

**PRODUCT PURCHASING SPECIFICATION
TRANSFORMER ENGINEERING DEPARTMENT
BHEL BHOPAL**

Specification No. TRE 036
Page 1 of 6 Pages
Rev. 08 Date : 08.09.2018

**EPOXY COATED PAPER COVERED CONTINUOUSLY TRANSPOSED COPPER CABLE
(0.1% PROOF STRESS)**

1. This Specification governs the quality of continuously transposed Copper cable exactly similar to specification AA28129 except following modification /additional requirements. The cable shall not be manufactured earlier than 30 days from date of dispatch since it has a limited shelf life.
In case on any conflict between AA28129 & TRE036, TRE036 shall prevail.
2. An extra coating of Semi cured ('B' stage) epoxy enamel shall be given over PVA enamel) on all the conductors. The coating shall be tack-free at room temperature and it shall be able to fully cure when heated at 130°C for 6 hours. The increase in dimension due to epoxy coating shall be $0.06 \text{ mm} \pm 0.02 \text{ mm}$ and due to enamel coating increase in dimensions shall be $0.085 \pm 0.025 \text{ mm}$.
3. Nominal value of 0.1% proof stress of conductor shall be specified on order.
4. Tolerance on overall width and thickness (bare strip + PVA enamel + epoxy) of individual conductor shall be as per Annexure 2 of this document.
5. Paper used for outer coverings shall comply to AA 21111 or as specified in order.
6. Insulation test between strips as per Cl. 12.1 of AA 28129.
7. In order to check the bonding strength of epoxy powder coating , samples after curing should be subjected to "Radial bending test" as per enclosed Annexure-1.
8. Test certificate shall be issued indicating observed and specified values of dimension and test as per Cl. 13 of AA 28129 and C1. 6 & 7 of TRE: 036. Packing and marking will be as per Cl. 14 of AA 28129. Packing shall be seaworthy and drums should be kept in a container/ Crate to avoid ingress of moisture in transit.

REV 08	DATE 08.9.18	ALT CHD	REV 07	DATE 05.9.18	ALT CHD.	-sd- -sd-	REV 04	NAME	SIGN	DATE
Annexure 1 & 2 updated.			Clause 5,6,7,8 of Annexure-2 revised.				PREP	S.K.MAHAJAN	-sd-	09.12.07
							APPD	J.S.KUNTIA	-sd-	09.12.07
DWI/TCB/TRE/010										

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ANNEXURE-1

RADIAL BENDING STRENGTH TEST FOR EPOXY BONDED CTC CABLE

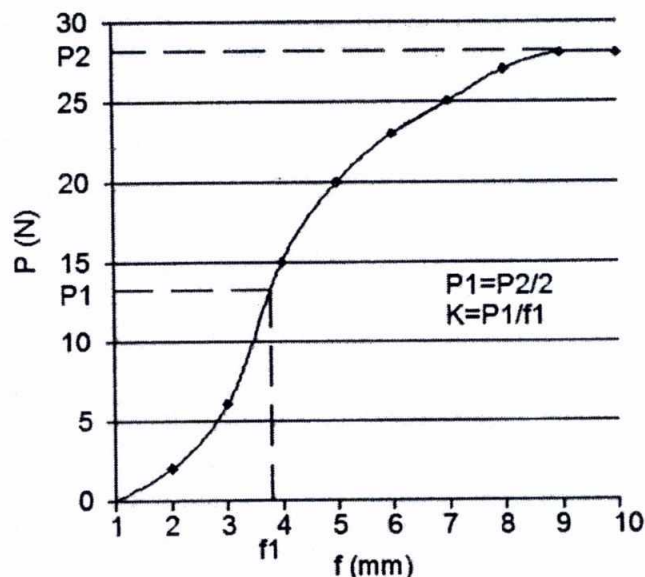
1. Determination of bonding strength radial bending strength test

The bonding properly is the property of proper bonding of various strands of CTC after curing.

In order to establish the proper bonding the test method as per CI 4.0 shall be followed. From the tests a curve of "P" as function of "f" is obtained, where P is the force on the cable [N]
f is the deflection or flexion [mm]

The curve gives:

- The value of the maximum load P2
- The ratio K corresponding to the ratio between the half of the maximum load and the corresponding deflection: $K = P1/f1$



RADIAL BENDING STRENGTH

2. Limitations & Assumptions

- The ratio between radial dimension RD of the bare CTC and axial dimension AW of the bare CTC is:
 < 5.0 for CTC made with not bondable strands
 < 4.5 for CTC made with bondable strands

$$RD/AW = \frac{((n+1)/2)(t+e+le)}{2(b+e+le)}$$

where, $e+le$ = double-sided thickness of enamel and epoxy if any

- The radial strand dimension $t \leq 3.2$ mm
- The axial strand dimension $b \leq 12.5$ mm

3. Calculation & Tables

The value of $P2 = \epsilon \times b \times n^2 \times t^2 \times 9.81/d$ (N)

Where:

ϵ = coefficient taking into account the number of strands of the CTC as per Table-1

d = distance between the supports

= 150 mm for CTC up to 31 strands

= 300 mm for CTC with more than 31 strands

The average value of K shall be greater or equal to the value calculated as

$$K = \eta \times E \times b \times t^3 \times ((n-2)^3 + 2)/d^3 \text{ (N/mm)}$$

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Where,

E is the Young modulus of the copper strand & its value is:

- For $R_p0.2\% \leq 180$ MPa is considered equal to 80000 N/mm^2
- For $R_p0.2\% > 180$ MPa and $R_p0.2\% \leq 230$ MPa is considered equal to 100000 N/mm^2
- For $R_p0.2\% > 230$ MPa is considered equal to $110\,000 \text{ N/mm}^2$

η is coefficient depending on the number of strands as per Table-2

Table 1 (For ϵ)

Number of strands	$R_p 0.2\% > 230 \text{ MPa}$	$230 \text{ MPa} \geq R_p 0.2\% > 180 \text{ MPa}$	$R_p 0.2\% \leq 180 \text{ MPa}$
Up to 23	7.0	5.4	4.4
25	6.6	5.1	4.2
27	6.2	4.8	4.0
29	5.8	4.3	3.7
31	5.0	3.9	3.2
33 to 41	4.6	3.5	3.0
43 to 51	4.0	3.1	2.8
53 to 61	3.6	2.9	2.4
63 to 71	3.2	2.6	2.0
Over 73	2.9	2.2	1.8

Table 2 (For η)

Number of strands	$t < 2\text{mm}$	$t \geq 2\text{mm}$
Up to 15	0.90	0.90
17 to 23	0.90	0.70
25	0.75	0.50
27	0.60	0.45
29	0.55	0.40
31	0.35	0.25
33 to 41	0.40	0.24
43 to 51	0.24	0.22
53 to 61	0.19	0.17
63 to 71	0.17	0.14
Over 73	0.14	0.12

4. Test Method

4.1 **Specimen** : 3 nos. CTC specimens as below shall be prepared for each supply.

Length = 450 mm for CTC with $n < 33$

Length = 600 mm for CTC with $n \geq 33$

4.2 **Sampling** : Each specimen shall be cut from the original drum without bending the cable. Strands shall be locked in a suitable way.

4.3 **Thermal treatment** : The specimens shall by means of a device be shaped to a diameter of 1000 mm and axially loaded with side jaws. Treatment in an oven with air circulation at a temperature of $120 \pm 5^\circ\text{C}$ for 24 hours or at $110 \pm 5^\circ\text{C}$ for 48 hours. Cooling at room temperature for at least 6 hours.

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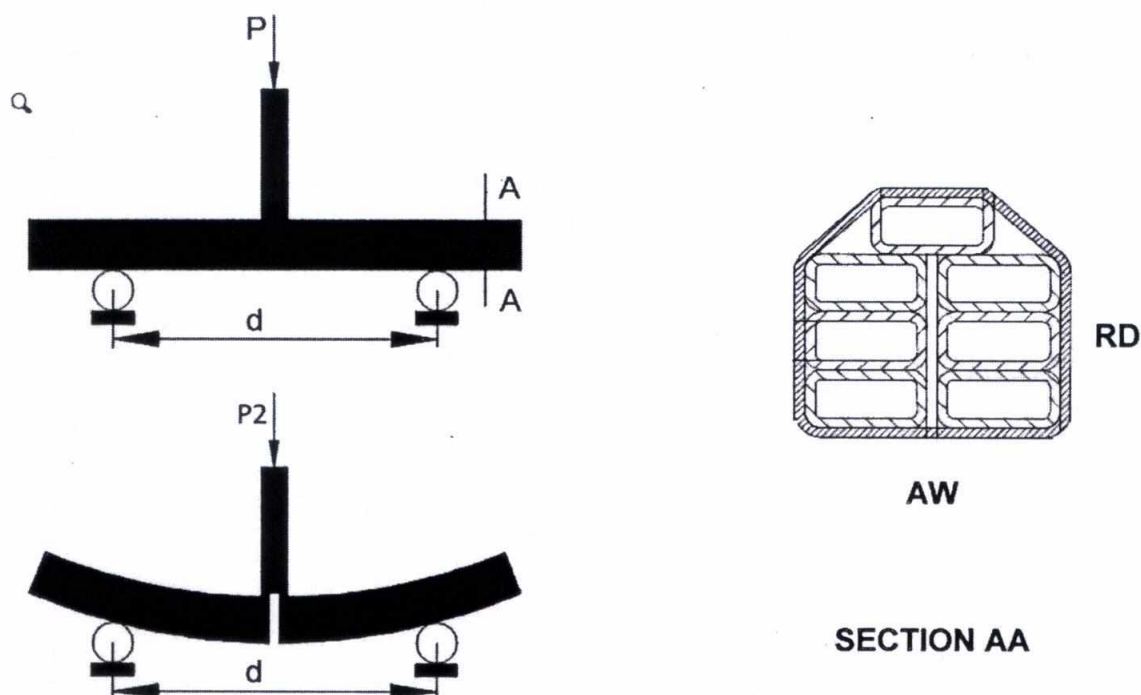
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4.4 Test Method

Each sample shall be placed over the cylindrical supports of the flexion machine-with the concave part towards the top and the convex part towards the bottom of the flexion machine.

In case of CTC with ratio $RD/AW > 3$, it is convenient to take the specimen in the correct position using suitable side-roll supports, without applying any stress.



5.0 Results - The parameters $P2$ & K are calculated and average value shall be greater than the values required in Cl. 3.0.

6.0 Detail of test set up:

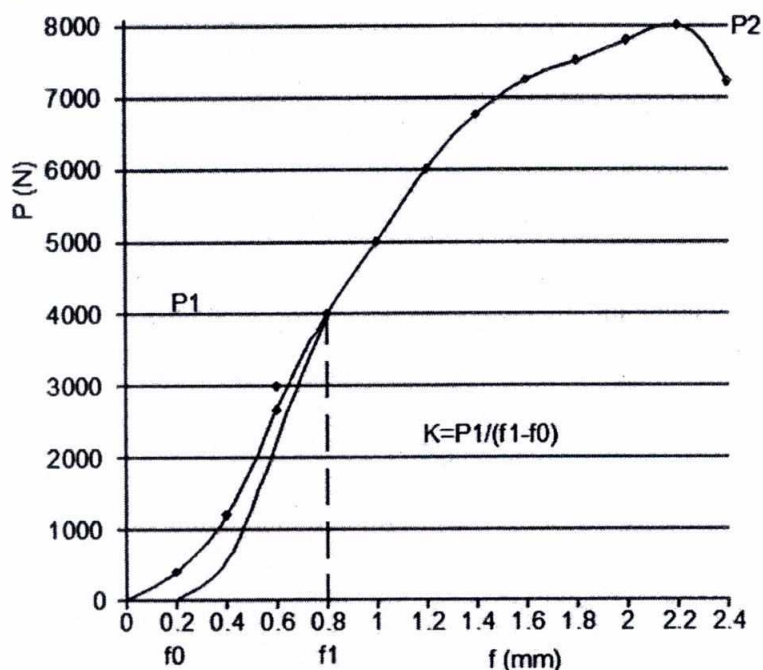
Flexion machine is composed by a dynamometer, a support device and a plotter. Support device consists of two cylindrical supports at distance of 150 or 300 mm depending on the number of strands of the CTC.

- 150 mm for CTC with $n < 33$
- 300 mm for CTC with ≥ 33

The dynamometer is used in compression with a jaw connected to a cylinder in order to apply the flexional load in the middle of the specimen. The plotter is used in order to plot the curve of load and flexion. The support device is placed at the bottom of the dynamometer and the arrow is measured with a strain gauge connected to a touch sensor to the bottom of the specimen. The touch sensor shall touch an area coincident with the width of the strand, when the spring of the touch sensor is put in tension. On the plotter the zeroing of the paper is done. The load is gradually applied to the specimen, plotting the diagram of load and arrows.

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Example : $K = P1/(f1 - f0) = 4000/(0.8 - 0.2) = 6660 \text{ N/mm}$

In order to keep the measurement independent of settling of paper and transpositions, the following test procedure is prescribed:

- Make a dummy test with one of the specimens. This test gives a maximum P2 value where the bonding breaks. $P1 = P2/2$ is calculated.
- On each of the other specimens the load shall be raised up to the theoretical value P1 and then decreased down to zero. Gives a remaining small flexion f0, which is the new, zero point for the flexion.

A load is then applied up to the break of the bonding properties of the specimen. This point is the P2 value for that specimen and is recognized in the diagram when the plotting mark is going towards the bottom showing a significant loss of bonding adhesion.

$P1 = P2/2$ is calculated.

- From the load/flexion curve, corresponding P1 and f1 values can be read. Calculate the ratio $K = P1/(f1 - f0)$

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ANNEXURE-2

COVERED DIMENSIONS OF TRANSPOSED CABLES

1.	Transposing Factor (Tp)		$T_p = \pi \times ID / (n \times b)$
2.	Nominal Covered Axial Width (AW)		$AW = 2 \times (b + e + le) + P + l_{cp}$
3.	Tolerance on AW		+0.15 / -0.10
4.	Nominal Covered Radial Depth (RD)		$RD = (n+1)/2 \times (t + e + le) + P$
5.	Tolerance on RD		
	n	If $T_p \geq 7$ & $t < 2.00$ & $R_p \leq 170$ MPa	If $T_p \geq 5$ & $t \geq 2.00$ & $R_p > 170$ MPa
	≤ 21	+ 0.30 / -0.20	+ 0.50 / -0.15
	23 to 35	+ 0.40 / -0.25	+ 0.60 / -0.25
	37 to 55	+ 0.80 / -0.40	+ 1.30 / -0.40
	> 55	+ 1.10 / -0.60	+ 1.40 / -0.50
6.	Tolerance on dimension t or b		
		≤ 3.15	± 0.030
		3.16 to 6.30	± 0.050
		6.31 to 12.50	± 0.070
		12.51 to 16.00	± 0.100
7.	Overall covered dimension AW & RD shall be measured under pressure of 100 N/cm ² .		
8.	Abbreviation		
	ID = Inner diameter of winding n = No. of single strands in transposed cable b = Nominal width of bare single strand t = Nominal thickness of bare single strand e = Nominal increase due to enamel le = Nominal increase due to epoxy P = Nominal thickness of paper (both side) lcp = Inter column paper, if specified (100 μ m) Rp= 0.1% proof stress value		
	(All dimension are in mm, if not specified)		



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	CORPORATE PURCHASING SPECIFICATION	AA 28129
		REV NO. 04
		PREFACE SHEET

**PAPER COVERED CONTINUOUSLY TRANSPOSED COPPER CABLE
(0.1% PROOF STRESS)**

FOR INTERNAL USE ONLY
REMOVE THIS PREFACE BEFORE ISSUE TO SUPPLIERS

Comparable standards :

1. INDIAN	: IS : 13730 PT – 17 – 1996	↑
	: IS : 13730 PT – 27 – 1996	
2. INTERNATIONAL	: IEC : 60317 – 17 – 1990	↑
	: IEC : 60317 – 27 – 1990	

Suggested/Probable Suppliers And grades :

1. M/S. Incab Industries Ltd . , Jamshedpur
2. M/S. ASTA Eisen und Gmbh , Austria
3. M/S. Lackdrath und gmbh , Germany
4. M/S. Invex Fillusolati Specicate SPA, Italy
5. M/S. Smith Drad , Netherland


User Plants And Replaced Plant Specifications / references :

1. BHOPAL -----
2. JHANSI -----


Revision : CI. 34.1.19 of MOM of MRC (E)			APPROVED : INTER PLANT MATERIAL RATIONALISATION COMMITTEE- MRC (E)		
Rev.No. 04	Amd.No.	Reaffirmed	Prepared BHOPAL	Issued Corp. R&D	Dt.of Ist Issue Aug. 1987
Dt :19.05.07	Dt:	Year:			

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<p align="center">PAPER COVERED CONTINUOUSLY TRANSPOSED COPPER CABLE (0.1% PROOF STRESS)</p>								
<p>1. GENERAL :</p> <p>This specification governs the quality requirements of paper covered continuously transposed copper conductor (CTC) incorporating a number of individual work hardened copper strips insulated with a polyvinyl – acetal based enamel of fine grade and covered over all with not less than three layers of paper and suitable for use in hot insulated oil. Paper shall conform to BHEL corporate purchase specification (CPS) No. AA 21111 or AA 21116. The material in insulating oil have temperature index of 105 .</p>								
<p>2. APPLICATION :</p> <p>Used for windings of Transformers .</p>								
<p>3. COMPLIANCE WITH NATIONAL STANDARDS</p> <p>There is no National Standard for this type of material . However assistance has been derived from the following standards .</p> <table border="0"><tr><td>IS : 13370 Pt. 17, 1996/ IEC : 60317-17,1970</td><td>- Specification for particular type of winding wires - Pt. 17 - Polyvinyl Acetal enameled Rectangular . Copper Wires. Class 105</td><td>↑</td></tr><tr><td>IS : 13730 Pt.27 – 1996 / IEC : 60317 - 27 – 1990</td><td>- Specification for particular Type of winding wires Pt. 27 - Paper covered Rectangular Copper Wire .</td><td>↑</td></tr></table>			IS : 13370 Pt. 17, 1996/ IEC : 60317-17,1970	- Specification for particular type of winding wires - Pt. 17 - Polyvinyl Acetal enameled Rectangular . Copper Wires. Class 105	↑	IS : 13730 Pt.27 – 1996 / IEC : 60317 - 27 – 1990	- Specification for particular Type of winding wires Pt. 27 - Paper covered Rectangular Copper Wire .	↑
IS : 13370 Pt. 17, 1996/ IEC : 60317-17,1970	- Specification for particular type of winding wires - Pt. 17 - Polyvinyl Acetal enameled Rectangular . Copper Wires. Class 105	↑						
IS : 13730 Pt.27 – 1996 / IEC : 60317 - 27 – 1990	- Specification for particular Type of winding wires Pt. 27 - Paper covered Rectangular Copper Wire .	↑						
<p>4. TEST SAMPLES :</p> <p>4.1 Paper :</p> <p>The supplier shall send the test certificate for papers for all the tests as per BHEL Corporate Purchase Specification (CPS) No. AA 21111 or AA 21116 for our approval. The test report shall be sent for each lot of paper and of different thicknesses received from the paper mill , which are to be used in the manufacture of BHEL paper covered continuously transposed copper cable .</p> <p>In the absence of proper test certificate 20 sheets of size 300X300 mm of paper from each lot and of different thicknesses shall be supplied for out testing.</p>								
Revision : CI.34 .1.19 of MOM of MRC (E)		APPROVED : INTER PLANT MATERIAL RATIONALISATION COMMITTEE- MRC (E)						
Rev.No. 04 Dt :19.05.07	Amd.No. Dt:	Reaffirmed Year:						
<table border="1"><tr><td>Prepared BHOPAL</td><td>Issued Corp. R&D</td><td>Dt.of Ist Issue Aug . 1987</td></tr></table>			Prepared BHOPAL	Issued Corp. R&D	Dt.of Ist Issue Aug . 1987			
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4.2 Finished Conductor

3 metre long sample of CTC shall be supplied for testing and inspection.

5. CONDUCTOR:

5.1 CTC of any size given in Transformer standard sheets shall be ordered. Maximum and minimum dimensions of bare cable shall be as per these individual orders. Conductor size, No. of parallels and radial paper covering shall be stated on the order.

5.2 Radial insulation shall be from 0.20 to 3.0 mm, both inclusive.

5.3 Bunched CTC consisting of 2 or more individual stacks of any size indicated in Transformer Standard sheets shall also be ordered whenever required.

6. LENGTH & WEIGHT OF CABLE:

6.1 The total weight of cable, the length of cable per drum and the total No. of drums shall be as stated on the order. Length of cable per drum specified in our order is very important and so, it shall neither be less nor more than the specified.

6.2 Weights indicated in our orders are nominal and can vary within ± 2 percent considering allowed tolerances on dimensions and on corner radius.

Excess weights more than 2 percent shall not be admissible under any circumstances.

7. TYPE OF ENAMEL COVERING:

Fine grade. However in exceptional cases when medium grade of covering is required, it shall be stated on the order.

8. CONDUCTOR:

8.1 Grade of Material:


The conductor shall be manufactured from ETP grade copper conforming to BHEL Corporate Purchasing Specification (CPS) AA 12024.

Note : Manufacture of the Copper conductors from continuous cast copper bars is preferable provided all other acceptance parameters and conditions remains same.

The conductor shall fully conform to IS : 13730 Pt. 27 - 1996 except 0.1% proof stress and resistance. The 0.1 % Proof Stress of the conductor after removal of paper when tested as per IS:1608 shall be as given below :

<u>Nominal Value</u>	<u>Tolerance</u>
115, 135 & 145 Mpa .	+15% , - 10%

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Tests shall be carried out on one sample taking 50 mm gauge length .However the conductor with any other nominal value of 0.1% proof stress can also be ordered .

8.2 ELECTRICAL RESISTIVITY:

The resistivity at 20 °C, when measured directly on the sample in "as received" condition shall not be greater than 0.01777 ohm/mm²/m. Refer Appendix "B of IS : 613 for temperature correction factor.

8.3 Enameled conductor :

The enameled conductor shall comply with fine grade of covering to IS :13730 Pt. 17, I with the exceptions as given below :

8.4 Joints :

8.4.1 Joints in Bare Conductor :

Joints shall not be made in the conductor after it is drawn . Any joint made during the drawing process shall be resistance welded .

8.4.2 Joint in Enameled conductor : I

If a joint in the enameled conductor becomes unavoidable due to breakage accidental stoppage of machine or when the specified length is in excess of the capacity of transposing machine bobbins, it shall be made by resistance welding , care being taken to ensure that the joint is made sound . All surplus weld shall be removed by filing and the joint finished with emery cloth / paper to give a smooth clean surface after I which it shall be patch enameled . Any joint shall be insulated from the adjacent strips by a single piece of 100 micron thick paper half overlapped . Joints in the individual strips shall be staggered so that the distance between individual joints along the cable shall not be less than 150 mm. A red tag shall be tied at the joint portion of cable for identification and inspection . Any such joint shall be made only after prior approval of BHEL .

9. PAPER:


9.1 Grade of Paper:

Kraft paper shall conform to BHEL Corporate Purchasing specification (CPS) No. AA 21111 or AA 21116. If kraft / manila mixture or any other paper is used, it shall conform to BHEL Corporate Purchasing Specification (CPS) No. AA 21111 or AA 21116.

9.2 Thickness:

The thickness of paper shall be within limits of 50 and 140 um both inclusive.



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10. CONSTRUCTION OF TRANSPOSED CABLE:

10.1 Cleanliness of Enameled Conductor:
The enameled conductor shall be free from copper dust and other extraneous matter prior to transposing and covering with paper.

10.2 Transposition of Enameled Conductor:

The cable shall be manufactured from any odd number of enameled conductors from a minimum of 5 to a maximum of 31, according to the size of the individual conductor and the overall size of the cable as specified in the order.

The cable shall be formed by placing the strips into two stacks, the stacks, being edge to edge and the whole group of strips being continuously transposed along the length of the cable.

The pitch of successive transpositions shall be approximately 15 times the width of bare strip subject to a minimum of 50 mm. Lay i.e. the distance over which a strip resumes its original position in the conductor shall be equal to pitch multiplied by the number of strips.

For cables of radial depth 10 mm and above it shall have an intercolumn paper (paper spacer) inserted between the vertical stacks of strip. This paper shall comply with clause 9 and thickness shall be 100 um. Width of the paper spacers shall not be less than the value calculated from the following formula.


$$\text{Width} = \frac{(\text{Number of strips} - 1)}{2} \times \text{thickness of enameled strip}$$

10.3 Application of Paper Covering:

10.3.1 General:
Each layer of paper shall be continuous, firmly applied and substantially free from creases. No bonding or adhesive material shall be used except to anchor the ends of paper. Any such bonding or adhesive material shall have no deleterious effect on transformer oil, insulating paper, or electric strength of the covering. When papers of different thickness are used, the outermost paper shall be the thickest. The thickness of the paper shall be progressively increased from the innermost to the outermost layer.

10.3.2 Width of paper:
The width of paper shall be within the limits of 15 and 40 mm, both inclusive.

10.3.3 Arrangement of layers:
All the layers shall be applied in the same direction, all except the two outermost layers shall be butt wound and the two outermost layers shall be applied together with a staggering of 50% so that they are interlocked giving 50% overlap effect. Within each group the positions of the butt joints of any layer relative to the layer below shall be progressively displaced by approximately 30 percent of the paper width.





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10.3.4 PAPER THICKNESS FOR BUTT AND OVERLAP INTERLOCKED WOUND LAYERS:

Thickness of paper for butt wound layers shall be between 50 μm and 100 μm (both inclusive) Two outermost overlap interlocked layers shall be wound with paper of thickness between 75 and 125 microns (both inclusive). However, when radial insulation is 2.2 mm or more, 140 μm paper for two outermost layers is allowed to avoid two paper covering operations due to availability of a maximum of 24 paper heads in the lapping machine of same manufactures. Special extensible high density and high mechanical strength paper meeting the requirements of clause 9 can be used in the two outermost interlocked layers.

11. DIMENSIONS OF TRANSPOSED CABLES :

11.1 Method of Calculating Maximum Bare Axial Width (AW) :

$$AW = 2(b + e) + F + \text{inter column paper if specified (100 } \mu\text{m thick)}$$

Where

$$AW = \text{Max. bare axial width of transposed cable.}$$

$$b = \text{Maximum axial width of bare individual conductor} \\ = \text{Nominal width} + \text{Tolerance (from table 1 below)}$$

$$e = \text{Maximum increase in dimension due to enameling} \\ (\text{as per IS : 13730 Pt. 0 /Sec. 2 : 1993 (R-2003), IEC 60317-0-2:2005}) \\ = 0.11 \text{ mm for fine grades of covering}$$

$$F = \text{Free space allowance} = 0.4 \text{ mm}$$

Table 1 - Tolerances on Nominal Dimensions - (IS :13730 Pt. 27 : 1996)

Dimension (Width or Thickness), mm		Tolerances \pm mm
Over	Up to and including	
-	3.15	0.030
3.15	6.30	0.050
6.30	12.50	0.070
12.50	16.00	0.100

11.2 Method of calculating Maximum Bare Radial Depth (RD)

$$RD = \frac{N+1}{2} (T + e) + \text{free space allowance (from Table 2)}$$

Where

$$RD = \text{Maximum bare radial depth of Transposed Cable.}$$

$$T = \text{Maximum thickness of bare individual conductor} \\ = \text{Nominal thickness} + \text{Tolerance (from table 1 in cl.11.1)}$$

$$N = \text{Number of conductors in parallel}$$

$$e = \text{Maximum increase in dimensions due to enameling} \\ (\text{as per IS : 13730 Pt. 0/Sec 2 : 1993 (R 2003), IEC 60317-0-2 : 2005}) \\ = 0.11 \text{ mm for fine grade of covering.}$$


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TABLE 2 - FREE SPACE ALLOWANCE - RADIAL DEPTH (mm)

No. of conductors	Free space allowance radial depth, mm	
	Thickness 1 -- 2 mm	Thickness 2.1 -- 3.15 mm
5 -11	0.28	0.63
13	0.30	0.70
15	0.33	0.78
17	0.36	0.85
19	0.39	0.90
21	0.42	1.00
23	0.44	1.05
25	0.50	1.15
27	0.55	1.25
29	0.60	1.40
31	0.65	1.50

11.3 Method of Calculating Maximum Axial Width & Radial Depth with Paper Covering:

Maximum covered Axial Width = $AW + t$
Maximum covered Radial Depth = $RD + t$

Where AW is taken from Clause 11.1

RD is taken from Clause 11.2

t = nominal increase in dimensions due to paper covering taken from Cl. 11.4.

11.4 Increase in Dimensions due to paper covering:


11.4.1 Increase in Dimensions:


The increase in dimensions due to covering shall have tolerance indicated below:

Increase due to covering (mm)		Tolerance %
Over	Up to & including	
-	0.5	+0 - 10
0.5	1.3	+0 - 7.5
1.3	-	+0 - 5

11.4.2 Measuring Equipment :

The measurement shall be made with a suitable ratchet micrometer . The spindle and anvil of the micrometer shall have a diameter of 5 to 8 mm .



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11.4.3 Measuring Method:
 Covered Dimension shall be measured at three positions not less than 100 mm apart.. The measurements shall be made on completely straight parts of the transposed cable. The measurement shall include at least one over lap. The covering shall be removed by any method which does not damage the conductor for three positions used for the measurement of "Covered Dimensions" and "Bare Dimensions" measured at these positions. The average of the three results shall be reported as "bare dimension". The difference between "Covered Dimension" and the "Bare Dimension" shall be reported as the increase in dimension due to covering.

11.4.4 Counter Check:
 The increase in dimension due to covering shall also be counter checked by adding up the thickness of paper used in each layer. The thickness of paper shall be measured by dead weight micrometer conforming to IS: 1060 (Part 1) by stacking the tapes of paper one above the other. Paper tape shall not be folded to form two or more tapes. Length of paper tapes shall not be less than 150 mm. Five measurements shall be made distributed over the stack. The paper thickness shall be computed by dividing by five the mean of five readings.

Radial insulation so computed in 11.4.4 shall not be less than the minimum allowed (considering the appropriate tolerance) as per 11.4.1.

12. TESTS ON FINISHED CABLES:

12.1 Insulation Faults Between Strips :

The insulation test at 250 V, AC for 1 minute shall be conducted on all drums between each and every other strip in CTC stack. There shall be no fault in the insulation. In case of bunched (twin) CTC, this test shall also be conducted between two stack.

13. TEST CERTIFICATE:

Unless otherwise stated three copies of the test certificate shall be supplied along with each consignment,


In additional the supplier shall ensure to enclose one copy of test certificate along with their dispatch documents to ensure quick clearance of the material.

The test certificate shall bear the following information

AA 28129 : Paper covered continuously Transposed Copper Cable. (0.1% Proof Stress) (Rev. 04) Covered & Bare Dimension of cable, No. and size of individual conductor, increase in dimensions due to paper covering, number of paper layers and thickness of paper in each layer, grade of enamel and length of cable shall be indicated in the test certificate.

BHEL Order No.
 Manufacturer's / Supplier's name
 Trade mark, if any
 Batch No./Lot No
 Test results of enameled and covered transposed cable as per Cl. 5, 8 to 12.



	CORPORATE PURCHASING SPECIFICATION	AA 281 29
		REV NO. 04
		PAGE 8 OF 9

Test certificates for compliance of characteristics of paper to BHEL Corporate Purchasing Specifications (CPS) No. AA 21111 and AA 21116.

14. **PACKING AND MARKING:**
The transposed cable shall be tightly and evenly wound, without twist, on drums in such a direction that when unrolled the exposed edge of the overlap of the outer layer of paper is towards the drum. The size of drum shall be selected from Annexure I. Drum flanges shall have an arrow mark showing the position of finishing end of cable.

Barrel dia 'C' of drum shall be at least 50 times of covered radial depth of cable subject to a maximum of 900 mm (Barrel 14) When specified on order, drums of barrel dia 1070 & 1140 mm shall be used. Out side flange dia A of drums can be reduced by the supplier considering the packing weight of CTC and capacity of the drum. How ever, it shall be ensured that cable is not packed up to the rim of the drum.

Before winding the insulated strip, a layer of polythene sheet or similar waterproof material shall be wrapped on empty drum. After winding the cable, the sheet edges shall be folded over the cable and then a polythene strip shall be wound on outside.

As a final protection, a layer of oiled canvas or similar waterproof material shall be wrapped over the polythene sheet, ensuring that no part of the cable is exposed.

Drums used for packing shall be made from seasoned wood. Circular disc separator shall be made from plywood.

Metal/Non –Metal straps used over, the drum shall be stamped/sealed with the manufacturer's identification marks. Similarly, end of the conductor shall also be stamped/sealed.

Each drum shall be labeled clearly stating the following information. The label shall preferably be cemented into a recess in the side of the flange of the drum.

AA 28129 - Paper Covered continuously Transposed Copper Cable. (0.1% Proof Stress)

BHEL Order No.
Manufacturer's Name / Suppliers Name

Maximum covered and bare dimension of cable, No. and size of individual conductor, increase in dimensions due to paper covering, No. of paper layers and thickness of paper in each layer, grade of enamel and length of cable.

Batch No./Lot No..
Net weight / Gross weight.

15. **REFERRED STANDARDS (Latest Publication Including Amendments) :** ↑

1. AA 21111	2. AA 21116	3. AA 12024	4. IS:13730-17
5. IS:613	6. IEC 60317-17	8. IEC : 60317-27	9. IS:1060
10 IS:13730 Pt.27	11 IS:1608		





CORPORATE PURCHASING SPECIFICATION

AA 281 29

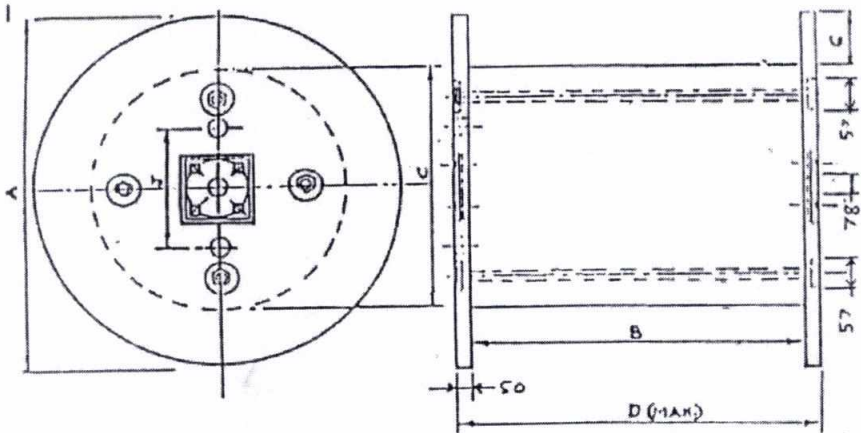
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ANNEXURE - I

Dimensions of Standard Drum

DIMENSION		Drum Designation						
		8	9	10	14A	14B	14C	14D
Outside Flange diameter	A	800	900	1000	1400	1400	1400	1400
Barrel dia	C	600	600	700	900	900	900	900
Overall width	D	440	440	660	440	710	910	580
Traverse	B	340	340	560	340	610	810	480
PCD of Driving Holes	J	300	300	600	600	600	600	600
Flange depth	G	88	138	138	238	238	238	238
Approximate Capacity in Kg.		300	480	890	1230	2200	2900	1730



- NOTE: 1. Partitions to hold multiple length in a drum shall be of 12.5 mm thick.
2. Any fixing bolt used within a circle of 600 mm diameter shall not project outside flange surface.

Note:

1. Partitions to hold multiple length in a drum shall be of 12.5 mm thick.
2. Any fixing bolt used within a circle of 600 mm diameter shall not project outside flange surface.

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		PAGE 5 OF 10

10.3.2 Width of paper :

The width of paper shall be within the limits of 15 and 40 mm, both inclusive.

10.3.3 Arrangement of layers:

All the layers shall be applied in the same direction, all except the two outermost layers shall be butt wound and the two outermost layers shall be applied together with a staggering of 50% so that they are interlocked giving 50% overlap effect. Within each group the positions of the butt joints of any layer relative to the layer below shall be progressively displaced by approximately 30 percent of the paper width. There shall not be any gap between edges of adjacent turns of first butt wound paper layer i.e. enameled copper should not be visible. In subsequent butt wound layers, a possible gap of 0.5 mm maximum and overlap up to 1 mm between edges of adjacent turns shall be allowed.

10.3.4 Paper thickness for butt and overlap interlocked would layers:

Thickness of paper for butt wound layers shall be between 50 um and 100 um (both inclusive). Two outermost overlap interlocked layers shall be wound with paper of thickness between 75 and 125 microns (both inclusive). However, when radial insulation is 2.2 mm or more, 140 um paper for two outermost layers is allowed to avoid two paper covering operations due to availability of a maximum of 24 paper heads in the lapping machine of same manufactures. Special extensible high density and high mechanical strength paper meeting the requirements of clause 9 can be used in the two outermost interlocked layers.

10.3.5 Wax Coating :

When specified on order, a coating of paraffin wax to IS:4654 of thickness not exceeding 0.02 mm shall be applied on the bottom flat sides of fully paper covered width of the conductor

11. DIMENSIONS OF TRANSPOSED CABLES :

11.1 Method of Calculating Maximum Bare Axial Width (AW) :

$AW = 2(b + e) + F + \text{inter column paper if specified (100 }\mu\text{m thick)}$

Where :

AW = Max. bare axial width of transposed cable.

b = Maximum axial width of bare individual conductor
= Nominal width + Tolerance (from table 1 below)

e = Maximum increase in dimension due to enameling
(as per IS : 13730 Pt. 0 /Sec. 2 : 1993 (R2003),IEC 60317-0-2:2005)
= 0.11 mm for fine grades of covering

F = Free space allowance = 0.2 mm

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**PRODUCT PURCHASING SPECIFICATION
TRANSFORMER ENGINEERING DEPARTMENT
BHEL BHOPAL**

Specification No. **TRE 218**
Page 1 of 1 Page
Rev. 01 Dt. : 08.09.2018

THERMALLY UPGRADED INSULATING KRAFT PAPER

1. **General** - This specification governs the quality of high density thermally upgraded insulating kraft paper for electrical purposes made entirely from soft-wood pulp manufactured by the sulphate process and upgradation to meet thermal stress. The kraft paper shall be dyed in green colour & shall be free from metallic particles. The material in insulating mineral oil shall have temperature index of at least 120.
2. **Usage** - This paper finds use in power transformer windings.
3. **Compliance with standards** – IEC:60554-3-5 grade 5A4-1M1 + Thermal upgradation.
4. **Sample for test** – 20 sheets of 300 x 300 mm shall be required for testing. Testing shall be as per IEC:60554-2.
5. **Properties** – Shall be as per Table 1 at page 2.
6. **Test certificates** - Unless otherwise stated, test certificates shall be supplied along with each consignment.

In addition, the supplier shall ensure to send one copy of test certificates along with their dispatch documents to facilitate quick clearance of the material.

The test certificates shall bear the information generally as per Table 1 along with nitrogen content.

7. **Packing & marking** - Packing shall be marked legibly at least with the BHEL spec. no., Order No., Quantity, Thickness & width, net/ gross weight & Date of manufacture.

REV	DATE	ALT CHD	REV-01	DATE 8.9.18	ALT CHD.	REV 00	NAME	SIGN	DATE
			COMPLETE SPECIFICATION REVISED.			PREP.	S.Sachdeva	-sd-	17.08.18
						CHD.	M.Kulkarni	-sd-	17.08.18
DWI/TCB/TRE/010									

[Handwritten signature]

**PRODUCT PURCHASING SPECIFICATION
TRANSFORMER ENGINEERING DEPARTMENT
BHEL BHOPAL**

Specification No. **TRE 218**
Page 2 of 2 Pages
Rev. 01 Dt. : 08.09.18

Table 1 – Properties of thermally upgraded insulating kraft paper

Property	Unit	Min.	Nominal	Max.
Nominal thickness	micron	45 57 68 90	50 63 75 100	55 69 82 110
Grammage				
50 micron	g/m ²	47.5	50	52.5
63 micron		62.0	63	68.0
75 micron		71.5	75	78.5
100 micron		95.0	100	105.0
Apparent bulk density	kg/m ³	950	1000	-
Air permeability	μm/Pa*s	0.05	-	0.10
Moisture content	%	-	-	8.0
Tensile index MD	Nm/g	93.0	-	-
Tensile index CD	Nm/g	35.0	-	-
Elongation MD	%	2.0	-	-
Elongation CD	%	4.0	-	-
Tear index MD			-	-
Up to 75 micron	mN*m ² /g	5.0		
Above 75 micron	mN*m ² /g	6.0		
Tear index CMD			-	-
Up to 75 micron	mN*m ² /g	6.0		
Above 75 micron	mN*m ² /g	7.0		
Electrical strength in Air	kV/mm	8.0	-	-
Ash content	%	-	-	0.5
Conductivity in aqueous extract	mS/m	-	-	4.0
pH in extract	-	6.0	-	8.0
Nitrogen content	%	1.0	-	-

DWI/TCB/TRE/010

Signature



विनिर्माण गुणवत्ता योजना अनुमोदन वैधता विस्तार/ MQP APPROVAL VALIDITY EXTENSION

संदर्भ: CC/QA&I/2024/Letter/390

दिनांक: 29.Jul.2024

निर्माता का नाम/ Name of Manufacturer	BHEL, Bhopal
सी.आई.एन संख्या/ CIN Number	L74899DL1964GOI004281
निर्माता का पता/ Address of Manufacturer	Piplani, Raisen Road, BHEL
	City: Bhopal Country: India Pin/Zip Code: 462022
निर्माता कोड/ Manufacturer Code	3000000057
नाम और संपर्क विवरण/ Name & Contact details	Sh. Abhishek Sharma
	Email: AKSHARMA1@BHEL.IN, Mobile: +919406903659
मद का नाम & गुणवत्ता योजना सं./ Item Name & MQP No.	Power Transformer, SMQP no CC/QA/SMQP/01 Rev 00 for Transformer up to 765 kV Class with exception sheet
पिछले अनुमोदन का संदर्भ/ Previous approval letter ref. No. & date	CC/QA&I/2024/Letter/058, 31.Jan.2024
संचार संदर्भ/ Communication reference	21107
वैधता विस्तार अवधि/ Validity extended upto	19.Jul.2025

This MQP shall be read in conjunction with the contract specific technical specification / approved drawing/ data Sheets / GTP / test procedures, relevant IEC / IS standards and project specific type tests. Manufacturer shall ensure that the above documents are available at the works so that proper inspection is carried out without delay. Please note that further approval shall be considered based upon performance, quality, and supplies during this approval period. Manufacturer shall ensure that request for renewal of above approval should come at least 1 month before expiry of this approval letter. All other clauses mentioned in above mentioned approval letter remain unchanged.

While on the subject, we wish to clarify that process inspection/ audit shall continue for above item in adherence to this MQP at your works. In case of serious and repeated observations of process / process parameter violation and if any problem is encountered with regards to the quality, we reserve the right to increase our involvement by way of additional quantum of inspection and / or additional Customer Inspection Points(CIP) at any stage or withdraw this MQP.

Special Remarks: This extension approval is provided considering BHEL email dtd. 26.07.2024 wherein it was informed that investment approval for the establishment of CCA chamber in old block is done and its establishment shall be completed by Mar'2025.

Note 1: "The ministry of MSME has launched the "Financial Support to MSMEs in ZED certification scheme" for benefit of MSMEs. MSMEs are requested to avail maximum benefits under the scheme. For more details on ZED, you may please visit this link- (<https://zed.org.in/>)."



Note 2: Letter regarding- Non-Indulgence in Fraudulent / Unethical Practices attached.

29/07/2024



Authorized Signatory

Raju K. Jainwal
Manager, QA&I

STANDARD MANUFACTURING QUALITY PLAN
FOR
EHV Transformer up to 765kV
(STANDARD MQP no. CC/QA&I/SMQP/01 Rev 00)

Manufacturer Name & Address:		Manufacturing Quality Plan for EHV Transformers up to 765kV											
 BHEL BHOPAL		Customer		VENDOR CODE	Item Description	MQP No.	Validity of MQP						
		Power Grid Corporation of India Ltd.		3000000057	EHV Transformers up to 765 kV	CC/QA/SMQP/01 Rev 00	As per MQP letter						
SI No.	Components and Operations	Type of check	Quantum of check	Reference document	Acceptance norms	Form of record	Applicable Codes						Remarks
							1	2	3	4	5	6	
Code 1: Indicates place 'where testing is planned' to be performed i.e. inspection location A. At equipment manufacturer's works B. At component manufacturer's works C. At authorised distributors place D. At independent Lab E. At Turn Key contractors location F. Not Specified						Code 2: Indicates 'who has to perform' the tests i.e. Testing agency J. The equipment manufacturer K. The component manufacturer L. The Third party M. The turnkey contractor							
Code 3: Indicates 'who shall witness the tests' i.e. witnessing agency P. Component manufacturer itself Q. Component manufacturer and equipment manufacturer R. Component manufacturer, equipment manufacturer and contractor S. equipment manufacturer itself T. equipment manufacturer and contractor U. equipment manufacturer and contractor and POWERGRID V. Third party itself						Code 4: Indicates 'review of test reports/certificates' W. By the equipment manufacturer X. By contractor during product/process inspection Y. By POWERGRID during product/process inspection Z. By contractor and/or POWERGRID during product/process inspection							
Code 5: Whether 'specific approval of sub vendor make is envisaged' E. Envisaged N. Not Envisaged						Code 6: Whether 'test records required to be submitted' after final inspection for issuance of CIP/MICC Y. Yes N. No							





Manufacturer Name & Address: <div></div> BHEL BHOPAL		Manufacturing Quality Plan for EHV Transformers up to 765kV												
		Customer			VENDOR CODE	Item Description	MQP No.			Validity of MQP				
		Power Grid Corporation of India Ltd.			3000000057	EHV Transformers up to 765 kV	CC/QA/SMQP/01 Rev 00			As per MQP letter				
SI No.	Components and Operations	Type of check	Quantum of check	Reference document	Acceptance norms		Form of record	Applicable Codes						Remarks
								1	2	3	4	5	6	

General Notes:



- The MQP should be read in conjunction with POWERGRID specification and shall deem to include additional tests required as per the contract
- POWERGRID specification shall include provisions of the 'Letter of Award', PBD/ specific agreements, POWERGRID approved drawings/technical data sheet/BOM/test schedule/test procedure applicable to the specific contract.
- In case of contradiction between the manufacturer's plant standard and this MQP and POWERGRID specification following preference shall be followed:
 - Power Grid Specification/ Technical Specification/GTR,
 - Project Specific Drawing/ Data Sheet
 - Manufacturing Quality Plan
 - Applicable IS/IEC
 - Manufacturer's plant standards
- It is the responsibility of the manufacturer to ensure that this document is readily available at their works, as well as the works of their sub vendor in order to avoid any delay at the time of inspection.
- The manufacturer shall ensure that their as well as their sub vendor's control, metering and testing instruments are duly calibrated and should have calibration certificates traceable to Indian/International standards. Calibration records should be available during inspection by POWERGRID. Key testing instruments will be calibrated by an agency having full membership & MRA of ILAC/APLAC.
- In case of any tests being carried out at third party Lab. such lab / facility should be an agency having full membership & MRA of ILAC/APLAC accredited / accepted by POWERGRID.
- The manufacturer shall maintain the proper correlation of test certificates from raw material stage to finished product stage and the records should be available during inspection by POWERGRID.
- Manufacturer shall show the approval of POWERGRID Engineering for all contract specific type tests, including specific type tests if any as per the POWERGRID specification at the time of final inspection.
- All packing cases should be marked with POWERGRID LOA Details, Name of project, item description and CIP/ MICC number (by which the material has been cleared for dispatch).
- One copy of test report, CIP & MICC shall also be sent along with the consignment.
- Inspection of Spare items ordered by POWERGRID shall also be governed by the provisions of this MQP. Items if not governed under this MQP shall be offered for inspection as per POWERGRID specification/ relevant Indian/ International standards.
- The manufacturer shall assign their quality systems and that of their sub-vendors to the requirements of latest ISO 9001 quality standards in a time bound manner.
- In case of the change in name of the sub vendor manufacturer shall submit request to update the same along with supporting documents.
- Wherever Indian/International standard are referred their latest amendment shall be included. The same shall be applicable in case of manufacturer specification also so long as these changes are made with the approval of the competent authority of manufacturer with prior intimation to regional inspection office POWERGRID.
- Raw material/ bought out items envisaged shall be procured from POWERGRID approved source only
- All outsourced services shall be from approved sources only.
- Surveillance checks shall be carried out by POWERGRID as and when deemed necessary no inspection call to be given for surveillance check.







Manufacturer Name & Address: <div> BHEL BHOPAL</div>		Manufacturing Quality Plan for EHV Transformers up to 765kV												
		Customer			VENDOR CODE	Item Description	MQP No.			Validity of MQP				
		Power Grid Corporation of India Ltd.			3000000057	EHV Transformers up to 765 kV	CC/QA/SMQP/01 Rev 00			As per MQP letter				
SI No.	Components and Operations	Type of check	Quantum of check	Reference document	Acceptance norms		Form of record	Applicable Codes						Remarks
								1	2	3	4	5	6	

18. Manufacturer to get clearance/approval from POWERGRID Engineering for Type test on first Transformer of each rating against each contract including Bushing, Buchholz relay, OLTC, Cooler control cabinet, cooling fan motor assembly, PRD, MOLG, Air cell, OTI & WTI & Terminal connector as applicable in the TS of contract in question.
19. POWERGRID may review the effective implementation of the processes during the product- inspection/ process-inspection. In case any violation in process or process parameters are observed, the reason along with corrective & preventive Measurements shall be conveyed to POWERGRID within 2 weeks.
20. This MQP is standard MQP for Transformers up to 765 kV manufactured by BHEL.
21. No inspection call shall be raised unless and until GTP/Drawings/ Design Reviews /Type test reports approved by POWERGRID Engineering
22. The following abbreviations are used in this MQP:
- EM : Equipment Manufacturer
 CM : Component manufacturer
 TC : Test Certificate
 TS : Technical Specification
 Vendor : BHEL
 Tech : Technical
 Spec : Specification
 Drg : Drawings
 Appvd : Approved
 Tol : Tolerance
 Min : Minimum
 Max : Maximum
 POWERGRID: Power Grid Corporation of India Ltd.
23. BHEL shall ensure that all tests mentioned in the technical specification of subject contract in question need to be carried out strictly, without fail.
24. MQP shall be read in conjunction with QIN and all stage inspection shall be done as per annex of transformer manufacturer QIN grade.



Manufacturer Name & Address:		Manufacturing Quality Plan for EHV Transformers up to 765kV																
 BHEL BHOPAL		Customer		VENDOR CODE	Item Description	MQP No.	Validity of MQP											
		Power Grid Corporation of India Ltd.		3000000057	EHV Transformers up to 765 kV	CC/QA/SMQP/01 Rev 00	As per MQP letter											
SI No.	Components and Operations	Type of check	Quantum of check	Reference document	Acceptance norms	Form of record	Applicable Codes						Remarks					
							1	2	3	4	5	6						
A	RAW MATERIAL																	
1.1	PAPER INSULATED COPPER CONDUCTOR (PICC)															E		
1.1.1	Check of a) Surface finish of conductor b) Finish of PICC c) Review of TC for oxygen content as per IS 12444	Visual/ Review	One Sample for each size for each Transformer	BHEL Tech Data Sheet BHEL Drg IEC 60317	No visible defects/ Review	CMTC	B	K	P/U	W		Y	For On shore(Indigenous): CIP for 01 sample of each size for three transformers of each rating per contract & for rest units are in CIP level II For Offshore(Imported): CIP for one sample of each size for one Transformer for contract. Balance Record review on surveillance basis					
1.1.2	Check of a) Dimension of bare copper b) Corner radius c) Number of layers of paper covering d) Arrangement of layers e) Increase in dimension due to paper covering	Measurement			IEC 60317-0-2 Min No. of Paper layers As per Manufacturer Spec. IEC 60317-0-2	CMTC	B	K	P/U	W/Z		Y						
1.1.3	Resistivity at 20 °C	Measurement			IEC 60317-0-2	CMTC	B	K	P/U	W/Z		Y						
1.1.4	Elongation (for annealed conductor)	Measurement			IEC 60317-0-2		B	K	P/U	W/Z		Y						

Manufacturer Name & Address:  BHEL BHOPAL		Manufacturing Quality Plan for EHV Transformers up to 765kV												 पावरग्रिड POWERGRID
		Customer			VENDOR CODE	Item Description	MQP No.			Validity of MQP				
		Power Grid Corporation of India Ltd.			3000000057	EHV Transformers up to 765 kV	CC/QA/SMQP/01 Rev 00			As per MQP letter				
SI No.	Components and Operations	Type of check	Quantum of check	Reference document	Acceptance norms	Form of record	Applicable Codes						Remarks	
							1	2	3	4	5	6		
1.1.5	Proof Stress for work hardened conductor (if applicable)	Measurement			As per BHEL Design Review documents		B	K	P/U	W/Z		Y		
1.1.6	Insulation test for bunched conductor	Measurement			Maximum Charging current 1A at 250V AC / 500V DC for 1 minute.		B	K	P/U	W/Z		Y		
1.2	CONTINUOUSLY TRANSPOSED COPPER CONDUCTOR (CTC)										E			
1.2.1	a) Check surface finish conductor b) Review of TC for oxygen content as per IS 12444	Visual/ Review	One Sample for each size for each Transf ormer	BHEL Tech Data Sheet BHEL Drg IEC 60317	No visible defects/ Review	CMTC	B	K	P/U	W/Z		Y	For On shore(Indigenous): CIP for 01 sample of each size for three transformers of each rating per supplier per contract & for rest units are in CIP level II	
1.2.2	Check of Dimension Width and thickness, Corner Radius of bare copper Check of the number of conductors	Measurement			IEC 60317-0-2		B	K	P/U	W/Z		Y		
1.2.3	Increase in bare dimension due to enamel and due to paper covering. Verification of axial width, radial depth and arrangement of paper covering	Measurement			BHEL TDS/ IEC 60317/ Design review docs		B	K	P/U	W/Z		Y		
1.2.4	Resistivity at 20 °C	Measurement			IEC 60317-0-2		CMTC	B	K	P/U	W/Z			Y
1.2.5	Elongation (for annealed conductor)	Measurement	One Sample for each size for each Transf ormer	BHEL Tech Data Sheet BHEL Drg IEC 60317 IS13730-27	IEC 60317-0-2	CMTC	B	K	P/U	W/Z		Y	For Offshore(Imported): CIP for one sample of each size for one Transformer for contract. Balance Record review on surveillance basis	
1.2.6	Proof Stress for work hardened conductor (if applicable)	Measurement			As per BHEL Design Review documents	CMTC	B	K	P/U	W/Z		Y		
1.2.7	Check for adherence of enamel coating & breakdown voltage test on enamelled conductor at room temp.	Measurement			IEC 60317-0-2	CMTC	B	K	P/U	W/Z		Y		

Manufacturer Name & Address:		Manufacturing Quality Plan for EHV Transformers up to 765kV											
 BHEL BHOPAL		Customer		VENDOR CODE	Item Description	MQP No.	Validity of MQP						
		Power Grid Corporation of India Ltd.		3000000057	EHV Transformers up to 765 kV	CC/QA/SMQP/01 Rev 00	As per MQP letter						
SI No.	Components and Operations	Type of check	Quantum of check	Reference document	Acceptance norms	Form of record	Applicable Codes						Remarks
							1	2	3	4	5	6	
1.2.8	Insulation test between strands of CTC (if applicable)	Measurement			Maximum Charging current 1A at 250V AC / 500V DC for 1 minute.	CMTC	B	K	P/U	W/Z		Y	
1.3	KRAFT INSULATING PAPER (FOR COVERING OF PICC & CTC)										E		
1.3.1	Checks of paper healthiness	Visual	One sample for each size per lot	BHEL Tech Data Sheet BHEL Drg IEC 60554	No surface defects.	CMTC	B	K	P	W		N	Record review on surveillance basis
1.3.2	Thickness	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.3	Apparent Density	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.4	Tensile index in Nm/g a) Machine Direction b) Cross Machine direction	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.5	Electrical Strength in air	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.6	Ash content	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.7	Conductivity of aqueous extract	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.8	PH of aqueous extract	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.9	Heat Stability	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.10	Air Permeability	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.11	Moisture content	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.12	Tear Index	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.13	Water absorption (Capillary rise)	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.14	Elongation at break	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.15	substance (grammage)	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.3.16	Degree of Polymerization	Measurement			IEC 554-3-5	CMTC	B	K	P	W		N	
1.4 A	PRECOMPRESSED PRESSBOARD- Note: BHEL shall ensure that samples of Pressboard are duly sealed annually (randomly on different sizes) by POWERGRID-RIO at the premises of transformer manufacturers/ Insulation cutter's/ PCB manufacturer & tested at third party lab.									E			
1.4.A1	Check for healthiness	Visual	One sampl	BHEL Drg BHEL Spec.	No visible defect	CMTC	A/B	J/K	S/P	W/Z		N	





BHARAT HEAVY ELECTRICALS LIMITED, BHOPAL

QUALITY PLAN FOR CTC (Continuously Transposed Conductor)

QA PLAN NO: QC/TCB/QAP/BO/55 REV 01

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SL	COMPONENT / OPERATION	CHARACTERISTICS	TYPE OF CHECK	REFERENCE DOCUMENT	QUANTUM OF CHECK	INSPECTION AGENCY	REMARKS
Raw material Inspection							
1	Kraft Insulating Paper	- Thickness - Routine tests - Type Test (test to be conducted for each manufacturer once in 5 Yrs.)	M / T	BHEL spec. AA 21111 AA 21116	1 Sample per lot for each thickness	CTC Vendor, BHEL/TPIA	- CHP For Record Review - CTC manufacturer shall send one set of samples (20 sheets of size 300mm x 300mm) and paper Manufacturer's test certificates for approval from BHEL Bhopal before use. Complete consignment details e.g. No. of reel, weight, invoice and linking paper shall be sent. - Paper from BHEL Bhopal approved source shall only be used.
2	CC Rod	- Surface finish. - Chemical composition: i) Copper including silver ii) Oxygen content. - Mass Resistivity. - Elongation	V / T	BHEL spec. AA 12024	1 sample per lot.	CTC Vendor, BHEL/TPIA	- CHP For Record Review - Any discrepancy observed in CC rod at any stage of processing should be reported to BHEL with full details stating coil no. nature of defect with photographs. - CC Rod from BHEL Bhopal approved source shall only be used.
3	a) PVA based adhesive used for Kraft paper Bonding	i) Type grade & make. ii) Non volatile matter content, consistency, bond strength, pH Value, Compatibility with Transformer oil (Type test)	T	IS 2257	1 sample per lot.	CTC Vendor	Record review by CTC vendor
	b) Enamel and Epoxy coat	Colour, appearance, Solid contents, Viscosity, Flash point, storage and shelf life of enamel, Compatibility with Transformer Oil	T	CTC Vendor's spec.	1 sample per lot	CTC Vendor	

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SL	COMPONENT / OPERATION	CHARACTERISTICS	TYPE OF CHECK	REFERENCE DOCUMENT	QUANTUM OF CHECK	INSPECTION AGENCY	REMARKS	
In process inspection								
4	Manufacturing and storage area	Proper cleaning of copper dust and normal dust in plant and machinery	V	BHEL Spec AA28125/ AA28128	100%	Vendor	- Surveillance Check By BHEL/TPIA/CQ	
5	(a) Drawing / Flattening and annealing	- Surface finish - Corner radius - Dimension - Elongation / Proof stress	V / M / T	AA 28127 AA 28129	100% mother reels	CTC Vendor	1-Surface defects like burrs, sharp edges, blisters, flakes, cracks, grease, foreign particles, and embedded impurities are not acceptable.	
	(h) Enameling and Epoxy coating	- Surface finish of bare strip - Appearance of enameled strip - Bare and covered Dimensions - Shelf life	V / M	AA 28127 AA 28129 IEC 317-18 TRE 036	100%	CTC Vendor	2-The conductor shall have smooth, bright and polished surface. 3-The enamel coating shall be smooth and continuous, free from streaks, blisters and foreign material.	
		- Tests: Resistance, Elongation, Proof stress (if applicable), springiness, flexibility and adherence, heat shock, resistance to solvents, BDV	T		3 samples per enamel setting (start, end and in between)		Complete records to be maintained by vendor for ensuring traceability from CC rod to Finish stage	
	(c) Transposition and Paper Covering	- Visual Inspection - Dimensions of CTC stack - Pitch of Transposition - No. of layers, width and arrangement of paper lapping	V / M / T	AA 28127 AA 28129	100%	CTC Vendor, BHEL/TPIA	CHP for witness of covering for 2 reels of each size. The CTC stack shall be compact in both the directions; there shall be no damage to enamel.	
Final inspection								
6	(a) Visual, Dimensions and Insulation covering	- Covered dimension of cable - Increase in dimension due to paper insulation. - Paper covering: Thickness, width, staggering and overlap - Inter column paper - Bare dimensions of cable - Pitch of transposition - Appearance of enameled conductor	V / M	AA 28127 AA 28129 IEC 317-18 TRE 036	3 samples per lot for each size	BHEL/TPIA	CHP for witness	

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SL	COMPONENT / OPERATION	CHARACTERISTICS	TYPE OF CHECK	REFERENCE DOCUMENT	QUANTUM OF CHECK	INSPECTION AGENCY	REMARKS
		<ul style="list-style-type: none"> - Increase in thickness due to enameling and epoxy coating. - Corner radius perpendicular ness of edges and merging - Bare thickness and width 					
	(b) Tests	<ul style="list-style-type: none"> - Resistivity - Elongation - Proof stress test (if applicable) - Flexibility and adherence - Springiness - Heat shock - resistance to solvent - BDV - Insulation test (between each and every other strip) at 250V - Epoxy curing check 	T	AA 28127 AA 28129 IEC 317-18 TRE 036	1 sample per lot per size	BHEL/TPIA	CHP for witness
7	Packing and Dispatch	<ul style="list-style-type: none"> - Provision of inter-layer paper. - Sufficient gap from drum brim to packed conductor top - Marking of winding direction. - Use of proper drum size - Proper identification - use of refrigerated container as per PO requirement 	V	AA 28127 AA 28129 TRE 036 TR 10133	100%	CTC Vendor	Surveillance check by BHEL/TPIA

LEGENDS: V - VISUAL, M - MEASUREMENT, T - TEST, TPIA - THIRD PARTY INSPECTION AGENCY, CQ- BHEL CORPORATE QUALITY, CHP - CUSTOMER HOLD POINT (VENDOR CAN NOT PROCEED WITHOUT GETTING CLEARANCE FROM BHEL CQ TPIA)

Changes in the revision:

- Remarks for clause 2 updated.
- Clause 4 added and renumbering done.

Prepared By

(S.K.Bhargava)

Approved By

J.B. Basfore

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