



# CORPORATE PURCHASING SPECIFICATION

AA28145

Rev No. 02

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## POLYESTER ENAMELLED ROUND COPPER CONDUCTORS (TEMPERATURE INDEX 155)

### 1.0 GENERAL:

This specification governs the quality of round copper conductors insulated with flexible insulating enamel based on terephthalate polyester of temperature index at least 155 in Fine, Medium and thick covering.

### 2.0 APPLICATION:

For use in winding of Transformer, Switchgear, Industrial Machines, control gear and Traction Motors etc.

### 3.0 COMPLIANCE WITH NATIONAL STANDARDS:

The specification generally conforms to IS: 13730 Part 3 with alternative/additional requirements laid in clauses 5, 6.3, 8.7

### 4.0 SIZES AND GRADE:

4.1 The conductor shall be supplied to the sizes and grade of covering specified on our order.

4.2 The sizes shall preferably be selected from column 1 of Table 1 and overall diameter of the covered conductor shall also be stated on the order.

### 5.0 JOINTS:

No joints shall be made in the copper conductor after it is drawn. Any joints made during the drawing process shall be only resistance welded.

### 6.0 CONDUCTOR:

#### 6.1 Tolerance on Nominal Diameter:

The tolerance on diameter of conductor shall be in accordance with column 2 of Table 1.

#### 6.2 Conductor Material:

The conductor shall be manufactured from ETP grade high conductivity copper conforming to IS: 191

#### 6.3 Electricals Resistance/Resistivity:

##### a) Upto and including 1.0 mm dia.

The resistance of the conductors in "as received" condition at 20°C shall be as per IS:13730, Part 3.

##### b) Over 1.0 mm dia.

The resistivity of the conductors in "as received" condition shall not be greater than 0.01739 ohm/mm<sup>2</sup>/m.

#### Revisions:

As per Clause No.40.4 of MOM of MRC – E&IM

#### APPROVED:

INTERPLANT MATERIAL RATIONALISATION  
COMMITTEE – MRC(E&IM)

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## 6.4 Elongation:

The elongation of fracture shall not be less than that given in column 3 of Table 1.

## 7.0 OVERALL DIAMETER & INCREASE IN DIAMETER:

The maximum overall diameter of the covered conductor for fine, medium and thick covering shall be as specified in column 4, 6 and 8 of Table 1 respectively. The increase in diameter due to fine, medium and thick covering shall not be less than that given in columns 5, 7 and 9 of Table 1 respectively.

## 8.0 ENAMEL COVERING:

### 8.1 General:

The conductor shall be completely and uniformly covered with a durable, flexible, synthetic enamel of terephthalate polyester base. The enamel shall have a smooth surface free from embedded particles of dust and other deleterious materials.

### 8.2 Flexibility and Adherence of Enamel:

#### 8.2.1 Mandrel Winding test:

After winding ten contiguous turns on a polished mandrel, the diameter of which is in accordance with column 10 of Table 1. The covering of the sample shall show no cracks when examined under a magnification of 10 to 15 times.

Conductor of bare nominal diameter up to and including 0.25 mm shall be stretched 20% or to the breaking point of the conductor material whichever is less before winding on the mandrel.

The mandrel shall be rotated at between 1 and 3 turns per second, the tension on the wire being just sufficient to keep it in contact with the mandrel. Care shall be taken to avoid elongation or twisting of the wire. Three tests shall be made.

#### 8.2.2 Jerk Test:

This test is applicable to conductors of diameter up to and including 1.0 mm. When the specimen is suddenly stretched to the breaking point or to the elongation as specified in column 3 of Table 1, the covering of sample shall show no cracks or loss of adhesion when examined under a magnification of 10 to 15 times.

#### 8.2.3 Peel Test:

This test is applicable to conductor of diameter over 1 mm. The enamel shall show flexibility and it shall not be possible to remove the enamel without difficulty from the wire e. g. with thumb nail, when the wire twisted in the rotating device to the extent that the product of the bare nominal diameter and the number of revolution is 150.

### 8.3 Cut through Test:

When tested in accordance with IS: 13730 Part 3 specimen shall show no break down Within 2 minutes at 240°C.

### 8.4 Springiness Test:

This test Is applicable to conductors of diameter from 0005 mm, upto and including 1.6 mm. When tested in accordance with IS: 13730 Part 3. The wires shall not extend the maximum spring as given in Table-3 of IS: 13730 Part 3 on a mandrel and under a tension specified therein.



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## 8.5 Heat Shock Test:

Three test specimens shall be prepared by winding 10 contiguous turns round a polished mandrel with mandrel diameter, given below. The samples shall be kept for 30 minutes in a forced air circulating oven at a temperature 175° - 180°C. After removal from the oven, the specimen shall be allowed to cool to room temperature and shall be examined under a magnification of 10 - 15 times. Each specimen shall be free from cracks.

| Nominal Diameter (mm) |                            | Mandrel<br>Diameter(mm) |
|-----------------------|----------------------------|-------------------------|
| Over                  | Over Upto and<br>including |                         |
| -                     | 0.04                       | 0.20                    |
| 0.04                  | 0.25                       | 5d                      |
| 0.25                  | 1.00                       | 7d                      |
| 1.00                  | 2.00                       | 7d                      |
| 2.00                  | 5.00                       | 8d                      |

## 8.6 Solvent Test:

When tested In accordance with IS: 13730 Part 3 / IEC 60851 Part 4. The enamel of the conductor shall not be removed down to the conductor in any one of three tests with a pencil of hardness "H".

## 8.7 Resistance of Enamel to Oil:

When tested in accordance with the method mentioned below the enamel shall be such that it shall not be removed down from the conductor by scraping with thumbnail.

### 8.7.1 Test Method:

The enameled wire shall be wound in contiguous turns on a polished metal mandrel 2.5 cm in diameter for about 10 mm length on the mandrel. The mandrel with the wire shall then be immersed in insulating oil to IS: 335 for 6 hours at 110° ± 2°C, then shall be taken out and allow to cool to room temperature. The specimen shall then be scraped with the thumb nail.

## 8.8 Breakdown Voltage:

### 8.8.1 Breakdown Voltage At Room Temperature

#### 8.8.1.1 Conductor Sizes up to and including 0.040 mm.

When tested in accordance with IS:13730 Part 3, at least four of five samples shall not breakdown at voltages less than those given in columns 11 & 12 of Table I.

#### 8.8.1.2 Conductor sizes over 0.040 mm, up to and including 2.5 mm:

When tested in accordance with IS:13730 Part 3 at least four of five samples shall not breakdown at voltage less than the value given in columns 11, 12 and 13 of Table 1. If however, one of the five samples tested one has a lower value than that mentioned in column 11, 12 and 13 of Table 1, the test shall be repeated with a second series of samples and no failure shall occur.

#### 8.8.1.3 Conductor Sizes Over 2.5 mm:

When tested in accordance with IS: 13730 Part 3 at least four of five samples shall not breakdown at voltages less than 1000 volts (for fine covering) 1600 volts (for medium covering) and 2400 volts (for thick covering).

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## 8.8.2 Breakdown Voltage at Higher Temperature:

75% minimum of the appropriate values gives in the columns 11, 12 and 13 of Table 1, when tested at 155°C.

## 8.9 Continuity of Covering:

This is applicable to conductors of diameter up to and including 0.5 mm. When tested in accordance with IS:13730 Part 3 the number of faults in a 50 meters length shall not exceed the appropriate value given in columns 14, 15 and 16 of Table 1.

## 8.10 Abrasion Test: (IS: 13730 Part 3):

Shall pass the test.

## 9.0 TEST CERTIFICATE:

Unless otherwise specified three copies of a test certificate shall be supplied along with each consignment.

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

The test certificate shall bear the following information:

AA28145 (Rev 02) - POLYESTER ENAMELLED ROUND COPPER CONDUCTORS  
(TEMPERATURE INDEX 155)

BHEL's Order No.

Supplier's Reference

Batch / Lot No, Grade of covering

Size of conductor

Test values obtained/certificate of compliance with clause 6 to 8.

**Note:** On first consignment for establishment of material, supplier shall indicate the type and make of enamel with life time characteristics along with the sample of enamel for infra red spectrograph for our approval on subsequent orders, Certificate that the supplier has used the approved enamel as identified by IR spectrographs method only shall be used.

## 10.0 PACKING AND MARKING:

The conductors shall be wound on reels, and packed, wrapped and labelled in accordance with IS: 482 - 'Specification for Reels for Covered, Solid, Round Electrical Winding Wires'

Flange diameters of reels shall conform to Table-1 of IS: 482 but wires between 0.914 mm and 0.315 mm shall be wound only on reels conforming to column 2 or 3 Table III of the above IS 482. Each reel shall be marked with the following:

AA28145 - POLYESTER ENAMELLED ROUND COPPER CONDUCTORS  
(TEMPERATURE INDEX 155)

BHEL Order No.

Supplier's Name.

Size and Grade of conductor.

Quantity

## 11.0 REFERRED STANDARDS (Latest Publications including amendments)

1) IS: 13730

2) IS: 335

3) IS: 482

4) IEC 60851 - 4



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Table 1

| NOMINAL<br>DIA MM | TOLERANCE<br>±<br><br>mm | ELONGATION<br>% MIN | COVERING (mm)      |                        |                    |                        |                    |                        | 80 V MIN | CONTINUITY |      |       |                  |    |    |
|-------------------|--------------------------|---------------------|--------------------|------------------------|--------------------|------------------------|--------------------|------------------------|----------|------------|------|-------|------------------|----|----|
|                   |                          |                     | FINE               |                        | MEDIUM             |                        | THICK              |                        |          | VOLTS(RMS) |      |       | NO.OF FAULTS MAX |    |    |
|                   |                          |                     | OVERALL<br>DIA MAX | INCREASE<br>IN DIA MIN | OVERALL<br>DIA MAX | INCREASE<br>IN DIA MIN | OVERALL<br>DIA MAX | INCREASE<br>IN DIA MIN |          | FINE       | MED  | THICK |                  |    |    |
|                   |                          |                     |                    |                        |                    |                        |                    |                        |          |            |      |       |                  |    |    |
| 1                 | 2                        | 3                   | 4                  | 5                      | 6                  | 7                      | 8                  | 9                      | 10       | 11         | 12   | 13    | 14               | 15 | 16 |
| 0.020             | -                        | 6                   | 0.025              | 0.002                  | 0.027              | 0.003                  | --                 | --                     | 0.150    | 40         | 100  | --    | 22               | 15 | 12 |
| 0.050             | -                        | 10                  | 0.062              | 0.005                  | 0.068              | 0.010                  | --                 | --                     | 3d       | 350        | 700  | --    | 22               | 15 | 12 |
| 0.100             | 0.003                    | 16                  | 0.121              | 0.011                  | 0.129              | 0.019                  | 0.141              | 0.028                  | 3d       | 600        | 1200 | 1600  | 16               | 11 | 6  |
| 0.125             | 0.003                    | 17                  | 0.149              | 0.013                  | 0.159              | 0.022                  | 0.171              | 0.032                  | 3d       | 700        | 1300 | 1800  | 16               | 11 | 6  |
| 0.140             | 0.003                    | 18                  | 0.166              | 0.015                  | 0.176              | 0.024                  | 0.189              | 0.034                  | 3d       | 800        | 1500 | 2200  | 16               | 11 | 6  |
| 0.160             | 0.003                    | 19                  | 0.187              | 0.016                  | 0.199              | 0.025                  | 0.213              | 0.037                  | 3d       | 800        | 1500 | 2200  | 11               | 7  | 4  |
| 0.180             | 0.003                    | 20                  | 0.209              | 0.017                  | 0.222              | 0.027                  | 0.237              | 0.040                  | 3d       | 900        | 1700 | 2500  | 11               | 7  | 4  |
| 0.200             | 0.003                    | 21                  | 0.230              | 0.018                  | 0.245              | 0.028                  | 0.261              | 0.043                  | 3d       | 900        | 1700 | 2500  | 11               | 7  | 4  |
| 0.224             | 0.003                    | 21                  | 0.259              | 0.019                  | 0.272              | 0.030                  | 0.290              | 0.046                  | 3d       | 1000       | 2000 | 3000  | 11               | 7  | 4  |
| 0.250             | 0.004                    | 22                  | 0.284              | 0.020                  | 0.301              | 0.031                  | 0.320              | 0.048                  | 3d       | 1000       | 2000 | 3000  | 11               | 7  | 4  |
| 0.280             | 0.004                    | 22                  | 0.315              | 0.021                  | 0.334              | 0.032                  | 0.353              | 0.051                  | d        | 1200       | 2200 | 3300  | 11               | 7  | 4  |
| 0.315             | 0.004                    | 23                  | 0.352              | 0.022                  | 0.371              | 0.034                  | 0.391              | 0.053                  | d        | 1200       | 2200 | 3300  | 11               | 7  | 4  |
| 0.355             | 0.004                    | 23                  | 0.395              | 0.024                  | 0.414              | 0.036                  | 0.435              | 0.056                  | d        | 1400       | 2400 | 3700  | 11               | 7  | 4  |
| 0.400             | 0.005                    | 24                  | 0.442              | 0.025                  | 0.462              | 0.038                  | 0.483              | 0.058                  | d        | 1400       | 2400 | 3700  | 11               | 7  | 4  |
| 0.450             | 0.005                    | 25                  | 0.495              | 0.027                  | 0.516              | 0.041                  | 0.538              | 0.062                  | d        | 1600       | 2800 | 4000  | 11               | 7  | 4  |
| 0.500             | 0.005                    | 25                  | 0.548              | 0.029                  | 0.569              | 0.044                  | 0.591              | 0.065                  | d        | 1600       | 2800 | 4000  | 11               | 7  | 4  |
| 0.560             | 0.006                    | 26                  | 0.611              | 0.030                  | 0.632              | 0.046                  | 0.656              | 0.067                  | d        | 1800       | 3100 | 4400  | --               | -- | -- |
| 0.630             | 0.006                    | 27                  | 0.684              | 0.032                  | 0.706              | 0.049                  | 0.730              | 0.071                  | d        | 1800       | 3100 | 4400  | --               | -- | -- |
| 0.710             | 0.007                    | 28                  | 0.767              | 0.034                  | 0.790              | 0.051                  | 0.815              | 0.074                  | d        | 1800       | 3100 | 4400  | --               | -- | -- |
| 0.750             | 0.008                    | 28                  | 0.809              | 0.035                  | 0.832              | 0.052                  | 0.858              | 0.075                  | d        | 1900       | 3500 | 4700  | --               | -- | -- |
| 0.800             | 0.008                    | 28                  | 0.861              | 0.036                  | 0.885              | 0.054                  | 0.911              | 0.078                  | d        | 1900       | 3500 | 4700  | --               | -- | -- |
| 0.900             | 0.009                    | 29                  | 0.965              | 0.038                  | 0.990              | 0.057                  | 1.017              | 0.081                  | d        | 2000       | 3700 | 5100  | --               | -- | -- |
| 1.000             | 0.010                    | 30                  | 0.068              | 0.039                  | 1.093              | 0.059                  | 1.123              | 0.084                  | d        | 2100       | 3800 | 5300  | --               | -- | -- |
| 1.060             | 0.011                    | 30                  | 0.130              | 0.040                  | 1.155              | 0.060                  | 1.134              | 0.085                  | d        | 2100       | 3800 | 5300  | --               | -- | -- |
| 1.120             | 0.011                    | 30                  | 1.192              | 0.041                  | 1.217              | 0.061                  | 1.246              | 0.087                  | d        | 2100       | 3800 | 5300  | --               | -- | -- |
| 1.180             | 0.012                    | 31                  | 1.259              | 0.042                  | 1.279              | 0.062                  | 1.308              | 0.088                  | d        | 2200       | 3900 | 5600  | --               | -- | -- |
| 1.250             | 0.013                    | 31                  | 1.325              | 0.042                  | 1.351              | 0.063                  | 1.381              | 0.089                  | d        | 2200       | 3900 | 5600  | --               | -- | -- |
| 1.320             | 0.013                    | 32                  | 1.397              | 0.043                  | 1.423              | 0.064                  | 1.453              | 0.091                  | d        | 2200       | 3900 | 5600  | --               | -- | -- |
| 1.400             | 0.014                    | 32                  | 1.479              | 0.044                  | 1.506              | 0.066                  | 1.535              | 0.093                  | d        | 2300       | 4000 | 5900  | --               | -- | -- |
| 1.500             | 0.015                    | 32                  | 1.581              | 0.045                  | 1.605              | 0.067                  | 1.638              | 0.094                  | d        | 2300       | 4000 | 5900  | --               | -- | -- |
| 1.600             | 0.016                    | 32                  | 1.683              | 0.046                  | 1.711              | 0.068                  | 1.741              | 0.096                  | d        | 2300       | 4000 | 5900  | --               | -- | -- |
| 1.700             | 0.017                    | 32                  | 1.785              | 0.047                  | 1.813              | 0.069                  | 1.844              | 0.097                  | d        | 2400       | 4300 | 6100  | --               | -- | -- |
| 1.800             | 0.018                    | 32                  | 1.888              | 0.048                  | 1.916              | 0.071                  | 1.947              | 0.099                  | d        | 2400       | 4300 | 6100  | --               | -- | -- |
| 1.900             | 0.019                    | 32                  | 1.990              | 0.049                  | 2.018              | 0.072                  | 2.049              | 0.100                  | d        | 2400       | 4300 | 6100  | --               | -- | -- |
| 2.000             | 0.020                    | 33                  | 2.092              | 0.049                  | 2.120              | 0.073                  | 2.152              | 0.101                  | d        | 2500       | 4400 | 6300  | --               | -- | -- |
| 2.500             | 0.025                    | 33                  | 2.601              | 0.052                  | 2.531              | 0.077                  | 2.665              | 0.107                  | 2d       | 2500       | 4400 | 6300  | --               | -- | -- |