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TECHNICAL SPECIFICATION FOR THE SUPPLY OF INSULATED ELECTRIC CABLES FOR RAILWAY VEHICLES

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REVISIONS

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Amendment		Amendment	
No.	Date	No.	Date

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1 - SUBJECT

1.1 - Scope

These specifications govern the supply of electric cables insulated and protected in elastomer or plastomer, which are intended to be fitted to all types of powered and hauled rolling stock.

These specifications are:

- of an obligatory nature for new stock built after 1-7-76,

- of a recommandatory nature for other stock.

1.2 - Terminology

In these specifications, the following specialized terminology is used:

- Core : central metallic part of a conductor which carries the current. A core is said to be twisted when it consists of several threads (or wires) assembled by twisting in such a way as to form one or more strands or twists.

- Strand : set of mechanically intertwined wires forming a helix of one or more layers.

- Twist : set of mechanically intertwined wires forming a helix in one direction.

- Insulation : continuous covering of the core intended to insulate it electrically.

- Sheathing : continuous covering round the outside of a conductor intended to protect its basic elements from external detoriation.

- Single insulation : continuous covering on the core, which has the dual function of protecting and insulating the conductor core.

- Separator : a secondary element of plastic tape or textile fibre between the various primary elements which form part of the conductor.

- Conductor : assembly formed by the core and the various coverings surrounding it which help to insulate and protect it.

1.3 - Classification

Conductors are classified according to the nominal voltage in use (in relation to earth) in three series:

- The 750-volt series

- The 1500-volt series

- The 3000-volt series

These nominal voltages correspond to the maximum voltages in use (d.c. or a.c.) laid down in UIC leaflet 619.

In addition there are three categories (I, II and III) for each conductor series :

- Category I, is intended for fitting to those vehicles parts not exposed to the action of mineral oil or liquid fuels,

- Category II , is intended for fitting to those vehicle parts exposed to the action of mineral oil, but not liquid fuels,

- Category III , is intended for fitting to those vehicle parts exposed to the action of mineral oil and liquid fuels.

Each of these conductor categories is sub-divided into two groups :

- Group A includes conductors designed for a working core temperature not exceeding 70° C,

- Group B includes conductors provided for a working core temperature not exceeding 100° C.

Finally, there are two types of conductor of increasing resistance to fire, depending on their behaviour in the presence of flames :

- type 1, resistant to the spread of flames,

- type 2, of fire - resisting capacity.

1.4 - Designation

The conductors covered by these specifications are designated in accordance with national standards in force in the countries of Member Railways.

2 - REQUIRED CHARACTERISTICS

2.1 - Composition

Cables covered by these specifications shall consist of:

- a core of circular cross-section,

- an optional separator around the core

- insulation on the core ,

- an optional separator around the insulation,

- protecting sheathing on the insulation.

It must be possible to replace the insulation and sheathing of the cable by single insulation combining the functions of electrical insulation and protection against external agents.

The core of the conductors shall be twisted in simple or complex strands or in twists and, depending on the nature of the equipment, it must conform to flexibility class 5 or 6, as defined in IEC publication No. 228,

- Class 5 for flexible conductors,

- Class 6 for extra-flexible conductors .

The number of wires, strands or twists in the conductors depends on the nominal sectional area and the class of flexibility to which these conductors belong. It must conform to the requirements set out in Table 1.

The Railways shall be free to decide whether to insert a separator between the core and the insulation. A separator is recommended when the core is not plated. If there is a separator, it shall be coloured.

Insulation should be closely fitted to the core in a single layer. If there is no separator, the insulation's degree of adhesion to the core must be low enough to prevent any difficulties when separating these two elements by hand.

The Railways shall be free to decide whether to insert a separator between the insulation and sheathing.

The protective sheathing shall be closely fitted to the insulation. Even if there is no separator, it must have a degree of adhesion to the insulation low enough to prevent any difficulties when separating these two elements by hand.

If single insulation is used, it shall be fitted tightly to the core. As with ordinary insulation, the degree of adhesion must be low enough to prevent any difficulties when separating the two elements by hand, when the optional separator is not used.

2.2 - Characteristics of the core

2.2.1 - Nature of the metal

The metal used for the core of the conductor shall be annealed copper in the form of bare wires.

At the Railway's request, the copper wires can be plated before use. In this case, the tin layer must be adherent, homogeneous, continuous and free from globules.

2.2.2 - Geometrical characteristics

The wires forming the core of the conductor must have the same nominal diameter.

The maximum diameter of the wires and the recommended size of the nominal cross-sectional area must correspond to the provisions laid down in table 1, depending on their flexibility classes.

The cabling pitch of the wires forming the outer layer of a simple strand or twist must not be more than 20 times the nominal diameter of the core . In the case of cores with a complex strand, the total cabling pitch of the simple strands or twists, based on the outer layer of the complex strand, must not be more than 20 times the nominal diameter of the core.

2.2.3 - Ohmic resistance

Depending on their nominal cross-sectional area and flexibility class, the ohmic resistance / unit length of the core of the conductor at a temperature of 20° C must not exceed the values laid out in table 1, which conform to IEC Publication 228.

In addition the ohmic resistance must not be less than 87% of the specified corresponding value.

TABLE 1 - COMPOSITION AND OHMIC RESISTANCE OF THE CORE
(according to IEC Publication 228)

Nominal area in mm2			0,5	0,75	1	1,5	2,5	4	6	10	16	25	35	50	70	95	120	150	185	240	300	400	500
Class 5 very flexible	Number of wires (1)		16	24	32	30	50	56	84	80	126	196	276	396	360	475	608	756	925	1221	1525	2013	1769
	Composition (n x t) (1)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	19×32	27×28	37×25	37×33	61×25	61×33	61×29
	Maximum diameter of wires in mm		0,21	0,21	0,21	0,26	0,26	0,31	0,31	0,41	0,41	0,41	0,41	0,41	0,51	0,51	0,51	0,51	0,51	0,51	0,51	0,51	0,61
	Nominal diameter of wires in mm (1)		0,20	0,20	0,20	0,25	0,25	0,30	0,30	0,40	0,40	0,40	0,40	0,40	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,60
	Maximum resistance at 20° C in Ohm/km	Bare wires	37,1	24,7	18,5	12,7	7,60	4,71	3,14	1,82	1,16	0,743	0,527	0,368	0,259	0,196	0,153	0,123	0,101	0,0763	0,0611	0,0463	0,0366
		wires coated with a metallic layer	38,2	25,4	19,1	13,0	7,82	4,85	3,23	1,85	1,18	0,757	0,538	0,375	0,264	0,200	0,156	0,126	0,103	0,0778	0,0623	0,0472	0,0373
Class 6 extra flexible	Number of wires (1)		28	42	56	85	140	228	189	324	513	783	1107	702	999	1332	1702	2109	2590	3360	4270	-	-
	Composition (n x t) (1)		-	-	-	-	7×20	12×19	7×27	12×27	19×27	27×29	27×41	27×26	37×27	37×36	37×46	37×57	37×70	48×70	61×70	-	-
	Maximum diameter of wires in mm		0,16	0,16	0,16	0,16	0,16	0,16	0,21	0,21	0,21	0,21	0,21	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	-	-
	Nominal diameter of wires in mm (1)		0,15	0,15	0,15	0,15	0,15	0,15	0,20	0,20	0,20	0,20	0,20	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	-	-
	Maximum resistance at 20° C in Ohm/km	Bare wires	37,7	25,1	18,8	12,4	7,54	4,63	3,14	1,83	1,16	0,758	0,536	0,376	0,264	0,198	0,155	0,125	0,102	0,0785	0,0618	-	-
		wires coated with a metallic layer	38,8	25,8	19,4	12,8	7,76	4,76	3,23	1,88	1,19	0,780	0,552	0,387	0,272	0,204	0,159	0,129	0,105	0,0808	0,0636	-	-

(1) The compositions and nominal diameters given are those from which the presented maximum ohmic resistance values at 20° C have been calculated. Compositions (in particular the number of wires) given as a guide, are recommended.

n = number of strands

t = number of wires per strand

2.3 - Characteristics of the insulation, sheathing, single insulation and separators (if any)

2.3.1 - Geometrical characteristics

The Railways shall be free to choose the thickness of sheathing and single insulation.

The mean value of the thicknesses on the insulation, sheathing and single insulation must not be less than the specified nominal value. Moreover, the thickness at anyone point can be less than the specified value, provided that the difference is not over:

- 0,1 mm + 10 % of the specified value for the insulation i.e.:

$$e_n - e_r \leqslant 0{,}1 \text{ mm} + \frac{10}{100} e_n$$

- 0,1 mm + 15 % of the specified value for sheathing and single insulation, i.e.:

$$e_n - e_r \leqslant 0{,}1 \text{ mm} + \frac{15}{100} e_n$$

where e_r is the thickness given in mm

e_n is the specified nominal thickness, in mm

2.3.2 - Mechanical characteristics

Whatever their category, the insulation, sheathing or single insulation of cables must be elastic and have appropriate mechanical strength.

In particular, their ultimate breaking strength and their corresponding elongation must not be less than the values specified below:

	Ultimate breaking strength in daN/cm^2	Elongation at rupture in %
Insulation	50	250 %
Single insulation or sheathing	100	250 %

2.3.3 - Physical and chemical characteristics

2.3.3.1 - Heat resisting capacity

Any change in the mechanical and elastic characteristic of insulation and sheathing or single insulation after subjection to heat must be limited, irrespective of the category index of the conductor.

In particular, after subjection to heat (7 days at 100° C for category A conductors, or 10 days at 120° C for category B conductors under the test conditions laid down in § 5.2.2.3., any variation in the ultimate breaking strength must be less than 20% of the values noted as ready for submission, and variation in the corresponding relative elongation must be less than:

- 30 % for category A conductors
- 40 % for category B conductors.

In this latter case, elongation after ageing must be at least equal to 200 %.

2.3.3.2 - *Resistance to ozone*

Whatever category they belong to, insulation, sheathing, or single insulation must have a resistance to ozone such that, under the test conditions laid down in § 5.2.4, no crazing or cracks appear after immersion of 3 hours in an atmosphere with an ozone concentration of between 0,025 % and 0.030 % in volume.

2.3.3.3 - *Resistance of sheathing or single insulation of conductors in categories I and II to mineral oil.*

It must be possible for sheathing or single insulation of conductors to be immersed in mineral oil over long periods without there resulting an excessive change in their geometrical and mechanical characteristics.

In particular, after immersion in oil No 2 (described in § 4.3.2.2) for 70 h at 100°C, under the test conditions laid down in § 5.2.3 and 5.2.2.4, variation in volume must be less than 20 % of the initial volume. Furthermore, variation in the ultimate breaking strength must be less than 30 % of the values noted as ready for submission, and variation in the corresponding relative elongation less than 40 %.

2.3.3.4 - *Resistance of sheathing or single insulation of conductors in category II to liquid fuel.*

It must be possible for sheathing or single insulation of conductors in category II to be immersed in the liquid fuels to which they may be exposed in ordinary service, without there resulting an excessive change in their characteristics.

In particular, after immersion in the liquid fuel described at § 4.3.3.2 for 168 hours at 70 °C under the test conditions laid down in § 5.2.3 and 5.2.2.4, variation in volume must be less than 20 % of the initial volume. Furthermore, variation in ultimate breaking strength must be less than 30 % of the values noted as ready for submission, and variation in the corresponding relative elongation must be less than 40 %.

2.3.3.5 - *Insulation resistance of insulation (conductors in the 3000-volt series)*

At room temperature (20 ± 5°C) the transversal resistivity of the insulation of conductors in the 3000 volt series, as calculated from the insulation resistance under the conditions laid down in § 5.2.5, must be more than 10^{15} Ω cm.

2.3.3.6 - *Longitudinal di-electric rigidity of the separators used*

When the conductor contains a separator inserted between the insulation and the sheathing, the separator must be of sufficient di-electric strength. In particular, there must be no break-down, under the test conditions laid down in § 5.2.6, with an alternating current of 12 kV maintained for 30 seconds.

2.4 - Characteristics of conductors as ready for delivery

2.4.1 - Geometrical characteristics

The Railway shall be free to choose the external diameter of the conductors.

Conductors must be cylindrical. In particular, the difference between any two conductor diameters measured at the same section must not be more than 15 % of the upper limit laid down for the diameter.

2.4.2 - Mechanical characteristics

Conductors must be capable of the deformations they are destined to undergo in service, without any change in their mechanical characteristics. In particular, it must be possible for the conductors to be coiled several times in succession around a mandrel without any change in their di-electric strength under the test conditions laid down in § 5.3.2.

2.4.3 - Electrical characteristics

2.4.3.1 -Transversal di-electric strength

Conductors must have sufficient transversal di-electric strength to ensure efficient functioning of equipment under ordinary operating conditions.

In particular, under the test conditions laid down in § 5.3.3., conductors must be able to withstand a test voltage at a frequency of 50 Hz for 15 minutes without any perforation. The effective values shall be as follows:

Conductor series	Voltage applied
750 V	2 kV
1 500 V	6 kV
3 000 V	12 kV

2.4.3.2 - Disruptive discharge

Under the test conditions laid down in § 5.3.3., there must be no disruptive discharge within ranges of voltage laid down below, for each conductor series.

Conductor series	Voltage applied
750 V	6 kV
1 500 V	16 kV
3 000 V	20 kV

2.4.3.3 - Longitudinal di-electric strength

Conductors must have protective sheathing which is sufficiently insulating to prevent serious leakage currents from developping or sparks jumping.

In particular, under the test conditions laid down in § 5.3.3. sheathing of conductors must have a longitudinal di-electric strength such that the measured intensity of the leakage current does not exceed that laid down in the table below:

Cross sectional area of conductor (mm^2)	Permissible maximum intensity of leakage current (mA)
$\leqslant$ 2.5	5
4 - 16	7.5
25 - 95	10
120 - 400	20

Furthermore, in all cases considered above, and irrespective of the conductor area, the arc-over voltage must not be less than 10 kV.

2.4.3.4 - Stability of insulation to humidity

Insulation of the conductors must be sufficiently stable in conditions of humidity to ensure efficient functioning of electrical equipment under ordinary operating conditions.

In particular, conductors immersed in an aqueous sodium chloride solution, under the test conditions laid down in § 5.3.3.5., must be able to withstand a D.C. voltage as stipulated in the table below, depending on the series to which they belong, without there occurring any disruptive discharge.

Conductor series	Voltage applied (d.c.)
750 V	1 000 V
1 500 V	1 800 V
3 000 V	3 600 V

2.4.4 - Physical and chemical characteristics

2.4.4.1 - Resistance to compression

Conductors must be sufficiently resistant to the compression they may be subjected to under ordinary operating conditions.

In particular, in the test conditions laid down in § 5.3.4.1., sheathing or single insulation of conductors must be able to withstand a load for prolonged periods without their thickness at the point of imprint being less than 50 % of the mean thickness recorded at two other points which are not compressed, near the imprint. For category A conductors this shall be at temperatures of 70 ± 2° C, and for category B conductors, at 100 ± 2° C.

2.4.4.2 - Resistance to cold temperatures

The insulation, sheathing or single insulation of conductors must be able to withstand prolonged periods of cold without change in their elastic and mechanical characteristics.

In particular, under the test conditions laid down in § 5.3.4.2.:

- conductors with a nominal diameter of at most 12.5 mm, must be capable of being coiled round a mandrel at a temperature of - 25° C without cracks visible to the naked eye appearing on the insulation, sheating or single insulation,

- conductors with a nominal diameter above 12.5mm must have corresponding basic elements (insulation, sheathing or single insulation) capable of undergoing a relative elongation of 20 % at - 25° C without cracks visible to the naked eye appearing.

2.4.4.3 - Resistance to fire

Conductors must be sufficiently uninflammable for fire not to be able to spread along them.

Distinction should be made between flame resisting capacity, which applies to all conductors and fire-resisting capacity, which only applies to type 2 conductors.

2.4.4.3.1 - Flame resistance

Under the test conditions laid down in § 5.3.4.3. possible combustion of conductors (whether type 1 or type 2) must be slow and its spread very gradual.

Any flame must extinguish of itself within 30 seconds of removal of the ignition source. When combustion has ceased, no carbonised or otherwise affected part must have reached the upper extremity of the sample.

2.4.4.3.2 - Flame retarding capacity

Furthermore, type 2 conductors must be able successfully to withstand the test set out in 5.3.4.4.

3 - MANUFACTURE

3.1 - Production of the basic components

The supplier shall have free choice of production method for the conductor components subject to compliance with the provisions governing conductor composition, as laid down in § 2.1 of the present specifications.

3.2 - Trademarks

The supplier's trademark must be shown on each cable, by means of an identification thread or by a seal, in line with the national standards of the Railway.

If the Railway so stipulates when the order is made, all cable lengths as ready for delivery must carry an indelible inscription on the outer surface of the sheathing or single insulation at intervals of no more than one meter, giving:

- series denomination
- flexible class (5 or 6)
- nominal cross-sectional area
- category, group and type
- manufacturer's trademark

Example: 1500-5-10mm^2-IB2-XYZ

4 - CHECKING CONDITIONS

4.1 - Supply presentation

Cables shall be presented as ready for delivery with their ends bare, in batches made up each of cable lengths, as ready for delivery, with the same composition (series, class, category), same nominal cross-sectional area and from the same manufacturing batch.

Each acceptance submission must be accompanied by a certificate from the manufacturer attesting that each of the batches satisfies the tests set out below.

This document must also give the date of submission, the order references and the consistency of supply. In particular, it will give the total length of conductors supplied, set out by series, category and nominal cross-sectional area.

4.2 - Nature and scale of checks and tests

Railways shall be free to decide on the number of series of tests or checks to be carried out according to the size of batches. The tests and checks to which conductors are submitted are set out in the table below, which also lists the relevant articles or paragraphs. All or some of these tests can be carried out each time a supply is submitted if the Railway so wishes.

Nature of checks or tests				Number of Test pieces per test	Form and size of test pieces
Checking of characteristics	Conductor category				
	I	II	III		
I - CORE OF CONDUCTORS					
- Composition	5.1.1	5.1.1	5.1.1		
- Geometrical characteristics	5.1.1	5.1.1	5.1.1	1	Section of cable 50 cm long
- Plating	5.1.3	5.1.3	5.1.3		
- Ohmic resistance per unit length	5.1.2	5.1.2	5.1.2	1	Section of cable at least 1 m long

Nature of Checks or tests				Number of Test pieces per test	Form and size of test pieces
Checking of characteristics	Conductor category				
	I	II	III		
II - INSULATING OR PROTECTING ELEMENTS OF CONDUCTORS					
Thickness:					
- of insulation	5.2.1	5.2.1	5.2.1	3	Section of conductors 60 cm long
- of sheathing or single insulation	5.2.1	5.2.1	5.2.1	3	
Tensile strength					
- as ready for submission					
a) of insulation	5.2.2.1	5.2.2.1	5.2.2.1	3	
b) of sheathing or single insulation	5.2.2.2	5.2.2.2	5.2.2.2	3	
- after exposure to heat					
a) of insulation	5.2.2.3	5.2.2.3	5.2.2.3	3	Test pieces H2, H3 or tubes taken from sections of conductor to determine thickness and cylindricity
b) of sheathing or single insulation	5.2.2.3	5.2.2.3	5.2.2.3	3	
- after immersion in oil No. 2 of sheathing or single insulation		5.2.2.4	5.2.2.4	3	
- after immersion in liquid fuel of sheathing or single insulation			5.2.2.4	3	

Nature of Checks or tests				Number of Test pieces per test	Form and size of test pieces
Checking of characteristics	Conductor category				
	I	II	III		
Variation in volume					
- after immersion in oil no. 2 of sheathing or single insulation		5.2.3	5.2.3	3	1 - 3 cm^3 tubular portion of the sheathing or single insulation of the conductor
- after immersion in liquid of sheathing or single insulation			5.2.3	3	
Resistance to ozone					
- of the insulation	5.2.4	5.2.4	5.2.4	2	Appropriate conductor length
- of the sheathing or single insulation	5.2.4	5.2.4	5.2.4	2	
Insulating resistance of insulation	5.2.5	5.2.5	5.2.5	1	5 m conductor section stripped of its sheathing
Di-electric strength of separator	5.2.6	5.2.6	5.2.6	1	150 mm conductor section
III - CONDUCTORS AS READY FOR DELIVERY					
Geometrical characteristics	5.3.1	5.3.1	5.3.1	1	The cable itself
Mechanical characteristics	5.3.2	5.3.2	5.3.2	1	Appropriate conductor section

Nature of checks or tests				Number of Test pieces per test	Form and size of test pieces
Checking of characteristics	Conductor category				
	I	II	III		
Electrical characteristics					
- *Transversal di-electric strength :*					
a) as ready for submission	5.3.3.2	5.3.3.2	5.3.3.2	1	The cable itself
b) after immersion in liquid fuel			5.3.3.2	1	3 m conductor section
- *Disruptive discharge test*					
a) as ready for submission	5.3.3.3	5.3.3.3	5.3.3.3	1	1 m conductor section
b) after immersion in liquid fuel			5.3.3.3	1	
- *Longitudinal di-electric strength*					
- as ready for submission	5.3.3.4	5.3.3.4	5.3.3.4	1	50 cm conductor section
- after immersion in liquid fuel			5.3.3.4	1	
- *Checking of the stability of the humidity insulation ;*					5 m conductor section
- as ready for submission	5.3.3.5	5.3.3.5	5.3.3.5	1	

Nature of checks or tests				Number of Test pieces per test	Form and size of test pieces
Checking of characteristics	Conductor category				
	I	II	III		
Physical and chemical characteristics					
- *Compressive strength at high temperatures*					
a) as ready for submission	5.3.4.1			6	1 m conductor section from which 6 tubes or 6 strips are removed as test pieces
b) after immersion in oil no. 2		5.3.4.1	5.3.4.1	6	
c) after immersion in liquid fuel			5.3.4.1	6	
- *Resistance to cold temperatures*					
- of insulation:					
after subjection to heat	5.3.4.2	5.3.4.2	5.3.4.2	2	
- of sheathing or single insulation					Appropriate conductor section (or 6 H2 test pieces)
a) after subjection to heat	5.3.4.2	5.3.4.2	5.3.4.2	2	
b) after immersion in liquid fuel			5.3.4.2	2	
- *Flame resistance*					
- as ready for submission	5.3.4.3			1	600 ± 25 mm test piece removed from a 700 mm (approx.) conductor section
- after immersion in oil No. 2		5.3.4.3		1	
- after immersion in liquid fuel			5.3.4.3	1	
- *Fire retarding capacity*					
- as ready for submission	5.3.4.4	5.3.4.4	5.3.4.4	1	Appropriate conductor section

4.3 - Test pieces

4.3.1 - Method of sampling and preparation of test pieces

The number, method of sampling and possibly preparation of samples, as well as the conditions governing preparation of test pieces are set out in these specifications according to the nature of the checks and tests.

Samples and test pieces, and the conductors from which they come, must retain the indelible identification marks affixed on them in accordance with the instructions of the Railway inspector.

Tests and checks to which conductors are subjected shall be carried out on test pieces as ready for submission, or on test pieces which have undergone preliminary processing.

4.3.2 - Processing of test pieces

4.3.2.1 - Subjection to heat

The samples or test pieces to be subjected to heat shall be exposed in an ordinary drying oven with air circulation, in accordance with the conditions laid down in Recommendation ISO/R 188. The length of exposure and the temperature shall be as follows:

- 168 hours ± 2 hours at 100 ± 1°C for Category A conductors or conductor sections ;
- 240 hours ± 2 hours at 120 ± 2°C for Category B conductors or conductor sections.

After this exposure, the samples or test pieces shall be removed from the stove and left at room temperature for at least 16 hours before being tested.

4.3.2.2 - Immersion in the reference liquids

Characteristics of the liquids

The reference liquids shall be:

- oil No. 2, which is defined in Recommendation ISO/R 1817. Its composition and characteristics are given below:

  - aniline point : 93 ± 3 °C

  - kinematic viscosity : $(20 \pm 2)\ 10^{-6}$ m2/s

  - flash point : > 240 °C

- liquid fuel with the following characteristics:

  - maximum viscosity at 20°C = 20 cst

  - boiling point: between 180° and 400°C

  - flash point: ⩾ 80°C

  - aniline point: 69,5 ± 1°C

  - no discernible trace of mineral acids in free state

  - sulphur content: 0,4 - 1,0 %

- Instructions for immersion in the liquids

The samples or test pieces to be tested with oil No. 2 or liquid fuel shall be immersed in these reference liquids in line with Recommendation ISO/R 1817, and under the following conditions:

- the volume of oil or liquid fuel must at least equal 15 times the volume of the samples or test pieces,

- the container must be closed so as to reduce evaporation of the liquid to a minimum, and be kept for:

  70 hours ± 1 hour at 100 ± 1°C for oil No. 2

  168 hours ± 2 hours at 70 ± 2°C for liquid fuel

Unless otherwise indicated, the test pieces or samples shall be removed from the bath after undergoing this process, allowed to drip, then dried superficially and left for at least 3 hours.

5 - CHECKING AND TESTING OPERATIONS

5.1 - Checking of the characteristics of the conductor core

5.1.1 - Checking of the composition of the core and its geometrical characteristics

Preparation of the test piece

The test piece shall consist of a conductor section some 50 cm long, removed from 1 length as ready for delivery. This conductor section shall be stripped of all insulating and protective elements.

Procedure

The Member Railway's inspector shall ensure that the distance covered by an outer spiral of cabling is not more than the value laid down, and that the diameter of the wires corresponds to the flexibility class of the conductor.

The wires shall be measured, by means of a ratchet micrometer or a micrometer with dial, between circular smooth faces at least 5 mm in diameter. The average of the readings of two measurements taken at right angles to each other shall be accepted as the value of the diameter.

Results to be obtained

The results to be obtained are given in § 2.1 and 2.2.2..

5.1.2 - Measurement of the ohmic resistance / unit length

Preparation of the test piece

Conductor section at least 1 m long.

Procedure

The resistance of the core of the conductor shall be measured by means of one of the usual methods compatible with the scale of the result, in line with the provisions in IEC Publication 228.

The ends of the conductor section shall be stripped of their insulation and protection over a sufficient length to enable contact to be made with the core. The length of the test piece shall be the distance between the two contact points between which the resistance is measured.

The correction necessary for expressing the measurement actually made at any temperature t, in terms of a temperature of 20°C for a length of 1 km of cable, can be obtained by the formula:

$$R_{20} = R_t \frac{254.5}{234.5 + t} \cdot \frac{1000}{L}$$

where:
t is the temperature in °C of the test piece, at the time of measurement.

R_{20} is the linear resistance at 20°C in ohms per km

L is the length of the test piece in meters

R_t is the recorded resistance in ohms of L meters of cable at t°C

Results to be obtained

The results to be obtained are given in 2.3.3.

5.1.3 - Checking of the plating of the copper

When the copper wires forming the core are plated, checking shall consist of determining the adhesion and continuity of the protective layer.

The test piece shall consist of the conductor section which was used for checking the composition. Appropriate lengths of wire shall be removed from this conductor section for the purposes of this operation.

Monitoring of the adhesion of the protective layer

A piece of wire shall be wound round a mandrel of equivalent diameter, to form 5 continuous turns.

Results to be obtained

No separation of the protective layer must be visible to the naked eye.

Monitoring of the continuity of the protective layer

Three pieces of wire approximately 25 cm long shall be immersed for about an hour in carbon tetrachloride or toluene, then dried

with cotton wool. These three test pieces shall then be immediately immersed for 30 seconds in a sodium polysulphide solution at 20°C with a density of 1.142.

Next they shall be dried with cotton wool to remove non-adherent coloured deposits, and then examined with the naked eye.

Results to be obtained

There must be no black stains adhering to the test pieces; stains less than 1 cm across (maximum distance) shall not be taken into account. Slight change in colour of the protective layer shall be permissible, as long as it can be removed by rubbing, scratching or any other means without exposing the copper.

5.2 . Checking of the characteristics of insulating or protecting elements of conductors

5.2.1 - Checking of the geometrical characteristics of the insulation and sheathing or single insulation

Preparation of the test pieces

Conductor sections, about 60 cm long, shall be removed from 3 points no less than 100 cm apart on a length as ready for delivery. On each of these conductor sections, either the insulation and the sheathing of the core, or the single insulation of the core and other elements shall be separated, taking care not to damage the tubes thus formed.

From each of three tubes, coming from the insulation or the sheathing or the single insulation, a test piece shall be removed by cutting a piece off the end some 5 mm long, at right angles to the longitudinal axis.

Procedure

When the test pieces have been prepared in this way each one shall be placed on the stage of a measuring microscope (or any equivalent optical instrument) with its cross-section perpendicular to the optical axis. Each test piece shall then be measured at 6 points on the circumference as regularly spaced as possible, where the wall seems to be thinnest.

To eliminate the influence of external or internal surface irregularity caused by imprints from the core wires or the separators (if any), the microscope cross-hairs shall be placed as shown in Appendix 1.

Results to be obtained

The average of the six values thus obtained for each test piece of insulation, sheathing or single insulation shall be calculated, in mm to one decimal place. This average shall be taken as the average thickness.

The average thickness, and each thickness recorded, must satisfy the condition in § 2.3.1, according as to whether insulation, sheathing or single insulation is involved.

5.2.2 - Checking of the mechanical characteristics of the insulation and sheathing or single insulation.

5.2.2.1 - Checking procedure

The mechanical characteristics of the insulation, sheathing or single insulation shall be checked by determining the tensile strength and the corresponding elongation under the following conditions:

- as ready for submission

- after subjection to heat.

- after immersion in oil No. 2
- after immersion in liquid fuel

} according to conductor category

Sampling

The test pieces for checking under the conditions described above shall be removed from the remaining part of the tubes which provided the test pieces used for checking the geometrical characteristics of the insulation, sheathing or single insulation.

The three tubes corresponding to the insulation shall be marked in order X, Y, Z.

The three tubes corresponding to the sheathing or single insulation shall be marked in order A, B, C.

2 test pieces numbered 1 and 2 shall be cut from each tube X, Y and Z. These test pieces shall be designated:

X1 X2
Y1 Y2
Z1 Z2

4 test pieces numbered 1-4 shall be cut from each tube A, B and C. These test pieces shall be designated:

A1 A2 A3 A4
B1 B2 B3 B4
C1 C2 C3 C4

Preparation of the test pieces and precedures for the tensile test

The preparation of the test pieces, and procedure for the tensile test must conform to the recommendations of IEC publications 227,245 and 330, which are given in Appendix 2.

5.2.2.2 - *Tensile strength of the insulation, sheathing or single insulation as ready for submission*

The tensile strength and corresponding relative elongation shall be determined for the insulation, sheathing or single insulation on test pieces X1, Y1, Z1, and A1, B1, C1 at 20 ± 5° C.

Results to be obtained

The average of the values recorded must meet the conditions laid down in § 2.3.2..

5.2.2.3 - *Tensile strength of the insulation, sheathing or single insulation after subjection to heat*

Procedure

Test pieces X2, Y2, Z2 and A2, B2, C2 shall be subjected to heat in a normal drying oven with circulating hot air in accordance with the provisions laid down in § 4.3..

The coefficient of deterioration of the tensile strength and elongation shall be calculated by means of this formula:

$$\frac{O - A}{O} \times 100$$

where:

O is the average tensile strength, or the elongation, as ready for submission

A is the average tensile strength or the elongation, after subjection to heat.

Results to be obtained

The coefficients of deterioration obtained in this way must meet the conditions laid down in § 2,3,3,1..

5.2.2.4 - Tensile strength of the sheathing or single insulation after immersion in oil No. 2 or liquid fuel

Procedure

Test pieces A3, B3, C3 shall be immersed in oil No. 2 for conductors in categories II and III.

Test pieces A4, B4, C4 shall be immersed in liquid fuel for conductors in category III.

After this preliminary treatment, conforming to the conditions laid down in § 4,3, the test pieces shall be removed from the bath, allowed to drip, then dried to constant mass under a pressure of about 0.2 daN/cm^2 at a temperature of around 40°C. They shall then be cooled down to room temperature and left in the open air for at least 3 hours.

The test pieces shall then be subjected to the tensile test.

The coefficient of deterioration of tensile strength and the elongation of the sheathing or single insulation shall be calculated by means of this formula:

$$\frac{O - A}{O} \times 100$$

where:

O is the mean tensile strength or the elongation, as ready for submission

A is the average tensile strength or the elongation after immersion in oil No. 2 or liquid fuel.

Results to be obtained

The coefficients of deterioration thus determined must meet the conditions laid down in § 2,3,3,3 and 2,3,3,4.

5.2.3 - Variation in volume of the sheathing or single insulation after immersion in oil No. 2 or liquid fuel

Preparation of test pieces

Depending on whether conductors in category II or category III are being tested, either 3 or 6 tubular test pieces formed of pieces of sheathing or of single insulation of the core shall be cut from one of the two conductor sections discarded when removing the sample sections for checking the geometric and mechanical characteristics of the insulation or sheathing.

These tubular test pieces must have dimensions giving a volume of between 1 and 3 cm^3.

Procedure

Conductors in category II :

- 3 test pieces shall be immersed in oil No. 2.

Conductors in category III :

- 3 test pieces shall be immersed in oil No. 2,

- 3 test pieces shall be immersed in liquid fuel.

The duration of immersion of test pieces, and the temperature must conform to the conditions in § 4.3.

The conditions for testing and determining the variation in volume after immersion are laid down in Recommendation ISO/R 1817 (volumetric method).

Results to be obtained

The sheathing or single insulation must show a variation which is between the limits fixed in § 2.3.3.3 and 2.3.3.4, depending on whether they were immersed in oil No. 2 or liquid fuel.

5.2.4 - Checking of the resistance to ozone of the insulation, sheathing or single insulation

Sampling and preparation of test pieces

This checking shall be carried out on the conductor as such and on the conductor stripped of sheathing and any intermediate covering.

In each case two test-pieces, each consisting of a conductor section of suitable length, shall be removed from two distinct areas of the conductor under examination ; they must be at least 1m apart,

Before testing, each test piece shall be inspected to ensure that it is free from mechanical flaws such as cracks, indentations etc.

Procedure

The instructions for testing are given in Appendix 3.

Results to be obtained

The results to be obtained for the sheathing or single insulation and the insulation must conform to the criteria laid down in § 2.3.3.2.

5.2.5 - Checking of the insulation resistance of the insulation

Preparation of test piece

The test piece shall be a 5m conductor section which has been stripped of its sheathing and any intermediate covering.

Procedure

The test piece shall be completely submerged, except for its ends which must protrude a few centimetres, in water at 20 ± 5°C, and left there for at least an hour before testing.

The measurement shall be made between the core and the water.

A D.C. voltage of between 300 V and 500 V shall be applied for a sufficiently long time to obtain a stable reading; this time should in any case not be less than 1 minute.

Once the insulation resistance thus measured, the transversal resistivity shall be calculated by means of this formula :

$$\rho = \frac{2 \pi l R}{L_n \frac{D}{d}}$$

where:

ρ = transversal resistivity in ohm centimetres

R = insulation resistance measured in ohms

l = conductor length in centimetres

D = outer diameter of insulation in millimetres

d = inner diameter of insulation in millimetres

Results to be obtained

The results to be obtained must conform to the requirements laid down in § 2.3.3.5.

5.2.6 - *Checking of the longitudinal di-electric strength of the separator*

Preparation of the test piece

When the conductor comprises a separator, a test piece consisting of a 150 mm conductor section shall be removed from the second conductor section discarded when samples were removed for checking geometrical characteristics.

Procedure

The test piece shall be conditioned for 4 consecutive hours at a temperature of 20 ± 2°C in an atmosphere of 95% relative humidity. After this period of conditioning, the test piece shall be superficially wiped with fluffless filter paper.

Two annular copper electrodes placed 50 mm apart shall be fixed on the separator which has been made readily accessible at the centre of the test piece. When the electrodes are being fitted, care shall be taken to avoid damaging the separator when it has been exposed.

A virtually sinusoidal alternating voltage of 50 Hz frequency shall then be applied between those two electrodes, and the voltage increased uniformly by 500 volts per second to reach the effective value of 12000volts, which shall be maintained for 30 seconds.

Results to be obtained

This result must be consistent with that defined in § 2.3.3.6.

5.3 - Checking of the characteristics of the conductors as ready for delivery

5.3.1 - Checking of geometrical characteristics

Test pieces

Checking of the geometrical characteristics shall be carried out on full cables as ready for delivery, and measurements taken at three places at least 1m apart.

Test procedure

The cable diameter shall be measured either by means of a caliper or a screw or indicating micrometer.

The cable diameter shall then be determined in two perpendicular directions in the same straight section.

Results to be obtained

The arithmetical average of the measured values and the maximum difference between two values taken at the same point must comply with the stipulations in § 2.4.1.

5.3.2 - Checking of the mechanical characteristics (tendency to deform)

Test piece

The test piece shall be a conductor section of suitable length removed from a conductor section discarded when removing samples destined for testing resistance to ozone.

Procedure

The test piece shall be wound, as ready for submission, in continuous coils round a cylindrical mandrel with a diameter several times that of the conductor :

- three times greater, when the conductor diameter is less than 20 mm,
- five times greater, when the conductor diameter is more than 20 mm.

It shall then be unwound, straightened out, then rewound, so that the fibres, which were originally compressed, become tensioned. This operation shall be repeated twice, thus giving three windings in one direction, and three in the opposite direction.

The test piece shall be then wound on to the mandrel after the last winding and subjected to the test for transversal di-electric strength described in § 5.3.3.2.

Results to be obtained

The results obtained must conform to the requirements of § 2.4.2.

5.3.3 - Checking of electrical characteristics

5.3.3.1 - Checking procedure

Electrical characteristics shall be checked:

- as ready for submission for conductors in categories I and II,
- as ready for submission and after immersion in liquid fuel for conductors in category III except when checking the resistance of the insulation to humidity, which shall only involve conductors as ready for submission.

This checking shall consist of submitting these different conductors to tests and checks covering :

- transversal di-electric strength,
- disruption discharge,
- longitudinal di-electric strength,
- resistance of insulation to humidity.

Preparation and treatment of samples

Samples destined to have their electrical characteristics checked as ready for submission shall be tested as such, without prior treatment.

The sample which is to have its electrical characteristics checked after immersion in liquid fuel, must be immersed in this liquid, in accordance with the provisions laid down in § 4.3.

This sample shall consist of a conductor section about 5 m long, removed at random from a delivery unit. It shall be wound into a coil which is put to soak, with its ends protruding 15 cm.

The sample shall then be cut into sections necessary for making test pieces for carrying out the various tests below.

5.3.3.2 - *Checking of transversal di-electric strength*

Preparation of test piece

The test piece shall consist of:

- the delivery length itself, for conductors in categories I and II,
- the delivery length itself, and a 3m section of the sample which has been immersed in liquid fuel, for conductors in category III.

Procedure

Each test piece shall be completely submerged up to the ends which shall protrude about 15 cm in water taken and maintained at 20 ± 5°C; it shall be left to soak there for 24 hours continuously.

While the test piece is still submerged, a virtually sinusoidal alternating voltage with a frequency of 50 Hz and an effective value of:

2 kV 6 kV 12 kV	for conductors in the	750 V 1 500 V 3 000 V	series

shall be applied between the core of the conductor and the water it is immersed in for 15 minutes.

Results to be obtained

The results to be obtained should conform to the requirements of § 2.4.3.1.

5.3.3.3 - *Test of disruptive discharge*

The test piece shall consist of:

- a 1 m conductor section, taken as ready for delivery, for conductors in categories I and II,
- a 1 m conductor section, taken as ready for delivery, and a 1 m conductor section removed from the sample which was immersed in liquid fuel, for conductors in category III.

Procedure

The test piece shall be completely submerged, except for its ends which protrude a few centimetres, in water taken and maintained at 20 ± 5°C; it shall be left to soak for 24 hours in succession and afterwards subjected to a virtually sinusoidal alternating voltage with a frequency of 50 Hz, applied between core and water and having an effective value of:

2 kV 6 kV 12 kV	for conductors in the	750 V 1 500 V 3 000 V	series

The voltage shall then be uniformly increased at:

100 V/s 150 V/s 250 V/s	for conductors in the	750 V 1 500 V 3 000 V	series

until disruptive discharge.

Results to be obtained

There must be no disruptive discharge at the voltages given in § 2.4,3.2.

5.3.3.4 - *Checking of longitudinal di-electric strength*

This checking shall only involve conductors with insulation and protective sheathing.

Preparation of the test piece

The test piece shall consist of:

- a 50 cm conductor section taken as ready for delivery, for conductors in categories I and II,
- a 50 cm conductor section taken as ready for delivery, and a 50 cm section removed from the sample which was immersed in liquid fuel, for conductors in category III.

Procedure

The test piece shall be fitted with every precaution, with two annular electrodes, each consisting of a short coil in copper wire, wound round the sheathing. The wire shall have a circular cross-section of about 1.8 mm in diameter. Each coil shall consist of at least three continuous turns. The two electrodes shall be fitted to the middle part of the test piece, with their last innermost turns at least 50 mm apart. When they are being fitted, any indentation of the wire in the sheathing must be avoided.

The test pieces fitted with electrodes shall be submerged, with their ends protruding about 50 mm, in water maintained at 20 ± 5°C, and left to soak there for 4 hours in succession. After soaking they shall be removed and superficially dried with fluffless filter paper.

Measurement of leakage current

The test pieces prepared as above shall be immediately subjected to a virtually sinusoidal alternating voltage at a frequency of 50 Hz, and an effective value of 2000V, passed between the electrodes.

After 10 seconds of charging, the leakage current shall be measured on a milliammeter.

Measurement of flash-over voltages

The voltage shall be uniformly increased at a rate of 100 V/s until flash-over occurs.

Results to be obtained

The intensity of the leakage current depending on the conductor area and the flash-over voltage, must meet the requirements in § 2.4.3.3.

5.3.3.5 - *Checking of the resistance of the insulation against humidity*

This checking shall involve conductors with single insulation and conductors with insulation and sheathing.

Preparation of test pieces

5 m conductor section taken as ready for delivery.

Procedure

The test piece shall be completely submerged, except for its ends which protrude about 25 cm, in an aqueous solution of sodium chloride at about 10 g/l, maintained at 60 ± 5°C, and left to soak for 240 hours in succession.

For the duration of the test the core of the conductor shall be linked to the negative pole of a d.c. source, and the positive pole of the source to a copper electrode immersed in the solution.

The voltage applied between core and water shall be :

1 000 V 1 800 V 3 600 V	for conductors in the	750 V 1 500 V 3 000 V series

Result to be obtained

The result obtained must conform to the requirements of § 2.4.3.4.

5.3.4 - Checking of physical and chemical characteristics

5.3.4.1 - Compression test at high temperatures

The samples from which the test pieces are removed shall be 1 m conductor sections. For conductors in categories II and III these sections shall be subjected to the following preliminary treatment :

- immersion of a sample in oil no. 2 for conductors in category II,
- immersion of a sample in oil no. 2, and another sample in liquid fuel for conductors in category III.

The samples to be treated shall be put to soak in the corresponding reference liquid, with their ends protruding. The duration and temperature for the tests must conform to the conditions set out in § 4.3.

The test pieces shall consist of :

- 6 4cm conductor sections removed from the middle of each treated sample, and the ends of each untreated sample, for cables with single sheathing ,
- 6 strips removed from the sheathing and cut in the direction of the conductor axis, with a width equal to about a third of the circumference, and about 4 cm long ; they shall be removed from the middle of each treated sample, for conductors with sheathing or insulation.

Procedure

The procedure for pressure test at high temperatures must conform to the recommendations of IEC Publication 330, which are given in Appendix 4.

Results to be obtained

The mean values recorded must lie within the limits fixed in § 2.4.4.1.

5.3.4.2. - Test of cold-resisting capacity

This test shall involve both the conductor as such and the conductor stripped of sheathing and any intermediate covering.

Removal and treatment of samples or test-pieces for testing

In every case considered below, the test pieces shall consist of a conductor section of about 1 m long, and shall be removed from distinct areas of the conductor being tested ; they should be at least 1 m apart.

The following test pieces are removed:

a) 2 test pieces from every type of conductor in categories I and II with insulation and sheathing or with single insulation,

b) 4 test pieces from every type of conductor in category III with insulation and sheathing or with single insulation,

c) 2 test pieces from only those conductors in categories I, II and III, with insulation and sheathing.

The two test pieces described in a) and 2 of the 4 pieces described in b) shall be aged in a drying oven.

The two test pieces described in c), for each category of conductor shall be aged in a drying oven after being stripped of their sheathing.

The conditions for artificial ageing are laid down in § 4.3.

- 168 hours at 100°C for conductors in group A,

- 240 hours at 120°C for conductors in group B.

The two remaining test pieces described in b) shall be immersed for 168 h. at 70°C in the liquid fuel defined in § 4.3.2.2.

After they have been aged, or immersed in liquid fuel:

- test pieces consisting of conductor sections with a diameter of at most 12.5 mm shall undergo the bending test at -25°C.

- test pieces consisting of conductor sections with a diameter greater than 12.5 mm shall have their basic elements separated.

After separation, three dumb-bell test pieces of the H2 type, conforming to those defined in figure 2 (Appendix 2) shall be cut, in tubes previously split longitudinally, from:

- the tubes of sheathing or single insulation of the test pieces described in a) and b),

- the tubes of insulation of the test pieces described in c)

to be subjected to the elongation test at -25°C.

Procedure

The test of resistance to cold temperature (bending or elongation) shall be carried out in accordance with the provisions of IEC Publication 330, completed and clarified in line with the details given in Appendix 5.

Results to be obtained

The results to be obtained must conform to the requirements of § 2.4.4.2.

5.3.4.3 - *Flame resisting capacity*

Preparation of test pieces

The test piece which is tested shall be a conductor section 600 ± 25 mm long removed from a conductor sample about 700 mm long :

- either as ready for delivery, for conductors in category I,

- or after immersion, except for its ends, in line with the conditions laid down in § 4.3.2.2.

- in oil no. 2 for conductors in category II,

- in liquid fuel for conductors in category III,

which have had their ends discarded.

Procedure

The test shall be carried out in accordance with the provisions of IEC Publication 332, as developed and clarified in Appendix 6.

Results to be obtained

The results to be obtained must conform with the requirements of § 2.4.4.3.

5.3.4.4 - *Checking of fire-retarding capacity*

Preparation of test pieces

The test piece which is tested shall be a type 2 conductor, of suitable length, as ready for submission.

Procedure

The test shall be carried out in line with the national standards of the Railway concerned.

In the absence of national standards, the method described in Appendix 7 is recommended.

5.4 - Conclusions of checks and tests

Any test result not meeting the required conditions can lead to the rejection of the corresponding batch.

If the Railway thinks it can accept complementary tests, the nature and number of these tests shall be defined in a special agreement between the supplier and the Railway.

6 - DELIVERY CONDITIONS

6.1 - Method of delivery

Cables shall be delivered in coils or reels of 100 m or multiples of 100 m. The prior agreement of the Railway is required for the delivery of lengths less than 100 m. In any case, the proportionssupplied in lengths of less than 100 m must not be more than 25 % of the total amount supplied.

Both ends of each delivery length of cable must be carefully provided with a suitable covering forming tight and durable protection. The supplier shall be left to decide on how to proceed in this connection.

Cables must be firmly fixed by their ends to the cheeks of reels, to avoid damage.

When delivery is requested in coils, each coil must be maintained with 4 links, consisting of textile rope wide enough to prevent the conductor deterioration.

6.2 - Supply identification

Each reel or coil must be provided with a tear-proof label fixed by lead. This label must remain visible when the cable is protected by packing, and it must bear the following information:

- supplier's trade-mark, with some distinctive wire if required,
- description of the cable (series and area),
- number and date of the order,
- date of manufacture (number of the month and last two figures of the yeur),
- effective length of the cable,
- mass of the cable.

APPENDIX 1

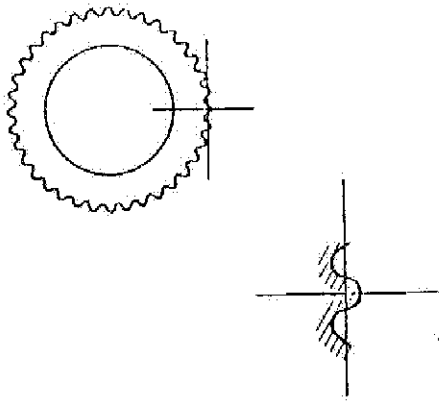


Fig. 1

Placing of the cross-wire of the measuring microscope

APPENDIX 2

TENSILE STRENGTH AND ELONGATION AT RUPTURE

(based on IEC Publications 227,245 and 330)

1 - Preparation of test pieces

Test pieces taken from the tube samples removed from the sheathing, insulation or single insulation of the conductors shall be used for determining the tensile strength and elongation at rupture.

They may be

- either tubular test-pieces
- or dumb-bell test pieces.

The tubular test-pieces shall correspond to sections of tube samples 100 mm in length.

The dumb-bell test pieces are of two types:

- dumb-bell type H2,
- small dumb-bell type H3.

the shape and sizes of which are given in Figure 2. They shall be taken at random from the tube samples split lengthwise beforehand and reduced to a thickness of between 0.8 and 2 mm by an appropriate method.

Dumb-bell test pieces of type H2 shall be used when the tube samples are taken from conductors with nominal cross-sectional area greater than 25 mm2.

APPENDIX 2

Tubular and small dumb-bell type H3 test pieces shall be used when the tube-samples are taken from conductors with nominal cross-sectional area not greater than or equal to 25 mm^2. In the latter case, small dumb-bell type H3 test pieces shall be preferred to tubular test-pieces whenever the dimensions of the tube samples so allow.

The area of the tubular or dumb-bell test-pieces shall be determined before any prior treatment.

In the case of dumb-bell test pieces, the area shall be calculated from the width and thickness of the test-piece between the two marker lines. The width and thickness shall be the mean value obtained from three measurements carried out by means of a micrometer exerting a pressure not exceeding 7 N/cm^2.

The area shall be determined, in the case of tubular test pieces:

- either from the dimensions of this area using the formula:

$$Q = \pi (D - i)\, i$$

where:

i is the mean value of the thicknesses as recorded on the corresponding tube

D is the mean recorded value of the outer diameter of the conductor

- or from the density mass and length of the test pieces using the formula:

$$Q = \frac{100\, m}{\rho\, l}$$

where:

m is the weight of the test piece in grams

l is the length in centimetres

ρ the density of the elastomer or plastomer used, expressed in grams per cubic centimetre.

2 - Tensile test procedure

Immediately before the tensile test, a section of:

- 20 mm for tubular or type H2 dumb-bell test pieces
- 10 mm for type H3 small dumb-bell test pieces

shall be defined by two marker lines on the central part of each test-piece.

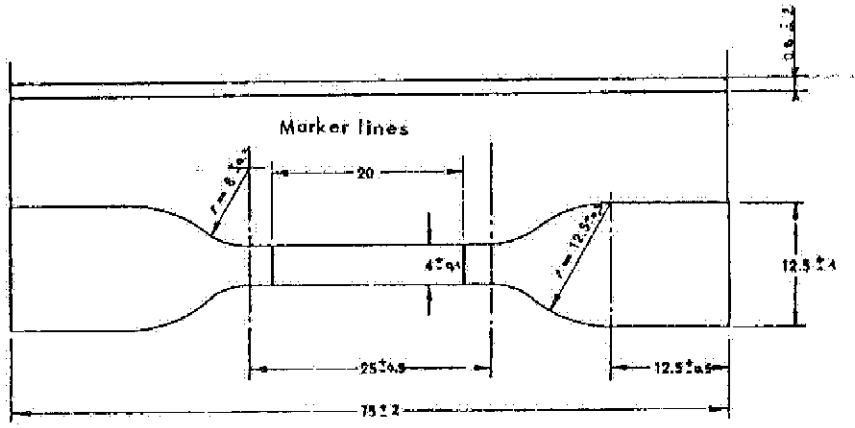
The grips of the tensile machine must preferably be of the self-tightening type. The free length between the grips must be:

- 50 mm in the case of type H2 dumb-bell test pieces and of tubular test pieces,
- 34 mm in the case of type H3 small dumb-bell test pieces.

The corresponding rate of separation of the grips of the tensile machine must be:

- 20 ± 5 cm/min. for type H3 small dumb-bell test pieces
- 30 ±5 cm/min. for type 2 tubular and type H2 dumb-bell test pieces.

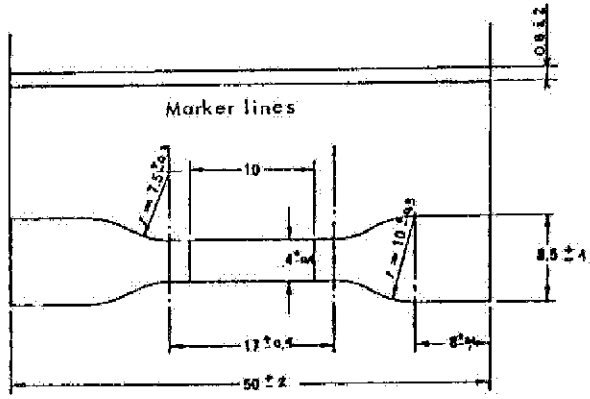
Large dumb-bell test piece (type H2)



Dimensions in millimetres

The marker lines are not relevant to the elongation test at low temperature

Small dumb-bell test-piece (type H3)



Dimensions in millimetres

Fig.2

CHECKING OF RESISTANCE TO OZONE

1 - Apparatus

The apparatus used for the test shall consist primarily of:

- an ozone generator ensuring controlled production flow,
- a compressed-air source,
- an air-drying device such that the dew-point, as measured by a suitable instrument, is less than - 45°C,
- a flowmeter ensuring a flow of between 280 and 560 dm^3/h,
- a test chamber built of ozone-resisting material. Its dimensions must be such that the ratio of the exposed area (test samples and their holders) expressed in cm^2 to the overall volume of the chamber, expressed in cm^3, does not exceed 1 : 25.

2 - Preparation of test pieces

The test pieces intended for checking, as such or without sheathing, shall be assembled in pairs.

For each pair, one test piece shall be wound in the same direction and plane as the initial curvature of the conductor and the other wound in the same way but in the opposite direction.

This operation shall be carried out at room temperature.

Each test piece shall be wound, as shown in figure 3, on a half-turn round the mandrel and maintained in position by means of a string.

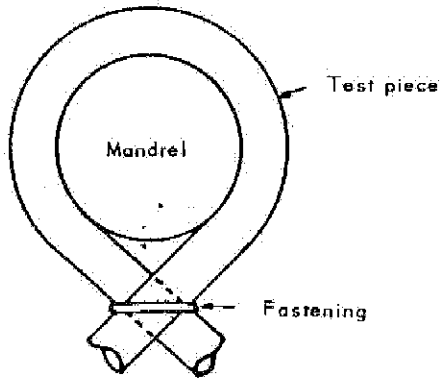


Fig. 3

Test piece on a mandrel for the ozone resistance test

If the test piece is too rigid for its extremities to be crossed, it may be curved U-wise and fastened in such a way that at least one length curved 90° on the appropriate diameter is obtained.

The diameter of the mandrels is shown in the following table:

Outer diameter of unstripped conductor (mm)	Mandrel diameter (multiple of outer diameter of conductor)
under 12.7	4
12.7 to under 19.0	5
19.0 to under 31.8	6
31.8 to under 44,5	8
44,5 and over	10

Immediately before they are placed in the testing chamber, the test pieces, curved round their mandrel, shall be wiped and arranged in a dryer for a period of 30 to 45 minutes.

3 - Test procedure

The ozone concentration shall be ascertained 15 minutes after starting the ozone generator and the circulation of air into the chamber at the stipulated rate.

The generator pressure and the air flow rate shall be set in such a way as to obtain an ozone concentration of between 0.025 % and 0.030 % in volume, with the air temperature inside the chamber being maintained at 25 ± 2°C. Once these criteria have been fulfilled, the test chamber shall be operated under identical conditions for 45 minutes.

The test-pieces and their mandrels shall then be placed 10 mm apart inside the test chamber and at the same distance from the walls, in a more-or-less vertical plane, with their free extremities pointed downwards.

PRESSURE RESISTANCE TEST PROCEDURE

(Based on IEC Publication 330)

The apparatus for this test (see figure 4) consists of:

- a cylindrical metal pin with a diameter approximately equal to the inner diameter of the sheathing,
- a device for applying the test force by means of a flat-edge knife 0.7 mm in width (see figure 4),
- an oven with hot-air flow.

When the test-piece consists of a strip, it shall be applied, and fixed by its hollow surface on the pin.

The test apparatus shall then be placed in the oven, which must be kept at a temperature of 70 ± 2°C or 100 ± 2°C depending on whether the conductors belong to category A or B, together with the test piece (conductor length or pin with test piece as the case may be), and exposed to heat for 16 hours consecutively.

The conductor-length or pin-test piece unit shall afterwards be placed on the support of the test apparatus at right angles to the force - applying knife, the edge of which shall rest on the outer surface of the test-piece. The latter shall then be loaded, and the apparatus and test-piece shall be kept thus in the oven for 4 hours consecutively.

The value of the test force P is given by the formula:

$$P \text{ (Newton)} = 0{,}8 \sqrt{2\,De - e^2}$$

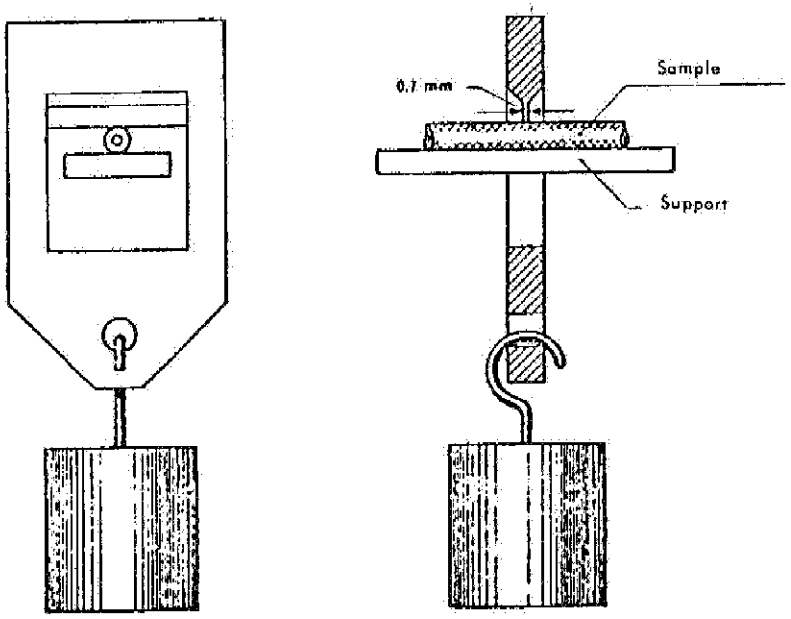
where:

e : the mean value, in millimetres, of the thickness of the single insulation or of the sample sheath,

D : the mean value, in millimetres, of the outer diameter of the conductor sample.

Once removed from the oven, the test piece (maintained loaded) shall be cooled by spraying cold water over the spot against which the blade is pressing. It shall then be taken away from the apparatus and immersed completely in cold water until fully cooled.

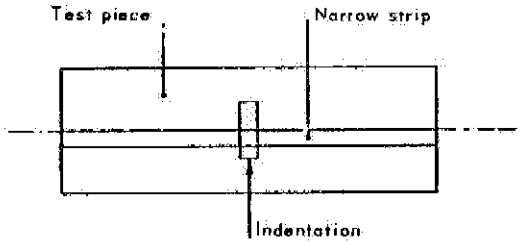
Immediately afterwards, a narrow strip shall be cut from the conductor length or sample strip in the direction of the axis (see figure 5). The strip shall then be laid flat under a measuring microscope, and the cross-wire shall be adjusted to the base of the indentation and to the outer surface.



Dimensions in millimetres

Fig. 4

Apparatus for pressure
resistance test at high temperature



Narrow strip for measurement of insulation

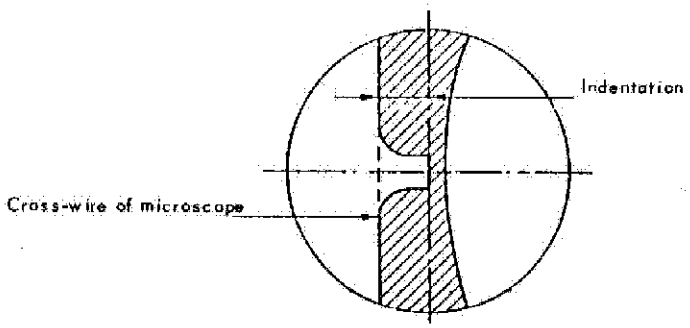


Fig. 5
Picture in measuring microscope

TEST OF RESISTANCE TO COLD TEMPERATURE

TEST PROCEDURE

(Based on IEC Publication 330)

1 - Bend tests for conductors not exceeding 12,5mmin diameter

The test pieces shall consist of pre-treated conductor lengths with or without their sheath as the case may be.

The apparatus for this test is illustrated in Figure 6. The diameter of the mandrels shall be four times that of the test piece.

One end of the test sample shall be fixed to the mandrel of the apparatus, while the other free end shall be inserted in the guide tube. Next, the apparatus with test-piece shall be placed in a cold chamber previously brought to a temperature of - 25 ± 2°C, and exposed to cold for 16 hours consecutively.

After this operation, and with the apparatus kept in the cold chamber, the test piece shall be bent round the mandrel in a close helix, at a rate of approximately one turn per second, using the adjustable round bar.

The number of turns is specified in the following table:

Outer diameter of test piece (mm)	Number of turns
Up to and including 2.5	10
from 2.6 up to 4.5 incl.	6
from 4.6 up to 6.4 incl.	4
from 6.6 up to 8.5 incl.	3
from 8.6 up to 12.5 incl.	2

Next, the test apparatus shall be removed from the chamber, allowed to attain room temperature together with the test piece, which shall then be examined while still on the mandrel.

2 - Elongation test for conductors with a diameter exceeding 12,5 mm:

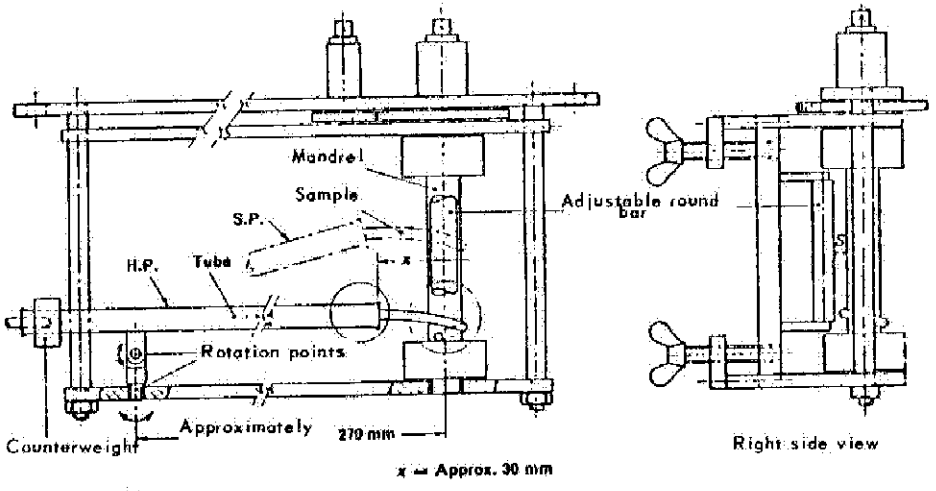
The test pieces used shall be type H2 dumb-bell samples.

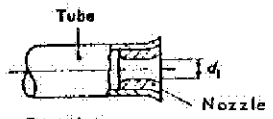
They shall be conditioned during a minimum of 4 hours at a temperature of - 25 ± 1°C, then elongated at this same temperature on a tensile machine.

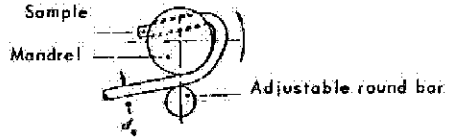
The initial distance between the jaws of the tensile machine shall be 30 ± 0,5 mm.

The speed of separation of the jaws of the tensile machine shall be 50 ± 5 mm/min.

The relative elongation of the test piece shall be determined by relating the increase in the distance between the jaws of the machine to the initial distance of 30 mm. The value of the tensile elongation shall be recorded.







Notes 1.— $d_s < S < 1{,}5\,d_s$

2.— $d_i = 1{,}2$ à $1{,}5 \times d_s$

3.— In horizontal position (HP), the tube should not press the sample down too much

4.— In slope position (SP), the tube should not press the sample upwards too much

Fig. 6

Cold bend test apparatus

APPENDIX 6

TEST OF FLAME RESISTING CAPACITY
TEST PROCEDURE

(Based on the IEC Publication 332)

The apparatus for this test shall consist of:

- a Bunsen gas burner with a nominal bore of 10 mm
- a three-sided metal screen, the cross section of which consists of a rectangle open on one side, with the following dimensions:
  - height 1200 ± 25 mm
  - width 300 ± 25 mm
  - depth 450 ± 25 mm
  - thickness of metal: 1 mm approximately.

The burner may be fired by either:

- propane gas
- butane gas

Propane gas shall be considered as the reference gas, and its characteristics shall be those fixed by the national norms of the Railway.

The test piece shall be fixed at the top of the screen and held vertically in the latter's axis by means of steel wires 0.3 mm in diameter, which shall be wound round the sample and fixed to the screen. The test piece shall be adjusted heightwise so that the bottom of the sample is approximately 50 mm from the screen base.

The test shall be carried out in a place free from draughts. The burner shall be regulated to give a flame approximately 125 mm long and an inner blue cone of 50 mm in length.

The burner axis shall be at an angle of 45° to the vertical and arranged so that the tip of the blue cone should be at a distance of 300 mm from the bottom of the test piece (see figure 7).

The flame shall be applied for a continuous period of T seconds derived from the formula:

$$T \text{ (seconds)} = 60 + \frac{M}{25}$$

Where M is the weight in grammes of the test piece corrected to a 600 mm length.

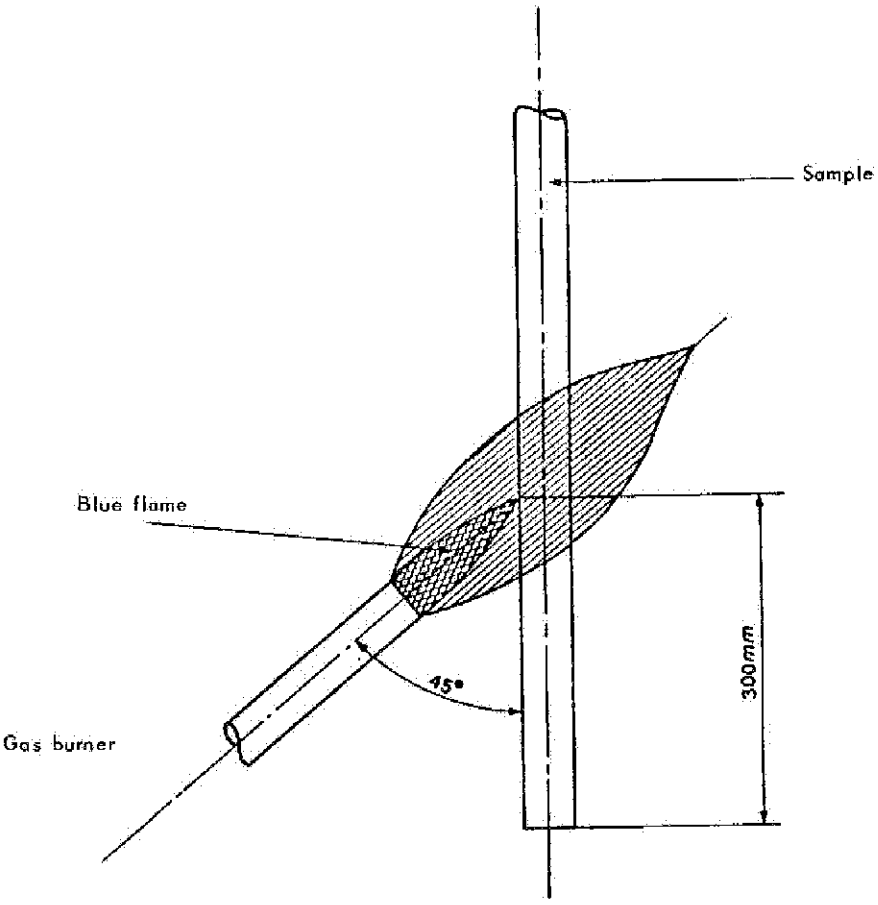


Fig. 7

Burner arrangement for the cable test

CHECKING OF FLAME-RETARDING CAPACITY

(Based on French Electricity Board's Normalisation Document HN 32-80 of January 1971)

1 - Principle of test

The cable samples arranged vertically shall be exposed for a specific period to infra-red radiation from an electric oven the characteristics of which are described in the present document.

A check shall be carried out after the test to determine that degradation of the sample by fire is limited to an agreed length. (See article 5).

2 - Apparatus

The test oven shall be positioned vertically on a metal frame (figures 8 and 9) on which it can slide so as to occupy two positions :

- high position, for the test

- low position, for temperature - setting and calibration.

The oven shall comprise mainly an aluminium silicate tube 100 mm in diameter, round which is wound a strong wire (in Kanthal) insulated by means of an asbestos gasket. Its main dimensions are shown on the diagram in Figure 10.

The silicate tube shall be extended in its lower part by a metal tube of similar inner diameter, open at the base.

The frame shall be provided with a top and bottom securing device, between which the cable test pieces shall be stretched vertically in the oven axis.

Under the bottom securing device shall be placed a removable brass cylinder incorporating a thermocouple, which must be fully housed inside the radiant part of the oven when the latter is in the low position, and which shall be used for adjusting the oven temperature before the test.

On the frame shall also be mounted, above the oven in the high position:

- two gas burners with low thermal power for use in burning, or maintaining combustion of the gases released in the oven during the test;

- a metal sheath of identical inner-diameter and axis as the oven, for use in channelling the flames against the cable at the oven exit.

The oven and its frame shall be mounted inside a glazed cabin ventilated by means of a canopy-shaped exhauster fitted to the top part, and the bottom part of which shall comprise two registers whereby the air-flow speed inside the cabin can be adjusted as necessary (figure 11).

This speed, which must be approximately of 120 ± 20 m/min, shall be controlled by means of a small bladed anemometer inserted between the bottom part of the metal sheath and the oven in the high position. The oven shall be switched off before being regulated.

The oven shall be supplied by means of a device ensuring a continuously variable voltage; its consumption shall be of about 1100 Watts for a supply voltage of 130 V.

The main design features of the oven, frame and cabin are given in Figures 8 to 11.

3 - Constitution of samples

The samples shall consist of cable elements 1.60 m in length, as ready for delivery.

When the cable diameter is in the 35 to 70 mm range, the sample shall consist of a simple element.

When the diameter is less than 35 mm, a bunch shall be formed from a number of cables sufficient for the diameter of the bunch thus formed to be comprised between the same values.

The tests shall always be carried out successively on two identical samples.

4 - Test procedure

4.1 Heating of the oven

For all the tests, it is recommended that the raising of the temperature should be effected gradually - over 45 minutes roughly - to avoid thermal shocks on the oven elements. The stability of the oven may be considered attained after about 3 hours' supply at constant voltage.

4.2 - Calibration of oven

The calibrated copper bar described in Figure 12 shall be installed, properly centred, in the cold oven in the high position; the latter shall next be moved to the low position; sealed by means of asbestos plates and heated up, without the fan operating, until stabilisation point is reached. It shall then be moved back rapidly to the high position so that the rate of rise of the bar temperature, which is linear initially, may be recorded.

It is possible to determine, through successive tests at different voltage values, the power absorbed by the oven corresponding to a temperature rise speed of 3°/second in a linear section of the curve (1).

Once this value has been obtained, the calibration bar shall be replaced by the brass tube with thermocouple, and the temperature θ indicated by the thermocouple on stabilisation shall be recorded. This temperature shall constitute the regulation value mentioned in 4.3.

It is recommended that this calibration exercise should be repeated periodically.

4.3 - Test on a cable sample

The sample constituted as indicated in article 3, shall be stretched vertically in the axis of the apparatus by means of the securing pieces provided to this effect., the brass cylinder with thermocouple being fixed on the lower part.

---

(1) Value determined experimentally as giving the best correlation between laboratory tests and full scale tests.

The oven shall be moved to the low position and its top part shall be shut by means of two plates in refractory material. Next, without operating the ventilation, the temperature shall be raised gradually until the thermocouple (marker 1, Figure 1) indicates under stabilised conditions, the regulation temperature 0 determined by the calibration as indicated in 4.2.

The two burners shall then be lit, and the oven raised to its high position. The fan shall be turned on and record taken of the time, which constitutes the starting point of the test.

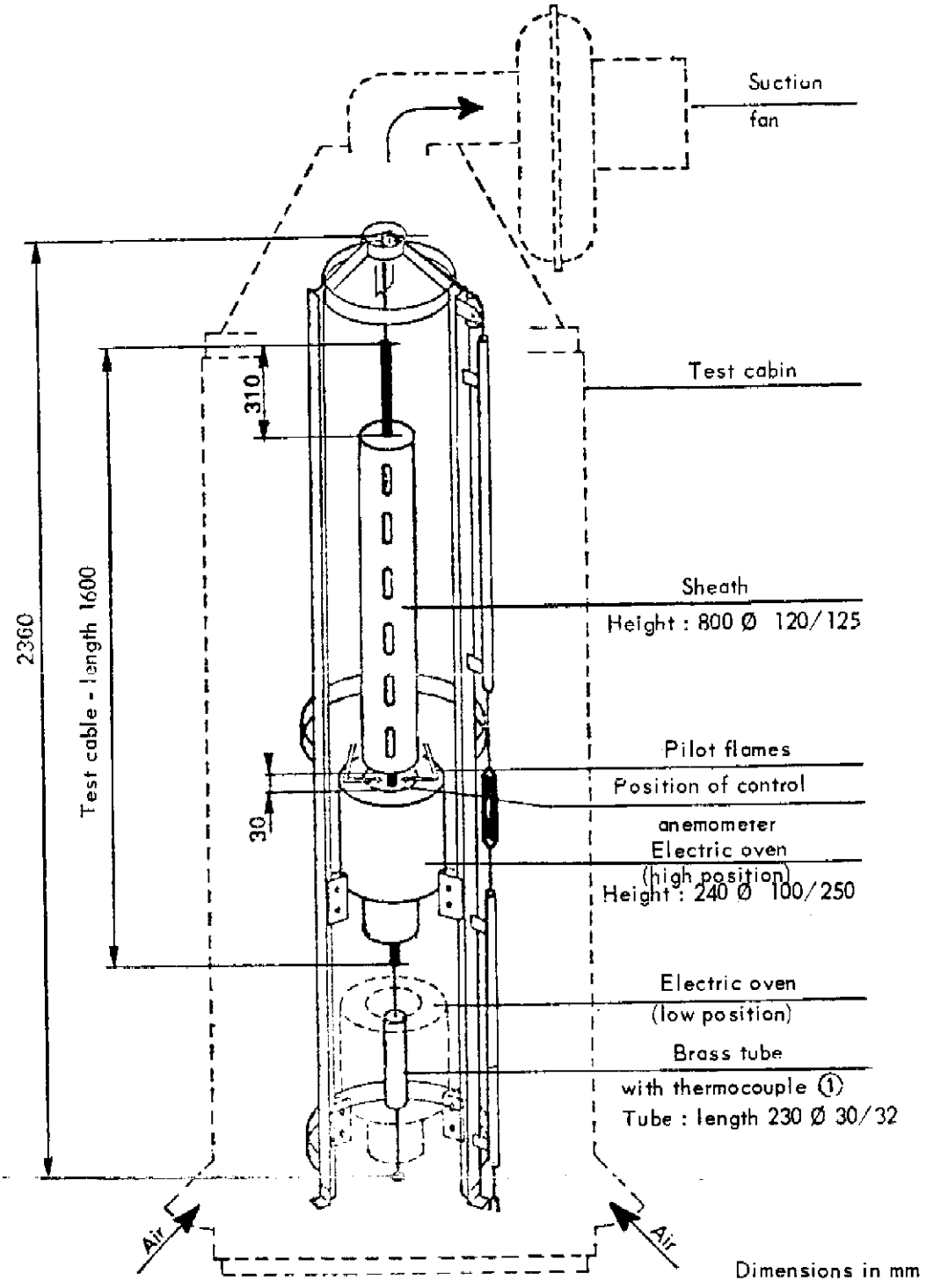
After 10 minutes' test, the fan shall be stopped for one minute.

After a total test time of 30 minutes, the oven shall be switched off and moved back to the low position, with the fan continuing to work. If necessary, the sample shall be allowed to cool down before being removed.

5 - Results to be obtained

The cable shall be deemed to have passed the test if, for each of the two samples tested, the outer sheath - or the insulation when there is no outer sheath - is intact beyond the length contained in the metal sheath.

Possible deposits left by the fumes shall not be taken into account.



Frontal view

Fig. 8

Oven for electric cable
Overall arrangement

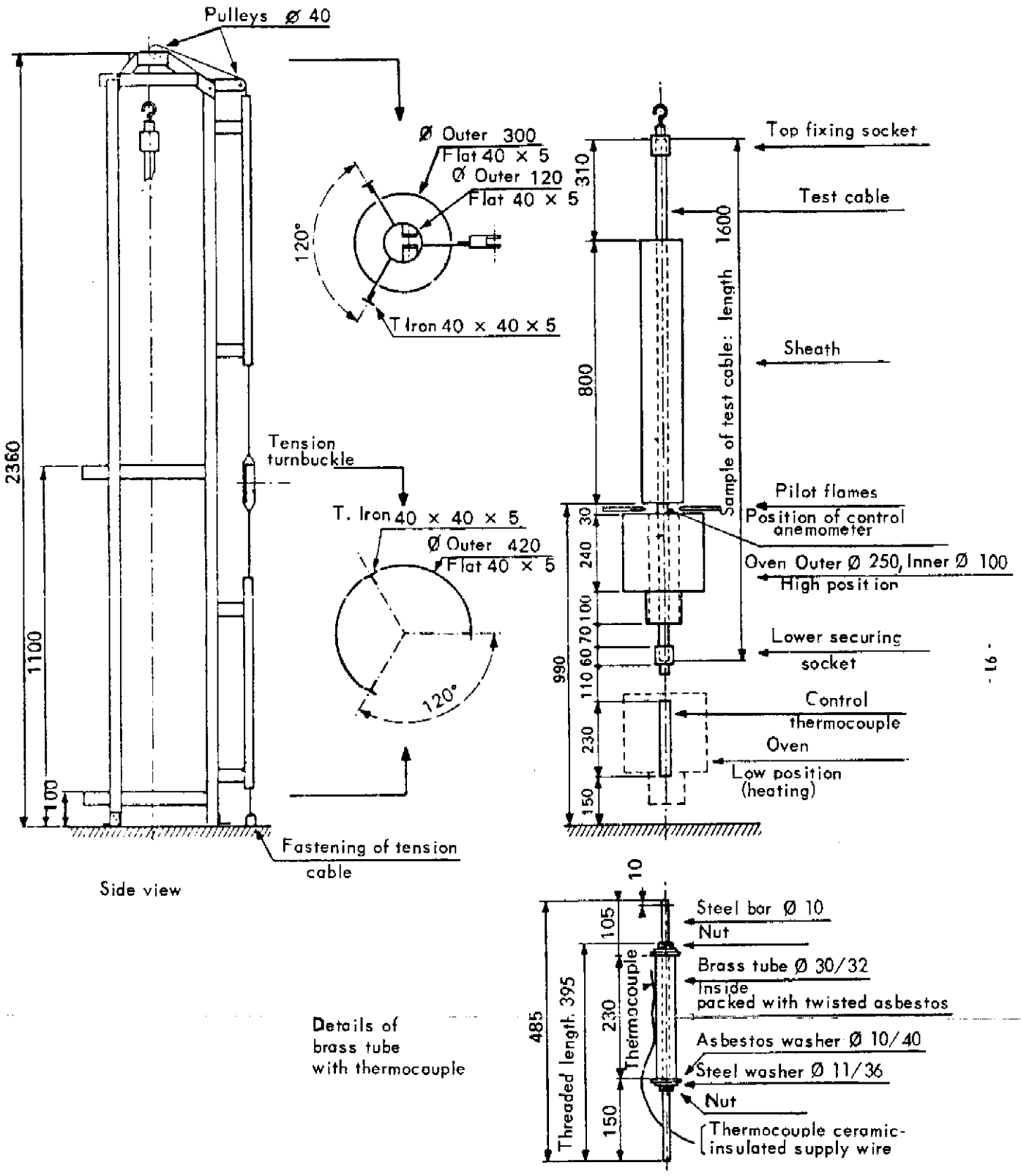


Fig. 9

Inner frame

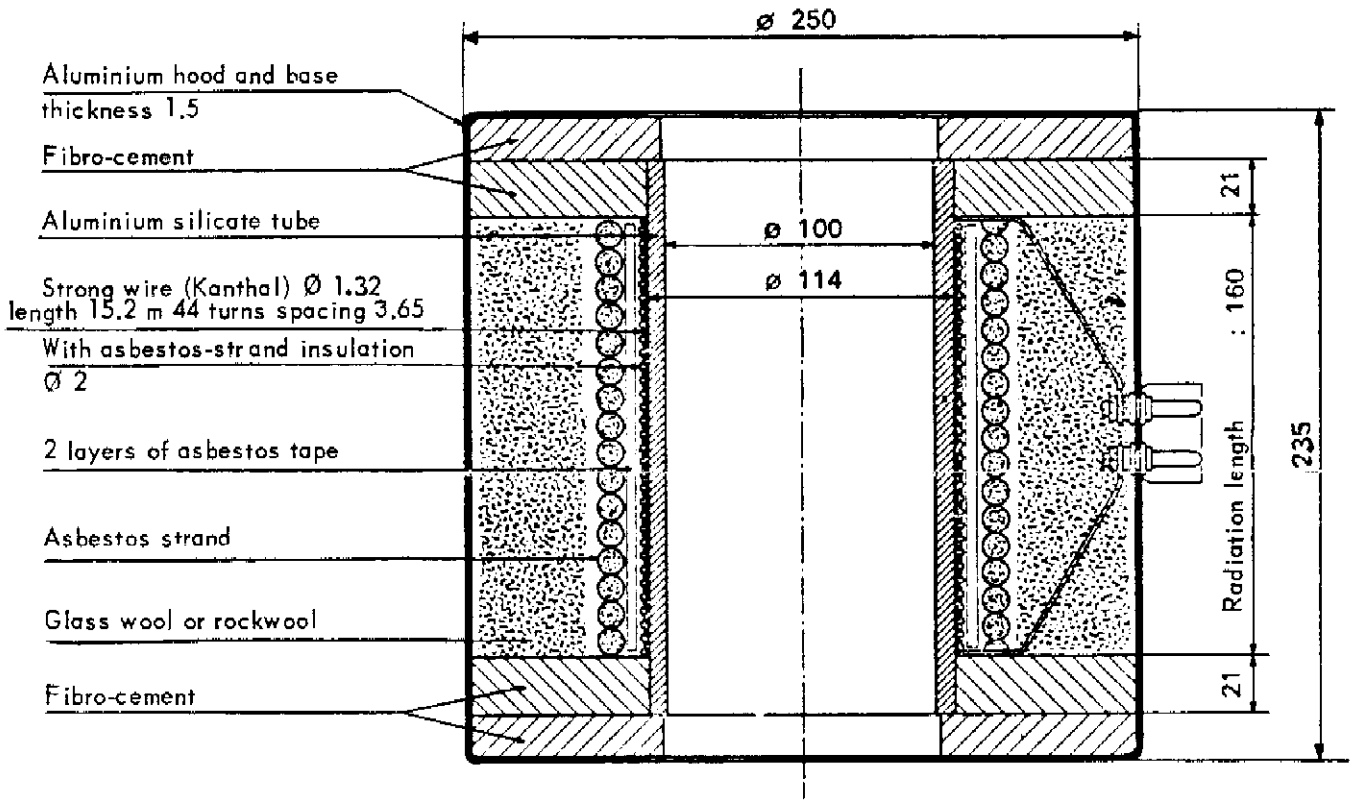


Fig. 10

Details of oven

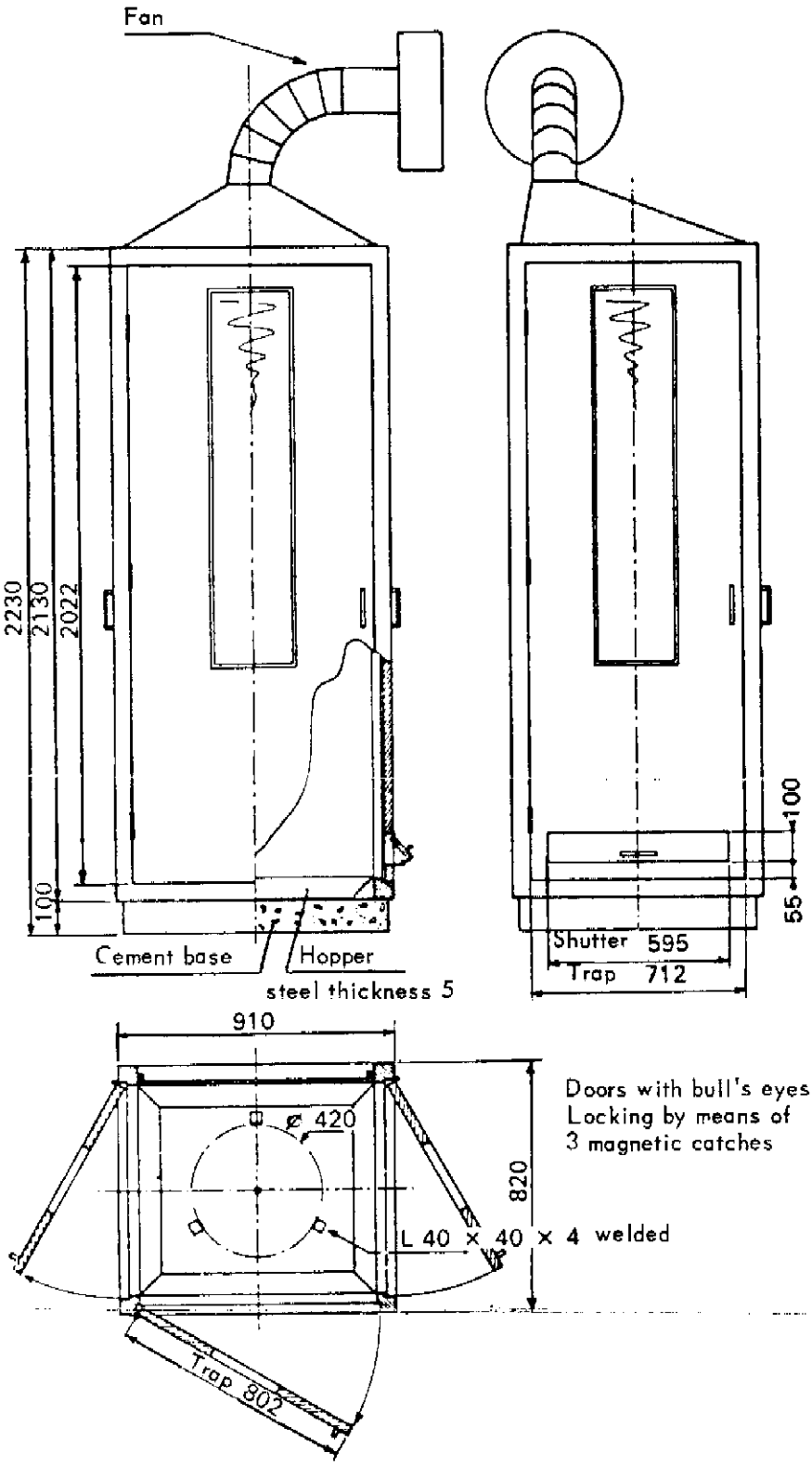
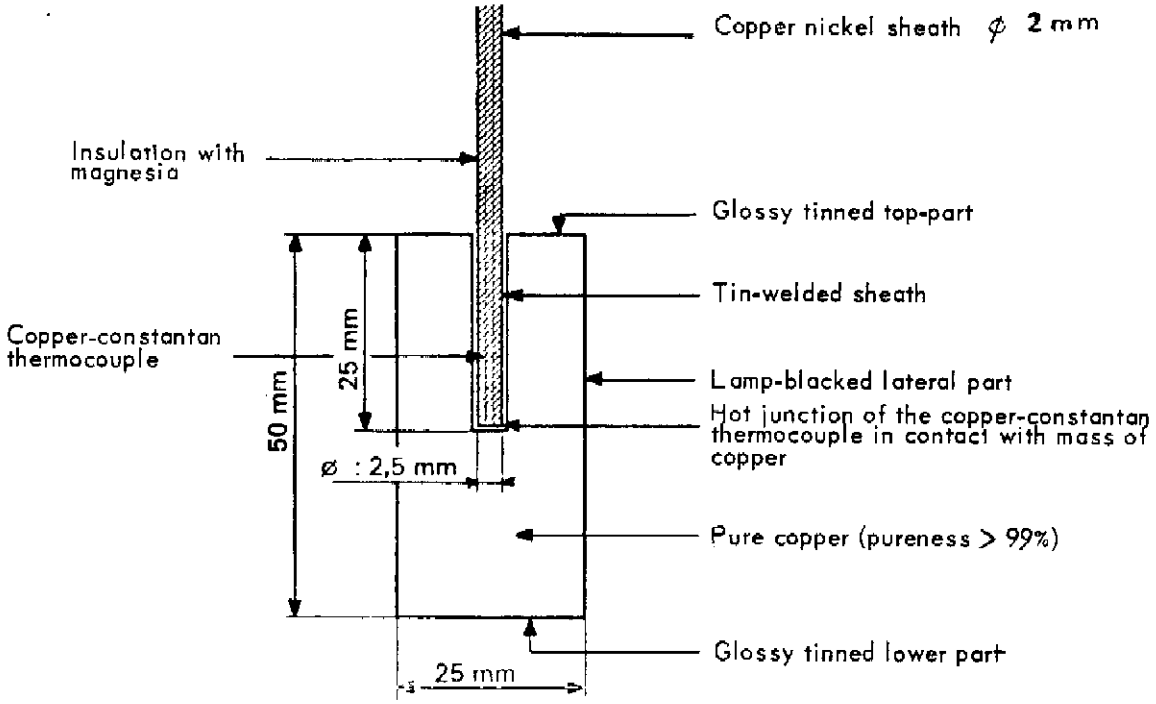

Fan
2230
2130
2022
100
Cement base
Hopper
steel thickness 5
100
55
Shutter 595
Trap 712
910
Doors with bull's eyes
Locking by means of
3 magnetic catches
Ø 420
820
L 40 × 40 × 4 welded
Trap 802

Fig. 11

Cabin



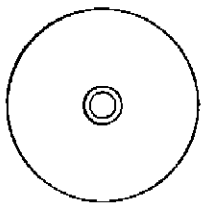


Fig. 12

Copper bar for oven calibration

* To obtain a fine and uniform layer of lamp-black, the bar must be passed over a candle at least 7 times, by wiping off the excess of black after each passage except the last one.

APPLICATION

With effect from 1 July, 1976 as regards obligatory provisions (see point 1).

All Railways in the Union, except the DB, to which a derogation has been granted as regards the leaflet in its entirety, for an unlimited period.

RECORD REFERENCES

Headings under which the question has been dealt with:

- Preparation of specifications concerning parts or component units used in the construction of electric locomotives or railcars.

(5th Committee -E.-: Copenhagen, May 1956; Paris, June 1957; Budapest, June 1958. - 5th Committee T.: Prague, June 1959; Stuttgart, May 1960).

- Revision of Leaflet 895 with the principal object of making it applicable to conductors with the thermoplastic sheaths.

(Sub-Committee for Electric Traction, January 1969).

- *Question 5/A/19* - Revision and possible amalgamation of leaflets 626-1 and 895, with special reference to the scope of utilisation of oil-proof or non oil-proof cables.

(Sub-committee for Electric Traction: Paris, January 1975; Sub-Committee for specifications; Paris, January 1976).