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**TECHNICAL SPECIFICATION
FOR
POLYIMIDE FILM BACKED MICA PAPER TAPE
USED ON TRACTION MOTORS OF DIESEL ELECTRIC LOCOMOTIVES**

विशिष्टि संख्या चा0 श0.0.२४.00.३२ (संशोधन-0२)

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LIST OF AMENDMENTS:

SN.	Amendment date	Revision	Reasons for amendment
1.	April-2005	00	First issue
2.	August-2005	01	Second issue
3.	October - 2023	02	<p>Title changed as “<i>Technical Specification for Polyimide film backed mica paper tape used on Traction Motors of Diesel Electric Locomotives</i>” from existing “<i>Technical Specification for KAPTON MICA TAPE used on Traction Motors of Diesel Electric Locomotives</i>”</p> <p>Addition of LIST OF AMENDMENTS</p> <p>Addition of INDEX</p> <p>‘Kapton’ has been replaced by ‘Kapton/Apical or equivalent Polyimide film’ at Para 1.0, 4.2, 6.2 & 11.0.</p> <p>At Para 4.1, testing during upgradation has been deleted.</p> <p>“supplied by DuPont, USA” at Para 4.2 - Deleted “of reputed and proven source” added and para modified.</p> <p>“<i>Silicone resin shall be procured from reputed and proven sources. The sources should be clearly indicated in the QAP and duly approved by the Vendor Approving Authority</i>”---Added at Para 4.3 supplier’s name for Silicone resin at Para 4.3 deleted.</p> <p>“RDSO” is replaced by ‘Vendor Approving Authority’ at Para 5.0, 9.1, 9.2.</p> <p>At Para 9.1, type tests in every three years & at the time of upgradation has been deleted.</p> <p>New Para 9.1.1 Field trial has been added</p> <p>New Para 13. PREFERENCE TO MAKE IN INDIA has been added.</p>

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Technical Specification for Polyimide film backed mica paper tape used on Traction Motors of Diesel Electric Locomotives

1.0 SCOPE:

This specification covers the technical requirements of silicone resin bonded Kapton / Apical or equivalent Polyimide film backed mica paper tape. The material shall be made out of mica paper with a Kapton / Apical or equivalent Polyimide film backing adhered to one side and evenly impregnated with silicone resin. The tape shall have good winding property. It shall be possible to rewind the tape without any deterioration. The composite insulation produced after pressing and curing shall have temperature index of at least 200.

2.0 APPLICATION:

This material shall be used as armature coil insulation in class 200 insulated stator and other parts of Traction Machines of Diesel Electric Locomotives / DEMUs.

3.0 DIMENSIONS AND TOLERANCES:

Dimensions and tolerances are given in table – 1.

Table – 1

Standard Thickness (mm)	Standard Width (mm)	Length/Roll (m)	Tolerance		
			Thickness (mm)	Width (mm)	Length (m)
0.10	25	30	+0.02 -0.03	± 0.5	+1.0

Thickness, width and length shall be as stated as per individual requirements. However, for special applications, any other size may be ordered.

4.0 BASIC MATERIALS:

4.1 Mica Paper:

Muscovite mica paper with aramid fibrils suitable for class 200 insulation scheme shall be used. It should be uniform in appearance, colour and

surface. It should be plain without particles, wrinkles, cracks and holes. It should be receptive to silicone resin impregnation and also with insulating varnish.

The following basic characteristics of mica paper with aramid fibrils shall be tested during Type testing of the firm: -

Sl. No.	Characteristics	Test Method	Unit	Required Values
1.0	Weight per unit area	IEC – 554-2	g/m ²	70 ± 4
2.0	Aramid fibrils	IEC – 371-2	g/m ²	2.1 ± 1
3.0	Porosity	ISO 3687	S/100 ml	< 2000
4.0	Impregnation time	IEC – 371-2	Sec.	< 60

4.2 Kapton / Apical or equivalent Polyimide Film:

Kapton / Apical or equivalent Polyimide film of HN grade with min. 1 mil thickness of reputed and proven source shall be used for composite insulation. The sources should be clearly indicated in the QAP and duly approved by the Vendor Approving Authority.

Kapton / Apical or equivalent Polyimide film shall contain no foreign particles and be free from holes, folds, blisters, corrugations & wrinkles. Film should be identified by Infra-Red Spectrophotometer or any other standard method at the time of Type testing.

4.3 Silicone Resin:

Silicone resin shall be procured from reputed and proven sources. The sources should be clearly indicated in the QAP and duly approved by the Vendor Approving Authority.

The resin of at least 200 thermal index used for bonding should be catalysed silicone as determined by Infra-Red Spectrograph or any other suitable standard method.

The following properties of Silicone resin shall be met during Type testing:-

Sl. No.	Properties	Test Method	Unit	Specified Values
1.0	Dielectric Strength	ASTM 149	Kv/mm	40 (Min)
2.0	Volume Resistivity at R.T	ASTM D257	Ohm.cm	4×10^{11} (Min)
3.0	Volume Resistivity at 200 deg. C	ASTM D257	Ohm.cm	4×10^{10} (Min)
4.0	Dielectric constant at 1 KHZ	ASTM D150	-	2.5 (Min)
5.0	Dissipation factor at 1 KHZ	ASTM D150	-	0.004 (Max)

5.0 MATERIAL COMPOSITION:

Materials shall have the following ingredients:

Total Substance	Mica content	Binder content
(g/m ²)	(%)	(%)
120 ± 15	56 ± 4	10 ± 3

Note:-

If manufacturer proposes any deviation regarding dimensions & tolerances (clause No. 3) and material composition, prior approval for acceptance of the deviation shall be required from Vendor Approving Authority. In addition, it will be the firm's responsibility that this deviation shall not adversely affect the performance of the motor against electrical properties, magnetic loading and air gap between armature & poles and other design parameters.

6.0 PROPERTIES:

6.1 Surface condition & unreeling characteristics:

The material should be tack-free, smooth and free from wrinkles & cuts. The material shall not be blocking within the roll after storing at 27 deg.C for 24 hrs. and it should be capable of being unreeling in a manner so as not to allow separation of mica paper from the film and it should also not show any sign of deterioration like swelling, becoming hard & porous for a period of at least Shelf life. The material shall not stick to the adjacent layers in the absence of the inter-leaving. The tape shall be suitable for application in hand taping, machine taping or wrapping.

6.2 Flexibility:

The tape shall be sufficiently flexible. When wound on a 3 mm dia. mandrel with Kapton / Apical or equivalent Polyimide film side up, at room temperature there shall be no sign of cracks occurring in the mica paper.

7.0 JOINTS:

The material shall be supplied in continuous lengths as stated on the order. Rolls having joint shall be packed separately and appropriately marked. 90% of the consignment shall be without joints. Per roll, maximum only one joint is permitted. Material used for jointing shall not adversely affect the properties of the cured insulation. If the material used for jointing is not compatible with the insulation, the supplier shall notify accordingly.

8.0 SHELF LIFE AND STORAGE:

At 25 ± 3 deg. C, 12 months, minimum.

The storage life depends upon storage temperature. For prolonged life, the tapes are stored in original carton without tampering polyethylene bags in cool dry cold storage preferably refrigerated cold storage. Optimisation of chemical composition of resin and process must ensure that the material shall retain the properties prescribed in the standard during storage at 25 ± 3 deg. C for 12 months (min.) after the date of manufacturing.

The tape roll should be taken out from refrigerator/cold storage 24 hrs. in advance before application, so that the tape can be brought fully to ambient temperature (room temperature). On account of this, the condensed water on the polyethylene bag will not come in contact with the tape and tape will be saved. If it comes in contact with water, the water will damage the sensitive chemicals of the resin inside the tape rolls.

9.0 TESTS & INSPECTION AT SUPPLIER'S WORKS:

9.1 Type Test:

Type tests shall be conducted on the prototype samples as per the tests mentioned in **Table – 2** and **clause Nos. 4.1 & 4.3** of the specification. Successful completion of the type tests is mandatory for product / firm approval.

Type tests shall be witnessed by Vendor Approving Authority's representatives. The supplier shall provide all facilities to the authority without any charge to satisfy the latter that the material is being furnished in accordance with this specification. The supplier shall prepare and provide necessary test specimens for testing to be carried out at his premises. If testing facilities for any test are not available at his premises, the supplier

shall make necessary arrangements for carrying out that test at outside laboratories, either reputed or Govt. approved. The supplier shall notify in advance about readiness of the material for inspection and testing.

In case of any change in the material or design, the complete type tests shall be repeated.

If the product is proved to be successful during type testing, at least two motors shall be manufactured with the insulating materials offered for type test and temperature rise test shall be conducted to see suitability of the materials for making the coils and also performance of the motors will be examined in practical condition.

9.1.1 Field Trial:

After successful completion of type tests and temperature rise test, required quantity of the insulating materials shall be subjected to field trials for specified time period. The required Quantity and Period for field trials shall be governed by Vendor Directory on UVAM.

Performance feedback of the motors manufactured with the insulating materials shall be furnished by User Railways in the following format:

S. No.	Name of Insulating Tape	Armature No.	Magnet Frame No.	Fitted on Loco No.	Qty. Used	Dispatched Date	Shed	Date of fitment in loco	Date of Failure, if any	Remarks regarding performance

9.2 Routine Tests:

Routine tests shall be carried out by the manufacturer on all finished products on lot basis to ensure consistency of the product. The supplier shall maintain records of Routine test results. These results shall be handed over to the purchaser before dispatch the materials to Rlys. Vendor Approving Authority may however, carry out these tests on samples sealed at random as per the relevant specification to verify the results observed by the manufacturer.

The Routine test schedule shall be constituted of all those tests marked as Routine Tests in **Table – 2**.

9.3 Acceptance Tests:

Acceptance tests shall be carried out on samples selected randomly from a lot ready for dispatch for the purpose of acceptance of the lot by the purchaser or any other inspecting agency nominated by the purchaser as per the tests marked as acceptance tests in **Table – 2** and Sl. no. 3.0(Porosity) & 4.0(Impregnation time) of **clause no. 4.1** of the specification.

The supplies offered for inspection shall be considered to be satisfactory and acceptable, if all the test results are within acceptable limits and statistically satisfactory.

If any of the test results does not meet the requirements, the whole tests shall be repeated on other samples selected again.

If the results of the repeated tests are not found within acceptable limit, the entire supplies shall be rejected. The purchaser shall have however the right to reject the supplies in full or in part.

If the results of the repeated tests are found within acceptable limit, the supplies shall be considered to be acceptable.

10.0 TEST CERTIFICATES:

Unless otherwise stated, three copies of test certificates shall be supplied along with each consignment bearing the following information:

- RDSO Specification no. -----
- Railway's purchase order no. -----
- Manufacturer's / Supplier's name -----
- Trade mark / Grade, if any -----
- Batch/Lot no. -----
- No. of rolls supplied and length per roll -----
- Date (Month & Year) of manufacture -----
- Date (Month & Year) of Expiry -----
- Test results -----

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

11.0 PACKING:

Silicone Resin Bonded Kapton / Apical or equivalent Polyimide backed Mica paper tape shall be supplied in rolls wound on cores with both sides well protected so as to prevent from distortion and damage of the rolls during transportation, handling & storage and from deterioration due to climatic condition. Rolls shall be wrapped in such manner that they will not stick to each other and also to the container.

Rolls without inter-leaving shall be supplied. If mica is found to be sticking to the adjacent layers to the extent that part of mica is getting lost from tape, then rolls shall be rejected.

The individual roll of the same thickness, width and length shall be individually packed in polyethylene to ensure that these can be easily separated and are protected from moisture, dust, direct sunlight and damage during transit.

The tape in the form of rolls packed in polyethylene bags should be kept in a suitable container to prevent damage during transit. Containers should be kept in suitable carton so that it may not get damaged during transportation. After the tape is received, it should immediately be transferred to the consignee's cold storage (not cooled by air-conditioners), which should run and maintain specified temperature continuously 24 hrs. without stopping after office hours & holidays and a log book should be maintained to monitor the temperature of the cold storage.

12.0 MARKING:

12.1 Each roll of the tape shall be clearly and legibly marked with the following information: -

- a) Manufacturer's / Supplier's name -----
- b) Type of tape / Designation / trade-mark, if any -----
- c) Length of roll, in meters -----
- d) Thickness and width of tapes, in mm -----
- e) Date (Month & Year) of manufacture -----
- f) Date (Month & Year) of expiry -----
- g) Batch No/lot No.-----

12.2 Each transit pack containing number of rolls shall have following information, clearly and indelibly marked on it: -

- RDSO specification no. -----
- Railway's purchaser order no. -----
- Manufacturer's / Supplier's name -----
- Type of tape/Designation/trade-mark, if any -----
- Batch/Lot No. -----
- Length of roll, in meters -----
- Thickness and width of tapes, in mm -----
- No. of Rolls & meters supplied -----
- Date (Month & Year) of manufacture -----
- Date (Month & Year) of expiry -----
- Condition of Storage & Preservation -----

13.0 PREFERENCE TO MAKE IN INDIA

The Government of India policy on 'Make in India' shall apply.

TEST METHODS & ACCEPTABLE CRITERIA**Table – 2**

S.No.	Tests	Type Test	Routine Test Per Lot	Acceptance Test Per Lot	Instruments	Test Methods	Acceptable Criteria
1.0	Thickness (mm)	√	√	√	Micrometer	IEC 60371-2, Cl. 3	0.10+0.02 -0.03
2.0	Width (mm)	√	√	√	Vernier Caliper / Scale	-----	25.0 ± 0.5
3.0	Total Substance (gm/m ²)	√	√	√	Electronic Balance	IEC 60371-2, Cl. 6	120 ± 15
4.0	Mica content (%)	√	√	√	•Electronic Balance •Muffle Furnace	IEC 60371-2, Cl. 6	56 ± 4
5.0	Binder Content (%)	√	√	√	•Electronic Balance •Muffle Furnace	IEC 60371-2, Cl. 6	10 ± 3
6.0	Tensile Strength (Kg/cm)	√	√	√	Tensile Tester	IEC 60371-2, Cl. 7	4 (min.)
7.0	Electrical Strength (BDV), KV / layer (min.)	√	√	√	BDV Testing m/c	IEC 60371-2, Cl. 15	Av. ≥ 5.5 Ind. ≥ 4.5 Av. ≥ 5.5 Ind. ≥ 4.5
	ii) After heat aging at 220 C, 1Hr.	√	√	√	BDV Testing m/c	IEC 60371-2, Cl. 15	
8.0	Temp. Index	√	-----	-----	TGA Analyser	IEC 60216 / TGA Method (As per Annexure – A)	Min. 200
9.0	Type of Binder	√	-----	-----	FTIR	Infra-red Spectrograph or Any Standard method	Silicone
10.0	Stiffness	√	-----	-----	-----	IEC 60371-2, Cl.10	40 N/m (Max)

Annexure – A

PROCEDURE TO DETERMINE RELATIVE TEMPERATURE INDEX BY TGA (THERMOGRAVIMETRIC ANALYSIS) METHOD

1.0 PROCEDURES

Heating rate – 1°C per minute
 Sample configuration – Cubical
 Atmosphere – Air
 Degree of cure – As per recommendation of the supplier
 Sample size – 10-20 milligrams
 Interpretation – By tangential technique and 50% loss criterion

2.0 INTERPRETATION OF TEST RESULT

2.1 Determination of factor X using standard Polyimide film of temperature index (Ti = 240) or Known value as reference.

2.1.1 Draw a thermogram in the TG equipment available in the laboratory as per procedure described in **Clause 1.0**.

2.1.2 Using 100% loss point as reference point, a tangent is drawn along the steep portion of the curve. Another tangent is drawn from the point at which curve deviates from its initial straight line. The point of intersection 'A' is the temperature at which decomposition starts.

2.1.3 The intercept of the curve at 50% weight loss 'B' arbitrarily picked up. A rectangle is now formed, ½ the difference between A and B is added to A, to correct for the slope of steep portion. (See curve)

2.1.4 With the above, calculate Factor X as under:

$$\frac{A + \frac{1}{2} (B - A)}{X} = 240$$

$$\text{Or, } X = \frac{A + \frac{1}{2} (B - A)}{240}$$

Note: The factor X shall be applicable for use to determine relative temperature index of any other materials e.g. Silicone varnishes, epoxy varnishes etc., in the equipment available in the particular laboratory.

3.0 CALCULATION OF RELATIVE THERMAL INDEX OF AN INSULATING MATERIAL

$$\text{Rating Index} = \frac{A + \frac{1}{2} (B - A)}{\text{Factor X}}$$

