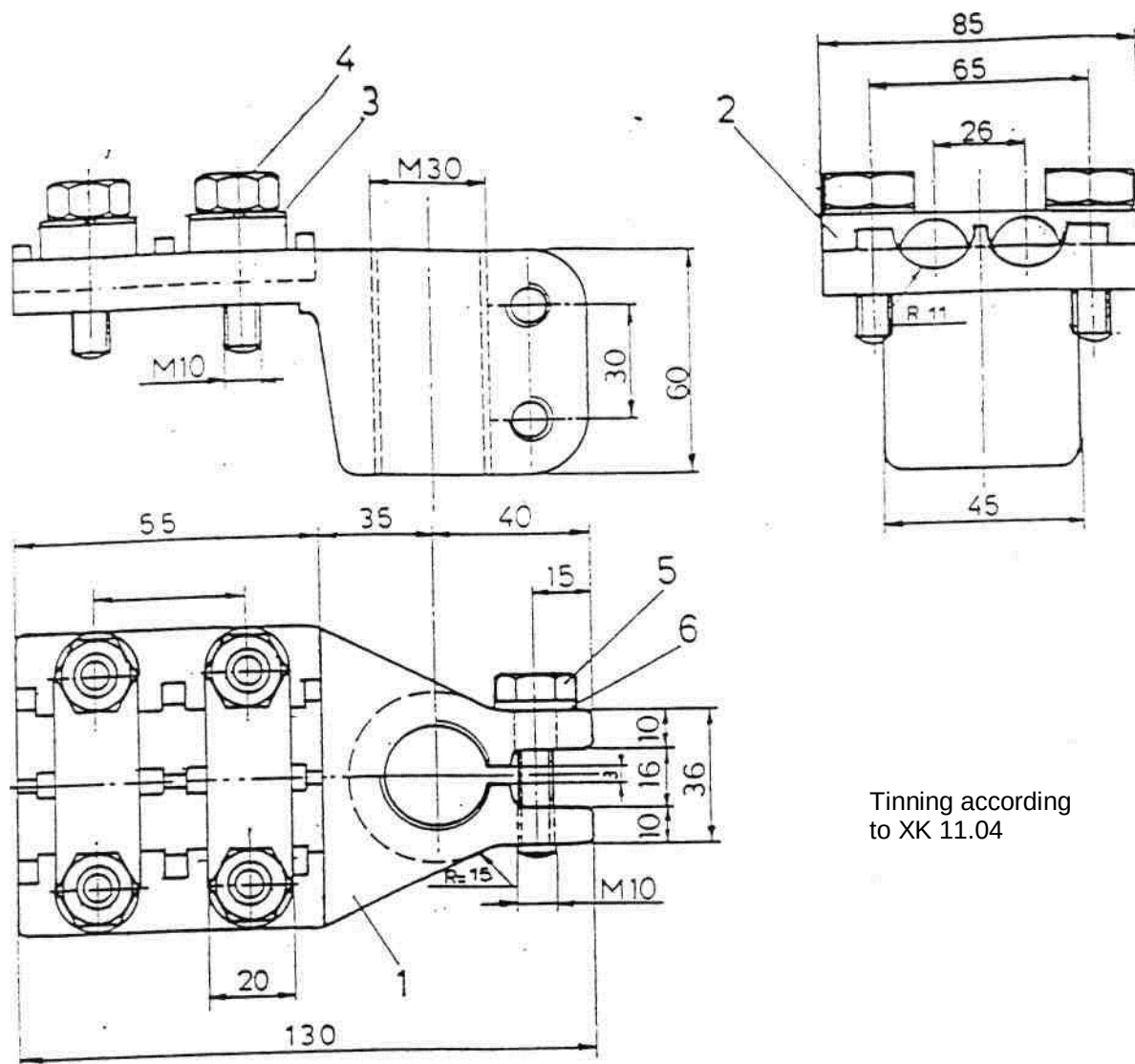
TERMINAL
95-150 mm²
430000057



Weight ~ 0.94 kg

1	WASHER B10		F St.	6	Iridium treatment - ALG acc.	0.009
	DIN 6796	010537			DIN 267/9	
5	HEXAGONAL SCREW M10 X 40		8.8	5	STAINLESS STEEL	0.17
	DIN 933	010582				
-	HEXAGONAL SCREW M X 45		5.6	4	TINNED	
	DIN 933					
4	GROVER B40		St	3	Iridium treatment - ALG acc.	0.01
	DIN 127				DIN 267/9	
2	TIGHTENER COLLAR			2	UNTREATED 010845	0.22
		408734				
1	TIGHTENER BODY			1	UNTREATED 010845	0.52
		408733				
ITEM	NAME		MATERIAL	IDX		WEIGHT
	SPECIFICATION	DRAWING NO.	CODE			kg

TERMINAL
150-300 mm²
430015394

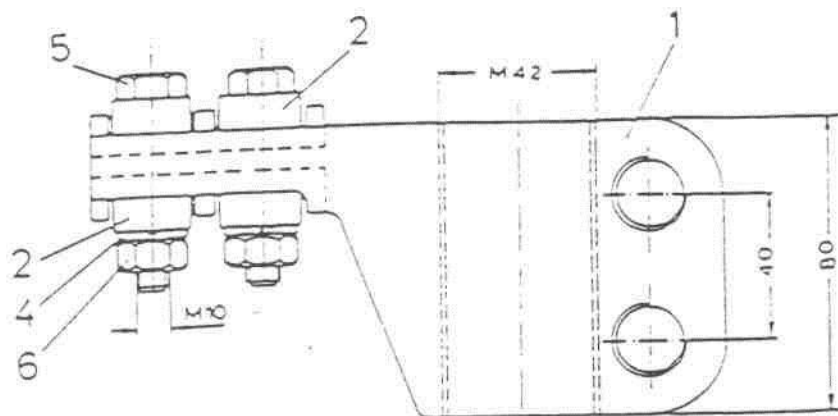
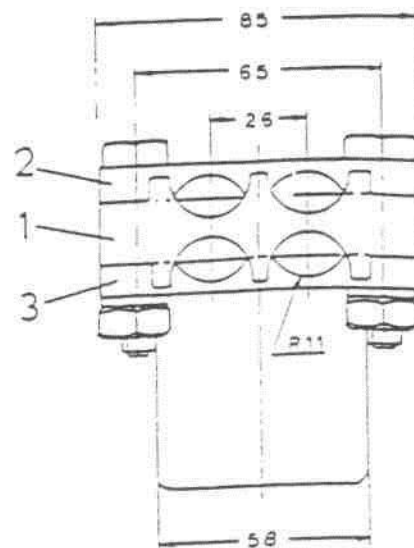
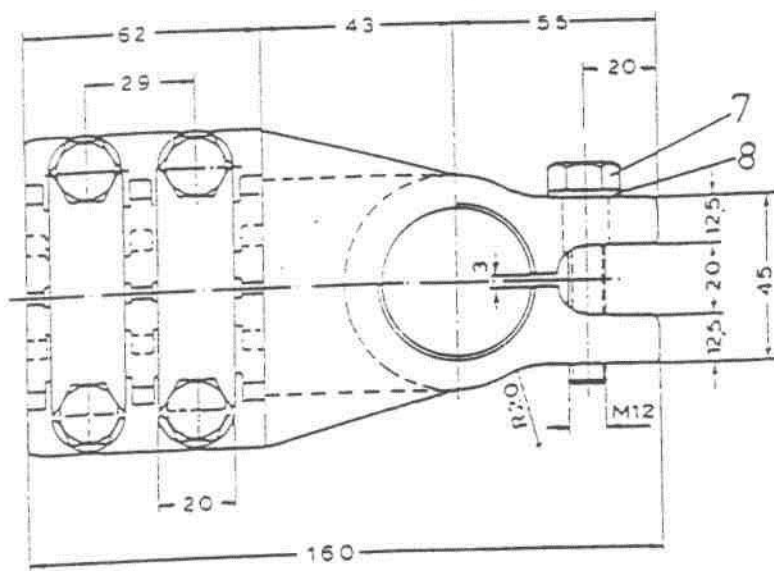


Tinning according
to XK 11.04

2	WASHER A 10.5		F St.	6	Iridium treatment - ALG acc.	
	DIN 125	010537	105/608		DIN 267/9	
6	HEXAGONAL SCREW M10 X 40		8.8	5	STAINLESS STEEL	
	DIN 933	010582				
-	HEXAGONAL SCREW M10 X 55		5.6	4		
	DIN 933					
4	GROVER B10		St	3	Iridium treatment - ALG acc.	
	DIN 127				DIN 267/9	
2	TIGHTENER COLLAR		G-CuZn33Pb	2	TINNED $\geq 30 \mu\text{m}$	
		411413				
1	TIGHTENER BODY		G-CuZn33Pb	1	TINNED $\geq 30 \mu\text{m}$	
		411412				
ITEM	NAME		MATERIAL	IDX	SEMI-TREATED MATERIAL SPAC. SEMI- TR.	WEIGHT
	SPECIFICATION	DRAWING NO.	CODE		ORDER RECOMMENDATION	kg

G - CuZn33Pb

TERMINAL
2 x 300 mm²
430015400

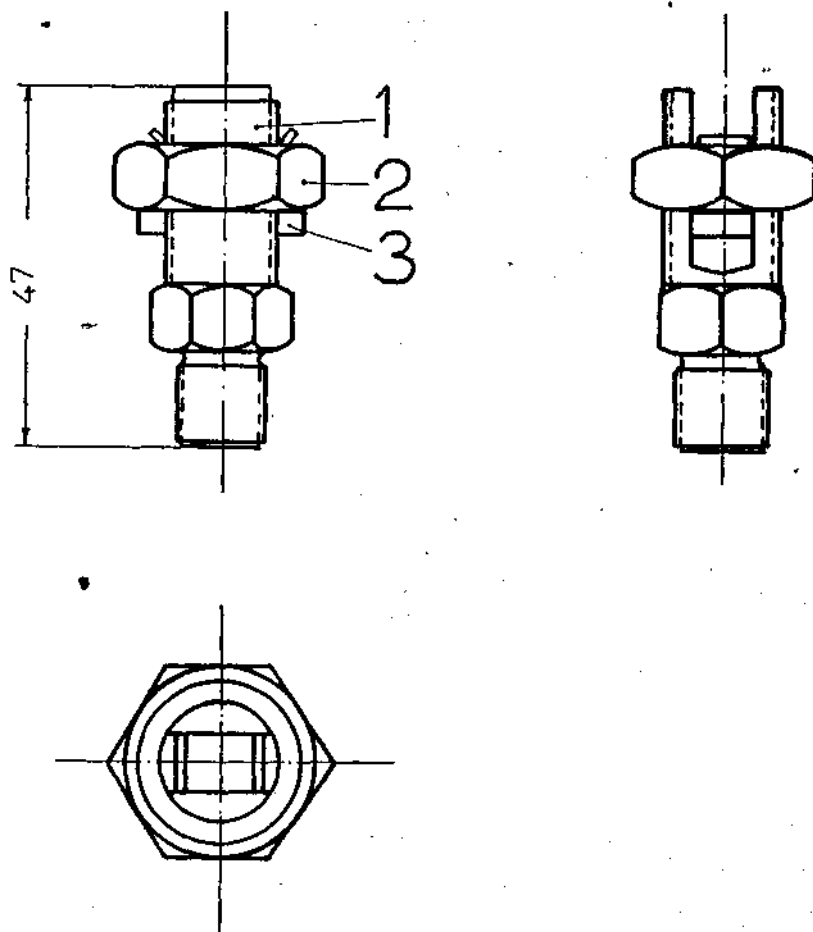


Tinning according
to XK 11.04

Weight ~ kg

2	WASHER A 13	F St.	8	Iridium treatment - ALG acc.	
	DIN 125	105/645		DIN 267/9	
2	HEXAGONAL SCREW M12 X 45	8.8	7	STAINLESS STEEL	
	DIN 933	010479			
4	NUT M10	6.	6	Iridium treatment - ALG acc.	
	DIN 934	010291		DIN 267/9	
4	HEXAGONAL SCREW M10 X 80	5.6	5	STAINLESS STEEL	
	DIN 933	010443			
4	GROVER B10	St	4	Iridium treatment - ALG acc.	
	DIN 127	105/600		DIN 267/9	
-	TIGHTENER COLLAR	G-CuZn33Pb	3	TINNED $\geq 30 \mu\text{m}$	
	412090				
4	TIGHTENER COLLAR	G-CuZn33Pb	2	TINNED $\geq 30 \mu\text{m}$	
	411413				
1	TIGHTENER BODY	G-CuZn33Pb	1	TINNED $\geq 30 \mu\text{m}$	
	414786			$\geq 30 \mu\text{m}$	
ITEM	NAME	MATERIAL	IDX	SEMI-TREATED MATERIAL SPAC. SEMI- TR.	WEIGHT
	SPECIFICATION	DRAWING NO.		ORDER RECOMMENDATION	kg

TERMINAL
4 x 300 mm²
430021758



Note: After the assembly, the ends of item No. 3 shall be opened, thus enabling it to be moved along by the nut

Weight 0.074 kg

1	CONDUCTOR TIGHTENER		3			
1	NUT M16 x 1.5	CuZn40Pb2F37 DIN 17673	2			
1	BOLTED CONNECTOR SHAFT		1			
ITEM	NAME	MATERIAL	IDX.	SEMI-TREATED MATERIAL SPAC. SEMI- TR.		
	SPECIFICATION	CODE		ORDER RECOMMENDATION		

GROUNDING BOLTED CONNECTOR

430020559



Supplement of T.D. DD-01.48 / 23.10.2017

Paragraph 5.4 of the T.D. DD-01.48/23.10.2017 is deleted and replaced by the following text and table of T/F losses:

«The load losses and the no-load losses shall comply with the requirements of the table I1 of the regulation No. 548/2014/EU of 21 May 2014 as shown below. At Double-ratio Transformers is not allowed increase in guaranteed loss values»

Rated Power T/F	No Load Losses	Load Losses
T/F 50 kVA	0,081 kW	0,750 kW
T/F 100 kVA	0,130 kW	1,250 kW
T/F 160 kVA	0,189 kW	1,750 kW
T/F 250 kVA	0,270 kW	2,350 kW
T/F 400 kVA	0,387 kW	3,250 kW
T/F 630 kVA	0,540 kW	4,600 kW
T/F 1000 kVA	0,693 kW	7,600 kW



SUPPLEMENT No. 2 of T.D. ND-01.48/23.10.2017
Transformers with Aluminum Windings, of 100 & 160 kVA rated power

Paragraph 5.7 of the T.D ND-01.48/23.10.2017 is removed and replaced with the following:

«5.7. Windings

*The Transformers shall be of two types depending on the material their windings are made of, **Type A** with Copper Windings and **Type B** with Aluminum Windings.*

The Transformers shall have two windings (the number of coils of each winding is given by the manufacturer). Both MV and LV windings shall be made of the same material.

5.7.1. Copper Windings

In case of circular conductors, their cross-sections shall be in accordance with standards IEC 60317-0-1:2013, A1:2019, grade 2, and IEC 60317-8:2010, class 180.

In case of rectangular conductors, their cross-sections shall be in accordance with standard IEC 60317-27-3:2020, with 0,45 mm thick insulation (paper tape cover) or with standards IEC 60317-0-2:2020, grade 2 and IEC 60317-28:2013, class 180 (enameled).

Let it be noted that copper foil may be used for the LV windings.

5.7.2. Aluminum Windings

In case of circular conductors, their cross-sections shall be in accordance with standards IEC 60317-0-3:2008, A1:2013, A2:2019, grade 2, and IEC 60317-15:2004, A1:2010, class 180 or according to IEC 60317-25, class 200.

In case of rectangular conductors, their cross-sections shall be in accordance with standard IEC 60317-27-4:2020, with 0,45 mm thick insulation (paper tape cover) or with standards IEC 60317-0-9:2015, grade 2 and IEC 60317-74:2018, class 180 (enameled) or IEC 60317-29:2018, class 200 (enameled).

Let it be noted that aluminum foil may be used for the LV windings.

5.7.3. Insulation level of MV windings.

Network voltage level	6,6 kV	15 kV	20 kV
- Power frequency withstand voltage for 1 min of r.m.s. value:	20 kV	38 kV	50 kV
- Full wave impulse withstand voltage, of shape 1,2/50µs, peak value:	60 kV	95 kV	125 kV

Chopped wave impulse withstand voltage with a peak value at least equal to that of the full wave for nominal voltages 6.6kV and 15 kV. For the 20 kV it shall be equal to 138kV according to EN 60076-3: 2013.



5.7.4. Insulation level of LV windings

Power frequency withstand voltage for 1 min, r.m.s. value: 10 kV

5.7.5. Dielectric distances

The 20kV winding parts that are under voltage shall have a minimum distance from the tank equal to 30mm. The minimum distance of the LV winding from the core shall be 2.5 mm with intermediate insulation.

No insulation material between windings and tank as well as between tap changer and tank is allowed.

Paragraphs 5.11.1., 5.11.5. and 5.11.8 of the T.D ND-01.48/23.10.2017 are modified as follows:

5.11.1. Construction

The construction of the tank shall be robust and shall not permit oil leaks. The Transformer tanks shall be manufactured with folded sheets. The folded sheet shall be at least of 1 mm thick. The tank shall be equipped with suitable lugs for lifting when it is empty.

In particular, for the 50 and 100 kVA Transformers, pole supporting lugs are required, according to drawing No 1, at the longer side of the tank on which the MV bushings are installed.

The tank cover shall be removable (by screws) with suitable gasket. The connections of all components that are screwed on the cover or on the tank shall also be made through suitable gaskets. The gasket material shall be weather-proof and oil-proof at temperatures up to 110 °C. All nuts and bolts of the tank cover shall have normal metric threads, according to ISO 4017 and ISO 898 respectively, withstand class 8.8.

5.11.5. Expansion tank

The Transformers of 250 kVA and above are required to have a detachable expansion tank.

Specifically for transformers of 160 kVA, they can either have a detachable expansion tank or they can be of a hermetically sealed type construction without expansion tank.

In case of Transformer with a detachable expansion tank, the tank shall have suitable height so that the oil level at 20 °C is at least 3 cm higher than the higher exhaust level of the MV bushing, and at 100 °C no oil overflow from the expansion tank is observed. At -20 °C the oil level shall be 35 mm higher from the bottom of the expansion tank.

In case of Transformers of 160 kVA without an expansion tank, these transformers must meet the necessary requirements regarding the tightness tests as described in paragraph 5.11.8. for the sealed type construction of 50kVA and 100kVA transformers.

5.11.8. Sealed type construction of 50 and 100 kVA Transformers

The 50 and 100 kVA Transformers shall be of sealed type construction without expansion tank and without overpressure safety valve. However, the Transformer tank shall be able to withstand an average overpressure of 20% of the nominal pressure, according to paragraph 6.1.6. Under the tank cover and up to the oil level, an up to 120 mm high air layer shall be provided. A design without the aforementioned air layer(or air cushion) is also acceptable. It is not permitted to use inert gas. For this purpose, the porcelain insulators shall have long neck, of a 160 mm length, so that their lower end shall remain immersed in the oil by 25 mm (at least) at a temperature of 20 °C. The last point of the tap changer under voltage shall be immersed in the oil by 30 mm at least. The above include the case of 160kVA transformers of sealed type construction without expansion tank.



Paragraph 5.12 of the T.D ND-01.48/23.10.2017 is modified as follows:

5.12. Overall dimensions of the Transformers

The overall dimensions of the Transformers shall not exceed the following limits:

- Dimensions for Transformers with rated power up to 400 kVA:

Length: 160 cm

Width: 130 cm

Height: 200 cm

However, these dimensions can be bigger for T/F with aluminum windings.

- Dimensions for Transformers with rated power 630 and 1000 kVA:

Length: 190 cm

Width: 130 cm

Height: 200 cm, for Transformers for indoor installation

Height: 230 cm, for Transformers with rated power 630 kVA for overhead networks

Note: A number of transformers, having a rated power of 630 and 1000 kVA intended to be installed indoors, that will be defined in each tender issued, shall have a maximum height of 175 cm, to be suitable for installation to rooms of limited dimensions.

Paragraph 6.1.6.b. of the T.D ND-01.48/23.10.2017 is modified as follows:

b) Test

The tightness test for the tank is performed on the above mentioned Transformers of 50 or 100 kVA in cold state, with overpressure equal to 20% of the nominal pressure. The pressure inside the tank is increased up to $1,2 \times P_m$ within a period of about 1 min with dry air or nitrogen. That pressure shall be maintained stable for one hour. The test is considered successful if during the one hour period no oil leakage, warping or deformation of the tank is observed. A leakage may be observed by several ways (change of the manometer indication).

Paragraph 7.3. of the T.D ND-01.48/23.10.2017 is modified as follows:

7.3. Phase marking

A print of reliefs or engraving type for each phase shall be provided on the cover of the Transformer near the base of the MV and LV bushings or engraving on the edge of the cover. It is not permitted to use welded plates. The symbols for the phases are provided in paragraphs 5.3.1.6, 5.3.2.6 and 5.3.3.6.

Supplement No. 3 of T.D. DD-01.48 / 23.10.2017

1. Paragraph §3.2.1 of T.D. DD-01.48/23.10.2017 is modified as follows:

3.2.1. MV System characteristics

Three phases, three (3) wires distribution network with grounded neutral, only at the sending end (without distributed neutral), either directly or through resistance for limiting earth faults current to 1000 A, with the following characteristics:

- Nominal system voltage U_r :	6.6 kV	15kV	20kV
- Maximum system voltage U_m :	7.2 kV	17.5kV	24kV
- Frequency :	50 Hz	50 Hz	50 Hz
- Short-circuit power system :	160MVA	250MVA	250 MVA
- Impulse withstand voltage 1,2/50 μ s :	60kV	95kV	125 kV

The 20/0.4 kV and 20-15/0.4 kV Transformers should be suitable for installation in a 350 MVA short-circuit power system.

2. In §4 of the T.D. DD-01.48/23.10.2017 the following standards are added:

«EN 50708-1-1: 2020 Power transformers - Additional European Requirements: Part 1-1: Common Part – General Requirements
EN 50708-2-1: 2020 Power transformers – Additional European Requirements: Part 2-1: Medium power transformers – General requirements"»

3. Paragraph §5.3.3.1 of the T.D. DD-01.48/23.10.2017 is modified as follows:

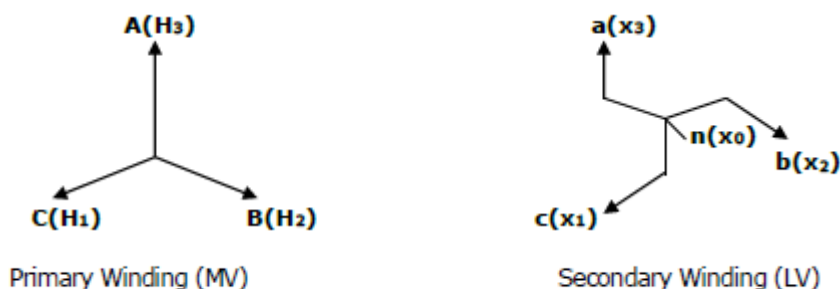
5.3.3.1. Rated power in kVA

50, 100, 160, 250, 400, 630

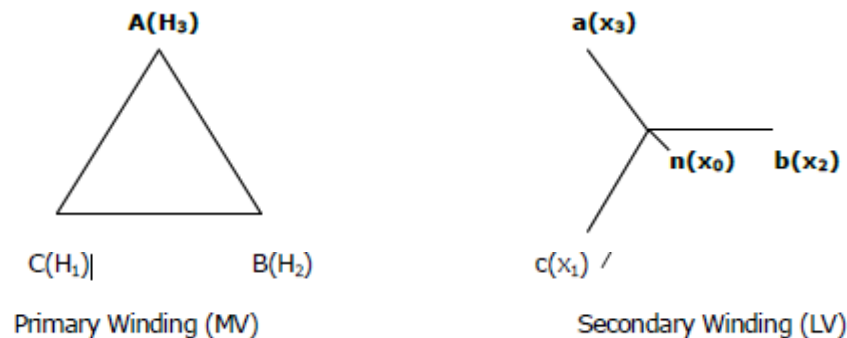
4. At the end of paragraph §5.3.3.5 of T.D. DD-01.48/23.10.2017 the following text is added:

«5.3.3.5. Connection group

Connection group of Transformers with rated power 50 up to 100 kVA: Yzn11 (Yzn1)



Connection group of Transformers with rated power 160 up to 630 kVA: Dyn11 (Dyn1)



5. Paragraph §5.3.4 is added in continuation of §5.3.3, as follows:

"5.3.4. Double ratio Transformers: 15-6.6 / 0.4 kV

5.3.4.1. Rated in kVA

160, 400

5.3.4.2. Nominal system voltage

- Primary: Medium Voltage (MV) : 15000 V 6600 V
- Secondary: Low Voltage (LV) : 400 V 400 V

5.3.4.3. Tapping at the MV side

The following tapping shall be provided at the MV side:

At the 20000V voltage: -2,5%, 0%, +2,5%, (14625, 15000, 15375 V)

At the 15000V voltage: 0%, -2,5%, -5%, (6600, 6435, 6270 V)

The change of taps will performed with the transformer out of voltage by means of a Tap Changer, which is described in paragraph 5.10. This switch should have two separate tap areas, one for the 6600 V and another for the 15000 V and conversely.

Since the Transformer operates at 6600 V, the moving of the switch in the tap area of 15000 V and conversely should be excluded.

5.3.4.4. Short-circuit impedance (at 75°C)

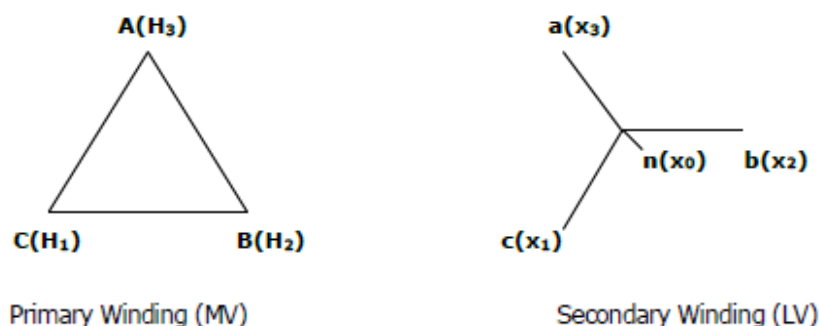
At the voltage of 15 kV : 4%

At the voltage of 6.6 kV: 4%

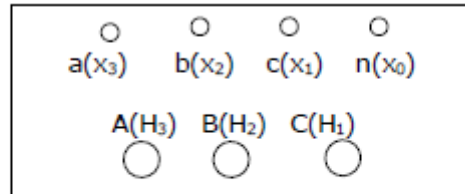
The short-circuit voltage tolerance in both cases shall be $\pm 10\%$.

5.3.4.5. Connection group

Connection group of Transformers with rated power 160 up to 630 kVA: Dyn11 (Dyn1)



5.3.4.6. Bushing arrangement on the cover and phase identifications



$A(H_3), B(H_2), C(H_1)$: MV Bushings
 $a(x_3), b(x_2), c(x_1)$: LV Bushings
 $n(x_0)$: LV Neutral Bushing

»

6. Paragraph §5.5 of T.D. DD-01.48/23.10.2017 is modified as follows:

«5.5. Sound level

The sound level of the Transformers shall not exceed the values specified in L_{WA} column of Table 1 of the EN 50708-2-1 standard for each rated power. The measurement shall be carried-out according to standard EN 60076-10: 2001».

7. Paragraphs §5.8, (§5.8.1, §5.8.2, §5.8.3) of the T.D. DD-01.48/23.10.2017 are deleted and replaced by the following text:

«5.8. Bushings

The LV bushings permeators (porcelain insulator and stud, nuts, washers and cover) shall be according to EN 50386:2002 and the MV (porcelain insulator or plug in) shall be according to EN 50180:2015. The LV and MV studs for up to 250 A shall be made of brass and the studs for higher currents shall be made of copper.

The distances between the centers of the LV bushings shall be 150 mm at least for currents up to 2000 A, and 165 mm at least for currents higher than 2000 A. The corresponding distances for the MV bushings shall be 270 mm at least.

For the 20 kV operating voltage, the minimum distance between bushing points under voltage from any earthed metallic parts shall be at least 22 cm. In the case of pole-mounted Transformers (50 and 100 kVA), the pole is considered to be earthed.

The bushings shall be installed on the cover of the Transformer's tank in vertical position and shall be sealed with suitable gaskets.

The MV and LV insulators of the Transformers shall be made of high quality porcelain manufactured with the wet method without pores, and they shall have brown color glazing.

The MV insulators shall be according to EN 50180:2015 and in any case they will be suitable for installation in a network with a short-circuit level of 350 MVA. The permitted types of MV insulators they are types 2, 3 or 8, with four or five sheds depending on the type offered. In case of tender of types 3 or 8, it shall be in compliance with the corresponding figures of the standard.

In case the offered type is type 2, the insulators shall deviate from the standard on the diameter of the sheds, which shall be 165 mm instead of the 150 mm as provided in this standard, in order to have a resulting creeping distance of at least 53 cm.

Moreover, for the supply of 50 and 100 kVA transformers, the length of the insulator's neck shall deviate from the standard and it shall be 160 mm instead of 83 mm. The total height of the sheds together with the MV insulator's neck shall not exceed 52 cm.

The LV insulators shall be according to EN 50386: 2002. »

5.8.1. Plugs on the MV side

Transformers with rated power 630 up to 2500 kVA, meant for indoor use, shall be equipped with special plug in bushing reception at the MV side of the tank cover instead of porcelain bushings. Specifically, on the tank cover, there shall be interface type A1 plug-in bushings in accordance with EN 50180:2015 and they shall be accompanied by a full set of elbow connectors. Especially for the supply of 630 kVA Transformers, if specified by the tender documents, shall also be manufactured with porcelain insulator bushings when they are to be used in overhead networks.

A full set of elbow connectors for the MV side connection shall be an integral part of the procurement of the transformers intended to be used indoors which shall be in accordance with HD 629.1S1:1996+A12001 and EN 61442:2005. This full set of connectors shall be suitable for the connection of the MV side of 630 kVA and 1000 kVA Transformers with 1X50 mm² NA2XS_Y cable per MV phase.

5.8.2. Electrical characteristics

5.8.2.1. MV Insulators

- | | |
|--|--------|
| a) Full wave impulse, with a 1.2/50 μ s shape, withstand voltage peak value: | 170 kV |
| b) Power frequency withstand voltage, wet, 1 min, r.m.s. value: | 70 kV |
| c) Minimum creeping distance: | 53 cm |

5.8.2.2. LV Insulators

- | | |
|--|-------|
| a) Full wave impulse, with a 1.2/50 μ s shape, withstand voltage peak value: | 30 kV |
| b) Power frequency withstand voltage, wet 1 min - r.m.s value: | 10 kV |

Especially for the insulators intended to be used on Transformers 50 and 100 kVA, an impulse withstand voltage of 22,5 kV with an 1,2 / 50 μ s shape, is acceptable due to the fact that they are not fully immersed into the oil.

5.8.2.3. MV Plugs

- | | |
|--|--------|
| a) Full wave impulse, with a 1.2/50 μ s shape, withstand voltage peak value: | 125 kV |
| b) Power frequency withstand voltage, wet, 1 min, r.m.s. value: | 55 kV |

8. The first paragraph of chapter 5.9 "Bushings Terminals" is deleted and replaced by the following:

-The MV bushings shall be equipped with split bolt connectors suitable for stranded copper conductors with cross-section from 16 and up to 35 mm², according to drawing N° 430020560 MV insulators type 2 or 3, and according to EN 50180:2015 for MV insulators type 8.

9. The last paragraph of chapter 5.11.2 " Wheels - Hanging Lugs - Jack bosses " of the T.D. DD-01.48/23.10.2017 is deleted and replaced by the following:

5.11.2 Wheels - Hanging Lugs - Jack bosses



- The 160, 250, 400 kVA Transformers, and the 630 kVA Power Transformers that are to be provided for outdoor installation, shall be equipped with a suitable base for installation on a two-pole structure according to drawing No. 2 (distance A from 245mm to 415mm). These bases will have the appropriate holes (e.g. oval) along them for the support of the T/S on the arms of the S/S."

Supplement No. 4 of T.D. DD-01.48/23.10.2017

1. The following subsection of section 7 (paragraph §5.8 «Bushings») of the Supplement No. 3 of T.D. DD-01.48, is deleted:

«...The total height of the sheds together with the MV insulator's neck shall not exceed 52 cm»,

and is replaced by the following text:

«...The total height of the sheds together with the MV insulator's neck shall not exceed 58,3 cm».