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MINISTRY OF RAILWAYS

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के लिए
तकनीकी विशिष्टि

TECHNICAL SPECIFICATION
FOR
INTER TURN CERAMIC SHEET
USED ON TRACTION MOTORS OF DIESEL ELECTRIC LOCOMOTIVES

विशिष्टि संख्या चा0 श0.0.२४.00.३५ (संशोधन-0२)

अक्टूबर, २०२३

SPECIFICATION No. MP.0. 24.00.35 (REV.-02)
OCTOBER, 2023

अनुसंधान, अभिकल्प एवं मानक संगठन

मानक नगर, लखनऊ - २२६ ०११

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LIST OF AMENDMENTS:

Sl. No.	Amendment date	Revision	Reasons for amendment
1.	April-2005	00	First issue
2.	August-2005	01	Second issue
3.	October - 2023	02	Addition of LIST OF AMENDMENTS
			Addition of INDEX
			"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"---Added at Para 4.2. Supplier's name for Silicone resin at Para 4.2 deleted.
			"RDSO" is replaced by 'Vendor Approving Authority' at Para 5.0, 9.1, 9.2.
			At Para 9.1, type tests in every three years & at the time of upgradation has been deleted.
			New Para 9.1.1 Field trial has been added
			New Para 13. PREFERENCE TO MAKE IN INDIA has been added.

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Technical Specification for INTER TURN CERAMIC SHEET used on Traction Motors of Diesel Electric Locomotives

1.0 SCOPE:

This specification covers the technical requirements of ceramic paper sheet impregnated with silicone resin to be used as high temperature materials for inter layer insulation between adjacent turns of stator coils. This ceramic sheet shall be characterized by outstanding resistance to normal aging and the ability to withstand high operating temp., heat shock and electrical degradation. The sheet shall be cured to tack free B – stage. The composite insulation produced after pressing and curing shall have temperature index of at least 200.

2.0 APPLICATION:

This material shall be used for inter turn insulation between adjacent layers of stator coils (main pole & inter pole coils) in 200 class 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		
	Main Pole	Inter pole		Thickness (mm)	Width (mm)	Length (m)
0.15	440	400	30	±0.03	± 2.0	+ 1.0 - 0.0

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 Ceramic Paper:

Ceramic paper of QUIN-T / IPI-T having grade CeQuin I & 0.13 mm thick shall be used. This material shall be characterized by outstanding resistance to normal aging and the ability to withstand high operating temp., heat shock and high electrical insulation.

Basic properties of Ceramic paper as given below shall be met during type testing:-

Sl. No.	Properties	Test Method	Unit	Specified Values
1.0	Thickness	ASTM D – 374	mm	0.13 (Max.)
2.0	Basic Weight	ASTM D – 202	Kg/m^2	0.12 (Max.)
3.0	Tensile Strength	ASTM D – 828	KN/m	1.0 (Min.)

4.2 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.

Silicone resin shall meet the following properties 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	-	2.9 (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	Binder content
(g/m^2)	(%)
190 ± 25	29^{+5}_{-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 27deg.C for 24 hrs. and it should also not show any sign of deterioration like swelling, becoming hard & porous for a period of at least Shelf life.

6.2 Flexibility:

The sheet shall be sufficiently flexible. When wound on a 18 mm dia. mandrel at room temperature, there shall be no sign of cracks in the sheet.

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 15 ± 3 deg. C, 12 months, minimum.

The storage life depends upon storage temperature. For prolonged life, the rolls 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 15 ± 3 deg. C for 12 months (min.) after the date of manufacturing.

The sheet should be taken out from refrigerator/cold storage 24 hrs. in advance before application, so that the roll 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 sheet and sheet will be saved. If it comes in contact with water, the water will damage the sensitive chemicals of the resin inside the rolls.

9.0 TESTS & INSPECTION AT SUPPLIER'S WORKS:

9.1 Type Test:

Type tests shall be conducted on the prototype samples as per tests mentioned in **Table – 2** and **clause Nos. 4.1 & 4.2.** 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 out side 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 despatch for the purpose of acceptance of the lot by the purchaser or any inspecting agency nominated by the purchaser as per the tests marked as acceptance tests in **Table – 2**. The supplies offered for tests 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:

Inter turn Ceramic Sheet 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 adhere to each other and also to the container. A suitable grade of plain polythene of non-conducting materials can be used as an inter-leaving between the turns on the tape.

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 sheet in the form of rolls packed in polyethylene bags should suitably be kept in a heat resistant thermocol boxes having wall thickness of minimum 25 mm and having dry ice (Frozen carbon dioxide gas) inside the thermocol boxes. The boxes shall be suitable to maintain the temperature below 20°C. Thermocol boxes should be kept in suitable carton so that it may not get damaged during transportation. After the sheet 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 logbook should be maintained to monitor the temperature of the cold storage.

12.0 MARKING:

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

a) Manufacturer's /Supplier's name ---------
b) Type of sheet/Designation/trade-mark, if any -------
c) Length of roll, in meters -------
d) Thickness and width of sheets, 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 sheet/Designation/trade-mark, if any -------
- Batch/Lot No. ---------
- Length of roll, in meters -------
- Thickness and width of sheets, 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 CRITARIA

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	0.15±0.03
2.0	Width (mm)	√	√	√	Vernier Caliper / Scale	----------	400/440±2
3.0	Total Substance (gm/m²)	√	√	√	Electronic Balance	IEC 60371-2, Cl. 6	190 ± 25
4.0	Xylene test	√	√	√	----------	As per Annexure –1	95% min should be dissolved
5 .0	Resin Content (%)	√	√	√	•Electronic Balance •Muffle Furnace	IEC 60371-2, Cl. 6	29 + 5 - 3
6.0	Tensile Strength						
	I) Before curing	√	√	√	Tensile Tester	IEC 60371-2, Cl. 7	3.5Kg/2.5cm
	II) After curing at 200ºC for 1 Hr.	√	√	√	Tensile Tester	IEC 60371-2, Cl. 7	6.7Kg/2.5cm
7.0	Electrical Strength (BDV), KV (min.)						
	I) Before curing(single layer)	√	√	√	BDV Testing m/c	IEC 60371-2, Cl. 15	Av. = 1.0 Min.= 0.8
	II) After curing(double layer) (Preparation of double layer specimen as per Annexure – 2)	√	√	√	BDV Testing m/c	IEC 60371-2, Cl. 15	Min. = 3

TEST METHODS & ACCEPTABLE CRITARIA

Table – 2 (continued)

S.No.	Tests	Type Test	Routine Test Per Lot	Acceptance Test Per Lot	Instruments	Test Methods	Acceptable Criteria
8.0	Temp. Index	√	-------	--------	TGA Analyser	IEC 60216 / TGA Method (As per Annexure – A)	Min. 200
9.0	Adhesive strength (Kg/cm²)	√	√	√	Tensile Tester	As per Annexure –3	15 (min)
10.0	Type of binder	√	-------	--------	FTIR	Infra-red Spectrograph Or any standard method	Silicone
11.0	Stiffness	√	-------	--------	----------	IEC 60371-2, Cl. 10	40 N/m(Max)

Annexure – 1

PROCEDURE FOR "XYLENE TEST"

1.0 Cut 100 mm x 100 mm sheet from the sheet and weigh (W1).

2.0 Put the sheet in a clean 500 ml glass beaker filled with Xylene solvent at room temperature. Care shall be taken to immerse the test piece completely in the Xylene solvent.

3.0 Stir the test piece time to time and allow the test piece to remain in the Xylene solution for one hour.

4.0 Remove the test piece from Xylene solvent and again dip in clean beaker containing pure Xylene solvent. Stir the test piece for one minute and remove from the Xylene solvent. Dry in the oven at 140 ± 5 deg. C for 10 minutes.

5.0 Allow to cool in a dessicator and weigh (W2).

6.0 $$\% \text{ Resin solubility} = \frac{W1-W2}{W1} 100.$$

Where W1 is the initial weight of the test specimen.

And W2 is the weight of the dried test specimen dipped in Xylene solvent for one hour.

ANNEXURE – 2

PROCEDURE TO PREPARE DOUBLE LAYER SPECIMEN OF INTERTURN CERAMIC SHEET FOR BDV TEST AFTER CURING

1.0 Take two pieces of 'B' stage inter turn ceramic sheets 150 mm x 150 mm and place one over another.

2.0 Now the sample specimen is put in between two release sheets.

3.0 Take two sheets of the cushioning pad, - one is placed on the top and the other in the bottom of the sample specimen.

4.0 The whole assembly is placed between hydraulic press and pressed at 180 deg. C for one hour under pressure 10-15 Kg/cm2.

Or

The whole assembly is placed between hydraulic press and pressed at 220 deg. C for 5 minutes under pressure 30 Kg/cm2.

5.0 The sample specimen is allowed to cool under pressure and then removed from the press to determine Breakdown Voltage (BDV).

Annexure-3

Testing Procedure for Adhesive Strength of Inter turn Ceramic Sheet with copper plate :

1.0 Take two copper plates of approximate size: 15mm x 175mm x 2mm.
2.0 Clean the Cu plates with sand paper and toluene to remove any dirt/foreign material stuck.
3.0 Cut the two pieces of sample specimen of B-stage product of size: 15mm x 15mm.
4.0 Place the two sample specimen on the edge of the cleaned copper plate.
5.0 Place the other Cu plate on the sample specimen with the clean surface facing the specimen on the opposite side of the first Cu plate.
6.0 Hold the plates at the overlapped area of 15mm x 15mm with pressure sensitive polyimide film tape.
7.0 Subject the overlapped area to a pressure of total 40 Kg load in a press and cure at temperature of 180ºC for 6 hours.
8.0 Cool under pressure to room temperature and remove the specimen from the press.
9.0 The cooled plates are clamped in Tensile Tester jaws at equidistant points approx. 5 " from the overlapping area after choosing the required load.
10.0 The moving jaw of the tensile tester shall be operated to move down at a speed of 30 cm/min.
11.0 The force required to separate the bond shall be read on corresponding scale when the bond opens.
12.0 Calculate the Adhesive Strength in Kg/cm².

OR

1.0 Take two copper plates of approximate size: 25mm x 100mm x 2mm.
2.0 Clean the Cu plates with sand paper and toluene to remove any dirt/foreign material stuck.
3.0 Cut one piece of sample specimen of B-stage product of size: 10mm x 10mm.
4.0 Place the sample specimen on the edge of the cleaned copper plate.
5.0 Place the other Cu plate on the sample specimen with the clean surface facing the specimen on the opposite side of the first Cu plate.
6.0 Hold the plates at the overlapped area with pressure sensitive polyimide film tape.
7.0 Subject the overlapped area to a pressure of total 30 Kg/cm2 load in a press and cure at temperature of 220ºC for 5 minutes.
8.0 Remove the plates from the press and cool to room temperature.
9.0 The cooled plates are clamped in Tensile Tester jaws separated by approx. 5 " from each other after choosing the required load.
10.0 The moving jaw of the tensile tester shall be operated to move down at a speed of 30 cm/min.
11.0 The force required to separate the bond shall be read on corresponding scale when the bond opens.
12.0 Calculate the Adhesive Strength in Kg/cm².

Annexure – A

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

1.0 PROCEDURES

Heating rate – 1ºC 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 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 the steep portion. (See curve).

2.1.4 With the above, calculate Factor X as under:

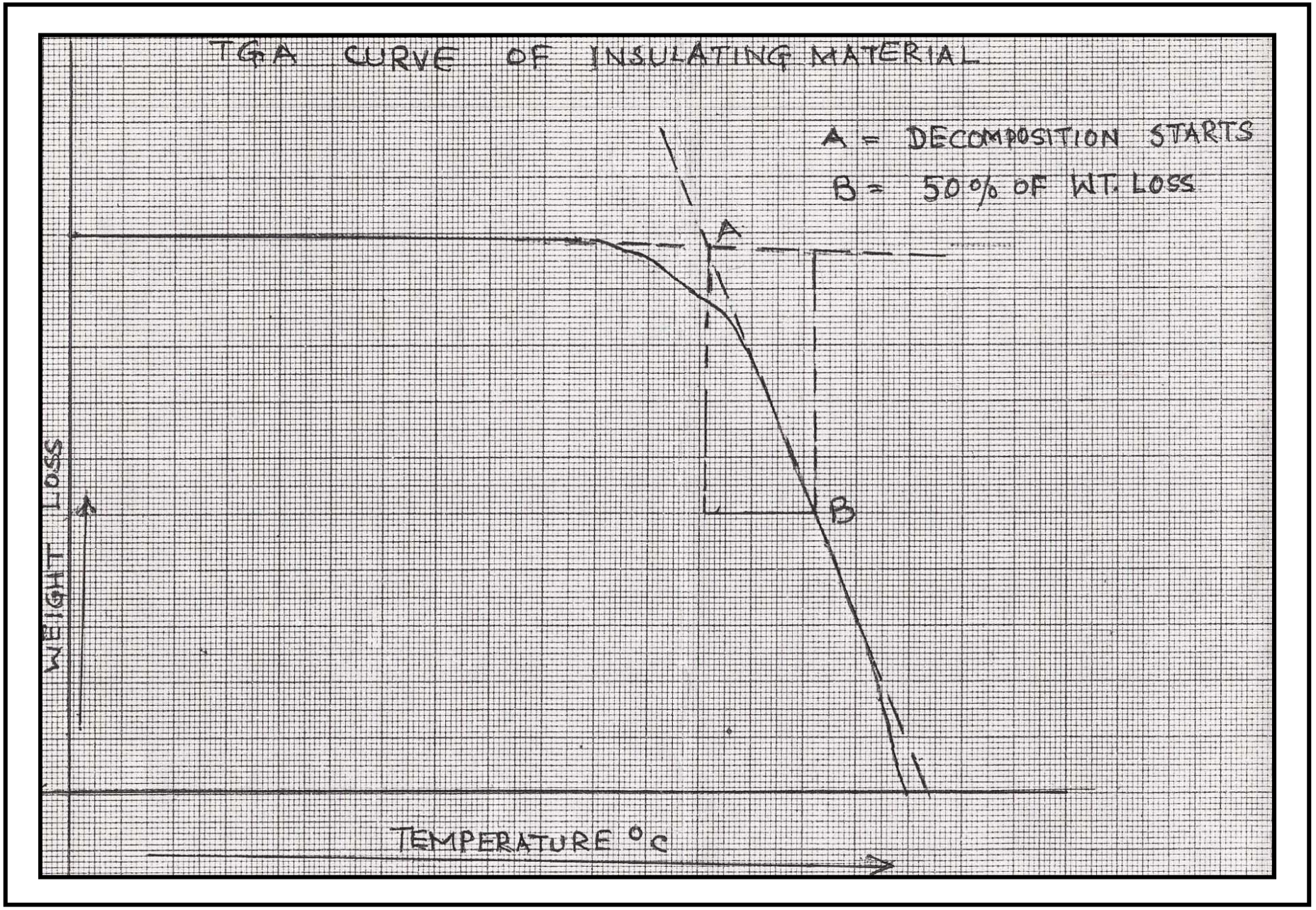
$$\frac{A + ½ (B – A)}{X} = 240$$

$$\text{Or, } X = \frac{A + ½ (B – A)}{240}$$

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

3.0 CALCULATION OF RELATIVE THERMAL INDEX OF AN INSULATING MATERIAL:

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


TGA CURVE OF INSULATING MATERIAL
A = DECOMPOSITION STARTS
B = 50% OF WT. LOSS
A
B
WEIGHT LOSS
TEMPERATURE °C