COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

NORME DE LA CEI

INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC STANDARD

Publication 855

Première édition — First edition

1985

Tubes isolants remplis de mousse et tiges isolantes pleines pour travaux sous tension

Insulating foam-filled tubes and solid rods for live working

Bureau Central de la Commission Electrotechnique Internationale

3, rue de Varembé

Genève, Suisse

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INSULATING FOAM-FILLED TUBES AND SOLID RODS FOR LIVE WORKING

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by IEC Technical Committee No. 78: Tools for Live Working.

The text of this standard is based upon the following documents:

Six Months' Rule	Report on Voting
78 (CO) 10	78 (CO) 13

Further information can be found in the Report on Voting indicated in the table above.

The following IEC publications are quoted in this standard:

Publications Nos. 50 (151) (1978): International Electrotechnical Vocabulary (IEV), Chapter 151: Electrical and Magnetic Devices.
60: High-voltage Test Techniques.
60-1 (1973): Part 1: General Definitions and Test Requirements.
212 (1971): Standard Conditions for Use Prior to and during the Testing of Solid Electrical Insulating Materials.
743 (1983): Terminology for Tools and Equipment to be Used in Live Working.

INSULATING FOAM-FILLED TUBES AND SOLID RODS FOR LIVE WORKING

INTRODUCTION

A specification of tests to verify the electrical and mechanical performance of insulating tubes and rods is dependent in part on their construction. This standard covers foam-filled tubes and solid rods such as those currently available without excluding possible future developments of tubes protected internally in other ways and tubes and solid rods protected externally. Any proposed equipment of different design may call for re-examination of the tests, so that they may be adapted to the construction proposed.

SECTION ONE - GENERAL

1. Scope

This standard is applicable to insulating foam-filled tubes and solid rods made of synthetic materials and intended for tools and equipment for live work on systems operating at voltages above 1 kV.

Separate special technical standards give details of tests for fittings and attachments to these poles and rods, adaptable tools and complete tools.

2. Definitions

The following terms are defined in accordance with IEC Publication 50(151): International Electrotechnical Vocabulary (IEV), Chapter 151: Electrical and Magnetic Devices.

2.1 *Type test*

A test of one or more devices made to a certain design to show that the design meets certain specifications (IEV 151-04-15).

2.2 *Routine test*

A test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria (IEV 151-04-16).

2.3 *Sampling test*

A test on a number of devices taken at random from a batch (IEV 151-04-17).

2.4 *Acceptance test*

A contractual test to prove to the customer that the device meets certain conditions of its specification (IEV 151-04-20).

2.5 *Other definitions*

For the definitions of general terms used in this standard, reference should be made to the International Electrotechnical Vocabulary (IEC Publication 50) or to special definitions laid down in IEC Publication 743: Terminology for Tools and Equipment to be Used in Live Working.

SECTION TWO - TECHNICAL CHARACTERISTICS

3. Materials

3.1 *Insulating tubes or insulating rods*

Insulating tubes or insulating rods shall be made from synthetic materials which may be reinforced with mineral or artificial fibre. The colour of the tube or rod shall be specified by the purchaser.

3.2 *Interior of insulating foam-filled tube*

The foam filling shall be bonded to the wall of the insulating tube, and neither the foam nor the bond shall deteriorate during the following tests, other than those leading to destruction of the parts.

4. Diameters of tubes and rods

All measured diameters shall fall within the tolerance limits specified in Table I below.

The difference between any two diameters at a given section shall be less than 1 mm.

TABLE I

Specified diameters

Item	External diameter (mm)	Tolerance on external diameter (mm)
Rod	10	±1
	15	±1
Tube	32	±1
	39	±1.1
	51	±1.2
	64	±1.3
	77	±1.5

All information and testing values relating to other diameters will be given in an amendment to this standard.

SECTION THREE - TYPE TESTS

5. General

To obtain approval for his equipment, the manufacturer shall provide:

10 lengths of 3 m for tubes,
10 lengths of 2.5 m for rods,

which will be retained by, or on behalf of, the purchaser.

After visual inspection and a dimensional check of all the samples, these are divided into three batches from which the various test pieces are taken to undergo the different tests (three test pieces per test) as shown in Table II:

TABLE II

Number of lengths of tubes and rods required for tests

Tests	Clause	Tube			Rod		
		Batch 1	Batch 2	Batch 3	Batch 1	Batch 2	Batch 3
Visual inspection and dimensional check	6	3 of 3 m	4 of 3 m	3 of 3 m	3 of 2.5 m	4 of 2.5 m	3 of 2.5 m
Dye penetration test	7			5 of 0.1 m			
Electrical tests	8.1	3 of 0.3 m			3 of 0.3 m		
Wet test	8.2		3 of 1.2 m			3 of 1.2 m	
Bending test	9.1	3 of 2.5 m			3 of 2 m		
Torsion test	9.2		3 of 1.2 m			3 of 1.2 m	
Crushing test	9.3		3 of 0.3 m*				
Mechanical ageing	10			3 of 2.5 m			3 of 2 m
Reference test piece	5		2 of 1 m**			2 of 1 m**	

*According to Sub-clause 9.3, the length of each test piece is three times the nominal diameter.

**These two test pieces shall be retained without undergoing any tests, so that they can be used as reference test pieces.

Each test is carried out on a test piece taken from each of the three, four or five lengths of tube (or rod) of the batch allocated to this test.

Should any test piece fail to pass any one of the tests mentioned in the preceding table, the product is rejected.

Once approval is granted, the purchaser's stamp is placed on the reference test piece; the second test piece is returned to the manufacturer, and the first remains with the purchaser for reference purposes.

Only those products that pass the tests specified herein may be marked as complying with this standard.

6. Visual inspection and dimensional check

These inspections are carried out on all the test pieces supplied to ensure that the general requirements are fulfilled and that the dimensions comply with the specifications.

6.1 *Visual inspection*

The samples are inspected visually to detect constructional defects (e.g.: evidence of faulty bonding between fibre and resin, air bubbles, foreign bodies or particles).

6.2 *Dimensional check*

The diameters are measured to verify conformity of the test pieces with the requirements of Clause 4.

7. Dye penetration test (this test does not apply to solid rods)

Five tube test pieces, each 100 mm long, which are cut from tubes of batch No. 3, shall be completely immersed in a container of 0.1% by volume fuchsine/distilled water solution, and this system placed in a vacuum chamber which is then evacuated to less than 6 500 Pa (about 50 Torr). The test pieces shall remain for 1 h in the dye solution and then the vacuum is released and the test pieces removed.

In order to avoid fuchsine spreading from the sample ends during cutting, it is necessary to dry the test pieces for 24 h in ambient air before cutting them.

After drying, the test pieces are cut 10 mm from each end.

The new test pieces thus obtained are then slit lengthways. They shall be free from any fuchsine dye penetration.

8. Dielectrical tests

These tests are carried out in order to verify the ability of the products withstand:

- dielectrical stress before exposure to humidity (Sub-clause 8.1.2);
- dielectrical stress after exposure to humidity (Sub-clause 8.1.3).

8.1 *Dielectrical tests before and after exposure to humidity*

8.1.1 *General test conditions*

Before dielectrical testing, each test piece shall be prepared by cleaning with a trifluorotrichlorethane solution ($CF_2ClCFCl_2$) and then dried in air for 15 min.

These tests are made on three test pieces, each 300 mm long, which are cut from tubes (or rods) of batch No. 1 in such a way as to avoid the use of material within 100 mm of the end.

The ends of these test pieces shall be covered with conducting adhesive tape before each dielectrical test. At the time of conditioning in a humid atmosphere, this conducting tape must be removed.

Conditioning in a humid atmosphere is carried out in accordance with IEC Publication 212: Standard Conditions for Use prior to and during the Testing of Solid Electrical Insulating Materials.

The test location shall be at the standard atmospheric conditions given in Table I of IEC Publication 212, with a temperature range of 18 °C to 28 °C.

The test arrangement is shown in Figure A1 (Appendix A). The measuring equipment shall be not less than 2 m from the H.V. electrode. The measuring leads, shunt and optional protective gap shall be shielded and earthed. The test piece shall be mounted approximately 1 m above the ground plane on an insulating support. A voltage of 100 kV r.m.s. at power frequency is applied between the electrodes, in accordance with IEC Publication 60: High-voltage Test Techniques, and the current passing through the test piece is measured (the guard electrode on the earth side is directly connected to earth).

The specified currents are given in r.m.s. values. The phase difference between current and voltage is measured as follows:

- current (earth end), by passing it through a known impedance;
- voltage (line end), by means of an appropriate divider.

During the tests there shall be no sign of flashover or puncture of any of the test pieces.

8.1.2 *Tests before exposure to humidity*

After at least 24 h in the ambient atmosphere of the test area, the current I_1 is measured at an alternating voltage of 100 kV r.m.s. at power frequency applied between the electrodes for 1 min. The maximum current and the phase angle φ_1 between current and voltage are recorded.

8.1.3 *Tests after exposure to humidity*

The test pieces are placed in a chamber and subjected to the following conditioning: 168 h/23 °C/93%, according to Table I of IEC Publication 212.

At the end of this 168 h period, the test pieces shall remain in an atmosphere of 93% relative humidity and be tested upon return to the ambient temperature of the test area. After the test pieces have been lightly wiped with a dry cloth, the current I_2 and phase angle φ_2 are measured under the same conditions as I_1 and φ_1.

The test piece shall be located in the same position in relation to earth; for both tests, the H.V. end shall remain the same.

8.1.4 *Test results*

The current I_1 measured shall not exceed the values given in Table III:

TABLE III

Limits of current I_1 before exposure to humidity

	Rod		Tube				
Diameter (mm)	10	15	32	39	51	64	77
Current I_1 (μA r.m.s.)	10	10	10	12	15	20	25

The test is passed if after exposure to humidity the current I_2 is lower than 2 I_1.

If I_2 is greater than 2 I_1, but lower than $I_1 + 40$ μA, the test is also passed if the phase angle between voltage and current is higher than 50° for tubes and 40° for rods.

In no case shall I_2 be greater than $I_1 + 40$ μA.

8.2 *Dielectrical wet test*

8.2.1 *General test conditions*

Before dielectrical testing, each test piece shall be prepared by cleaning with a trifluorotrichlorethane solution ($CF_2ClCFCl_2$) and then dried in air for 15 min.

These tests will be carried out on three test pieces, each 1.20 m long which are cut from tubes (or rods) of batch No. 2 in such a way as to avoid the use of material within 100 mm of the end.

The electrodes, made with three or four turns of aluminium tie wire 3 mm to 4 mm in diameter, are 1 m apart.

The test location shall be at the standard atmospheric conditions of IEC Publication 212 and the water temperature shall be within the same limits as the ambient temperature, i.e. 18 °C to 28 °C.

The test arrangement is shown in Figures B1 and B2 of Appendix B, page 32. The test piece shall be inclined at an angle of 45°. A voltage of 100 kV r.m.s. at power frequency shall be applied between the electrodes, in accordance with IEC Publication 60, for a period of 1 h.

8.2.2 *Wet conditions*

The wet test is carried out in accordance with the revised wet test procedure described in IEC Publication 60-1: High-voltage Test Techniques, Part 1: General Definitions and Test Requirements:

- average precipitation rate: 1.0 mm/min to 1.5 mm/min,
- resistivity of collected water corrected to 20 °C: $100 \pm 15\ \Omega m$.

However, contrary to the requirements of the above-mentioned publication the test piece shall not be prewetted before voltage application; spray and voltage shall be applied at the same time.

8.2.3 *Test results*

The test piece shall fulfil the following requirements:

- no flashover, no sparkover or puncture;
- no visual sign of tracking or erosion on the surface;
- no perceptible temperature rise.

9. Mechanical tests

These tests measure the ability of the test pieces to withstand bending and torsion.

As indicated in Clause 5, each test is made on three test pieces. The test environment shall be the standard atmospheric conditions of IEC Publication 212, with a temperature range of 18 °C to 28 °C.

Note. – If it is envisaged that the equipment will be used at unusually high or low temperatures, other tests will be necessary. They will be given in an amendment to this standard.

9.1 *Bending test*

This test is carried out on three test pieces from batch No. 1. A tube 2.50 m long or a rod 2 m long is placed between two supports consisting of pulleys (Appendix C) with the following distance between the axes:

- 0.50 m for solid rods;
- 1.50 m for 32 mm diameter tubes;
- 2 m for 39 mm diameter tubes or larger.

At the centre of the span, a vertical force F shall be applied to a leather or fabric strap, 50 mm wide, which is placed on the tube or rod.

Fd is the force for which the elastic limit is not exceeded.

The applied force F is increased at a rate of 200 ± 50 N/s and the deflection is measured for the loads $\frac{Fd}{3}$, $\frac{2Fd}{3}$ and Fd, these having been maintained for 30 s.

The difference between the deflections measured for $\frac{Fd}{3}$ and $\frac{2Fd}{3}$ and for $\frac{2Fd}{3}$ and Fd, shall be less than the value of f indicated below.

This force is then removed progressively and, 1 min after the force has been removed, the residual deflection is measured; this shall not exceed 6% of the deflection measured during application of the force Fd for tubes, and 1 mm for rods.

The tube or rod shall then be rotated through 90°, 180° and 270°, and the test repeated for each position. For the same load, the deflection f shall not vary by more than 15%.

The measured deflection produced by force Fd shall be compared with that for the previous test. With the tube or rod in the plane for which the total deflection was the greatest, the force is then reapplied and progressively increased under the same conditions as above, up to the value Fr, which is then maintained for 30 s. There shall be no sign of failure.

The test shall be continued until the test piece breaks and the actual breaking load is recorded for information.

Table IV gives the values of Fd, f and Fr for foam-filled tubes and solid rods:

TABLE IV

Values of Fd, f and Fr for bending test

External diameter of tube or rod mm		Distance between supports m	*Fd* N	*f* mm	*Fr* N	Length of test piece m
Rods	10	0.5	270	20	540	2
	15	0.5	1350	15	2700	2
Tubes	32	1.5	1100	35	2150	2.5
	39	2	1500	50	2950	2.5
	51	2	3250	45	6450	2.5
	64	2	5500	35	11000	2.5
	77	2	11650	30	23250	2.5

9.2 *Torsion test*

This test is carried out on three test pieces, each 1.2 m long, from batch No. 2.

The test piece is subjected to torsion over a length of 1 m (between collets or terminations).

The applied torque is increased at a rate of 5 ± 2 N·m/s up to the value Cd, which is the torque for which neither audible nor visible defects are observed. At this value, the angular deflection measured after a 30 s application of the torque shall be less than the corresponding angle ad (values specified in Table V).

The torque is then removed and, after 1 min, the residual angle of deflection is measured. This shall be less than 1% of ad for rods, and 1° for tubes.

An increasing torque is then reapplied, as above, up to a value Cr and is maintained for 30 s. There shall be no sign of failure.

The test is continued until the test piece breaks, for information purposes.

TABLE V

Values of Cd, αd and Cr for torsion test

External diameter of tube or rod (mm)		*Cd* N·m	*αd* degrees	*Cr* N·m
Rods	10	4.5	150	9
	15	13.5	180	27
Tubes	32	40	35	80
	39	80	40	160
	51	120	12	240
	64	320	12	640
	77	600	8	1 200

9.3 *Crushing test on tube*

This test is carried out on three test pieces from batch No. 2, each sample being three nominal diameters in length. The test piece shall be laid between smooth, flat, parallel, rigid plates and compressed (see Figure C4 of Appendix C, page 35). The length of the plates shall be at least equal to the sample length plus 20 mm. The distance between the two plates is then continuously decreased at a constant speed of 2 mm/min.

The force F applied to the test piece is recorded versus time.

Two values of F are to be considered:

a) $F = Fd$: minimum value of F where first linearity is lost. This corresponds to a loss of $\Delta F \geqslant 0.01\ Fd$;

b) $F = Fr$: maximum value of F recorded during the three first minutes of test (displacement $\leqslant 6$ mm).

Fd and *Fr* measured shall be higher than the following specified values:

TABLE VI

Values of Fd and Fr for crushing test

Nominal diameter of tube (mm)	32	39	51	64	77
Fd (N)	700	1 650	3 000	3 400	7 000
Fr (N)	1 400	3 300	6 000	6 800	14 000

10. **Mechanical ageing tests**

This test is carried out on three test pieces, each 2.50 m in length for tubes and 2 m for rods, taken from batch No. 3.

10.1 *Bending test*

The test consists of subjecting each test piece to 1000 bending cycles under the test conditions described in Sub-clause 9.1. The force *Fd* indicated in Table IV is applied at the midpoint of the test piece in each of four directions, 90° apart.

The frequency of application of the load shall be between one and two cycles per minute. The test piece shall be rotated through 90° after each 1000 bending cycles; after 4000 cycles, no test piece shall show any sign of deterioration, localized or otherwise, or have any permanent set, when examined visually without the aid of magnifying devices.

10.2 *Dielectrical tests*

Two test pieces each 0.30 m long shall be cut at the centre of the test pieces that have been subjected to 4000 bending cycles. These test pieces shall be subjected to the dielectrical tests (before and after absorption of humidity) defined in Sub-clause 8.1.

The current I'_1 measured before exposure to humidity shall not exceed the values given in Table VII:

TABLE VII

Limits of current I'_1 before exposure to humidity

	Rod		Tube				
Diameter (mm)	10	15	32	39	51	64	77
Current I'_1 (μA r.m.s.)	10	10	10	12	15	20	25

The test is passed if, after exposure to humidity, the current I'_2 is lower than 2 I'_1.

If I'_2 is greater than 2 I'_1, but lower than I'_1 + 40 μA, the test is also passed if the phase angle between voltage and current is higher than 50° for tubes and 40° for rods.

In no case, shall I'_2 be greater than I'_1 + 40 μA.

SECTION FOUR – ROUTINE TEST AND SAMPLING TESTS

11. Routine test

All tubes or rods shall be subjected to a routine test as follows:

- visual inspection;
- dielectrical test.

During the dielectrical test, carried out in accordance with IEC Publication 60, the tubes or rods shall be subjected to an alternating voltage of 100 kV r.m.s. at power frequency applied between electrodes 30 cm apart for 1 min.

The test arrangement shall be as given in Appendix D.

The test piece shall fulfil the following requirements:

- no flashover, no sparkover or puncture;
- no visual sign of tracking or erosion on the surface;
- no perceptible temperature rise.

By agreement between manufacturer and purchaser equivalent test arrangements, test voltages, electrode width and distance and testing durations may be used.

12. Sampling tests

Sampling tests as follows shall be carried out on the batch of tubes or rods delivered:

- dimensional check;
- mechanical test.

Each tube or rod shall be subjected to a deflection test as described in Sub-clause 9.1, with a maximum loading of *Fd*. Deflection shall be recorded at loads of $\frac{Fd}{3}$, $\frac{2Fd}{3}$ and *Fd*.

The load/deflection ratio (N/mm) shall be recorded for comparison with subsequent or previous readings.

For tubes, the test shall be repeated with the tube rotated through 90°. The difference in deflection shall not exceed 15%. Any tube or rod not complying with the specified value of *f* shall be rejected.

By agreement between manufacturer and purchaser the sampling test may comprise all or part of the tests described in Section Three.

13. Additional tests not indicated

At the request of the purchaser, additional tests not indicated in this standard may be carried out on the whole or on part of the batch of tubes or rods delivered.

SECTION FIVE - SPECIAL CLAUSES

14. Marking

Each tube or rod shall carry at least the following information:

- name or trade mark of the manufacturer;
- type reference;
- date of manufacture (year and, if possible, month);
- publication number of IEC standard.

The marking shall not affect the performance of the tube or rod. If a removable label is used the performance shall not be affected by its removal.

15. Modification

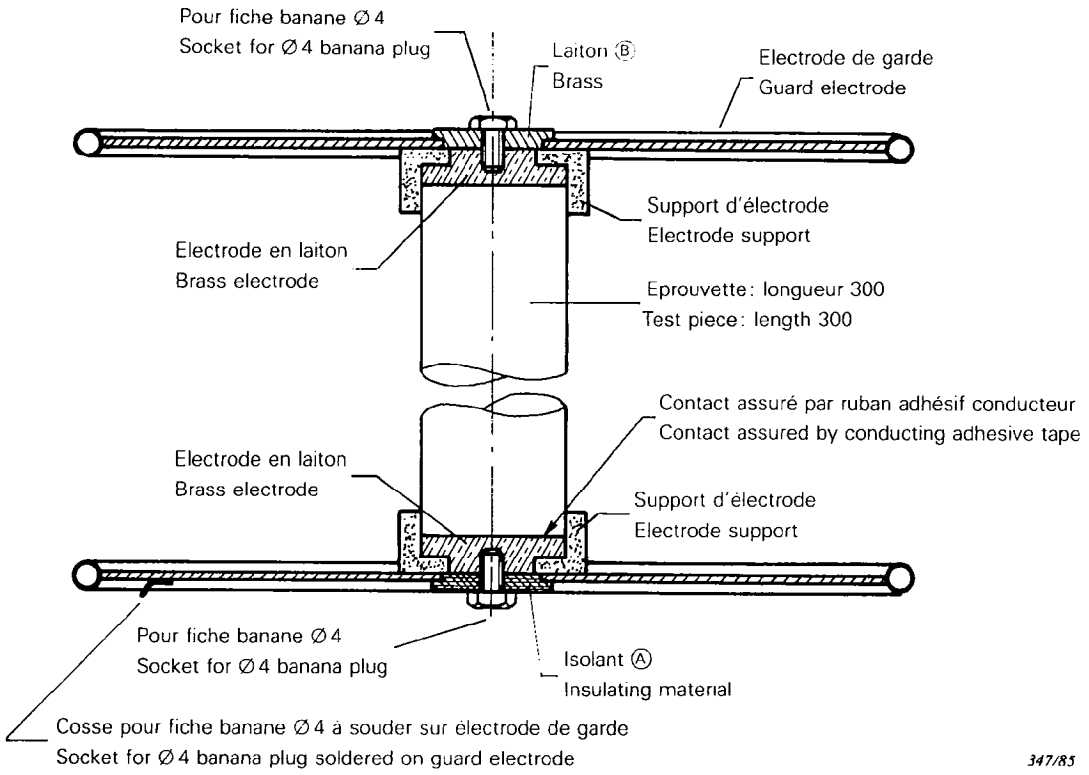
Within the duration of any one purchase order, the manufacturer should not carry out modifications which could change the material characteristics without obtaining the purchaser's approval.

The type tests shall be carried out once more in full or in part in case of any modification of the characteristics, unless otherwise agreed upon between manufacturer and purchaser.

In this case the type reference shall be changed and new samples shall be submitted for qualification.

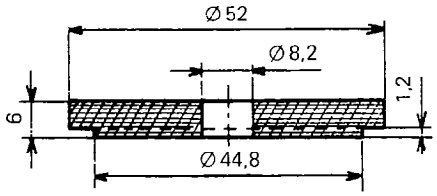
16. Acceptance

If, during the course of the checks and acceptance tests, the quality or performance of the equipment is shown not to meet the conditions prescribed herein, the purchaser reserves the right to refuse the batch of tubes or rods delivered.

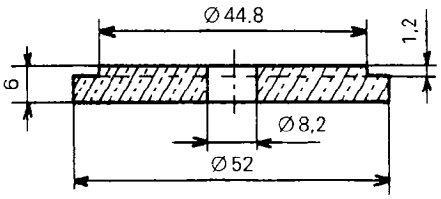


Dimensions en millimètres *Dimensions in millimetres*

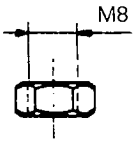
FIG. A2. – Schéma de montage.
Assembly diagram.



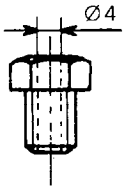
Isolant Ⓐ
Insulating material



Laiton Ⓑ
Brass



2 écrous M8 en laiton pour tiges
2 × M8 brass nuts for rods



2 vis M8–10 laiton percées à Ø 4 pour tubes
2 × M8–10 brass screws with Ø 4 holes for tubes

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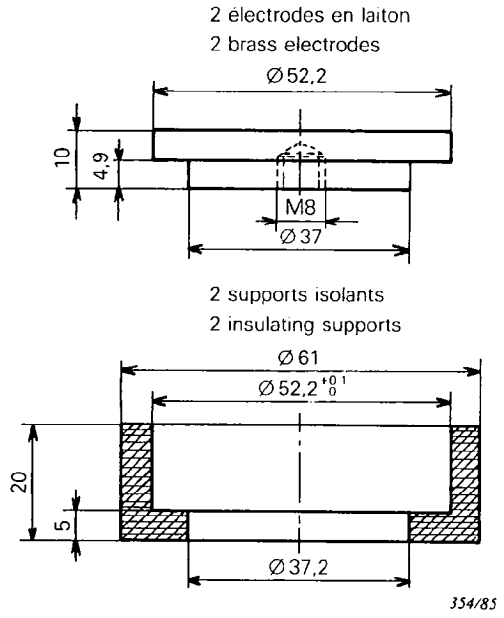
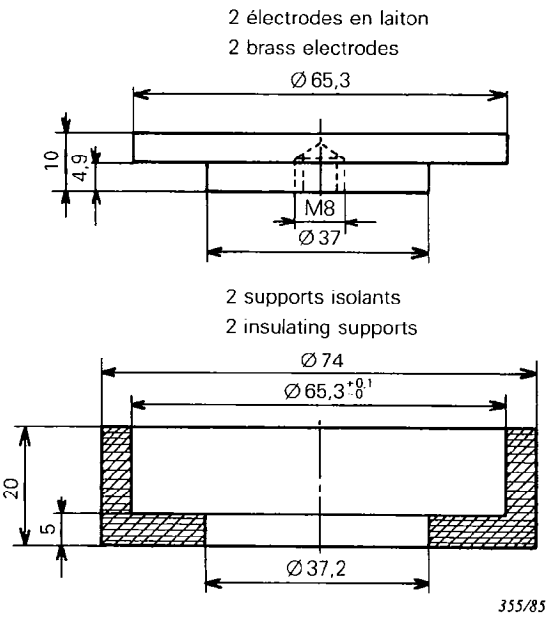
Dimensions en millimètres *Dimensions in millimetres*

FIG. A4. – Plan d'exécution des accessoires pour électrode de garde – Pièces Ⓐ et Ⓑ.
Constructional drawing for guard electrode – Parts Ⓐ and Ⓑ.



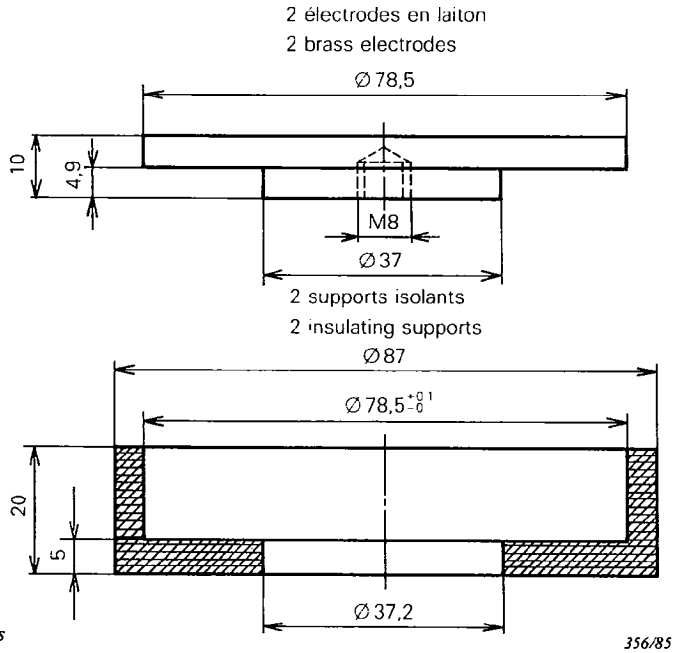
Dimensions en millimètres

FIG. A5*e*. - Pour tube de 51 mm de diamètre.
For 51 mm diameter tube.



Dimensions in millimetres

FIG. A5*f*. - Pour tube de 64 mm de diamètre.
For 64 mm diameter tube.



Dimensions en millimètres

Dimensions in millimetres

FIG. A5*g*. - Pour tube de 77 mm de diamètre.
For 77 mm diameter tube.

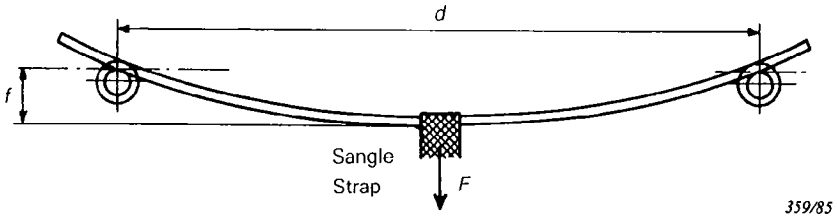
FIG. A5. - Plan d'exécution des accessoires pour électrode de garde selon le diamètre des éprouvettes.
Constructional drawing for guard electrode parts according to test piece diameter.

ANNEXE C

ESSAIS MÉCANIQUES

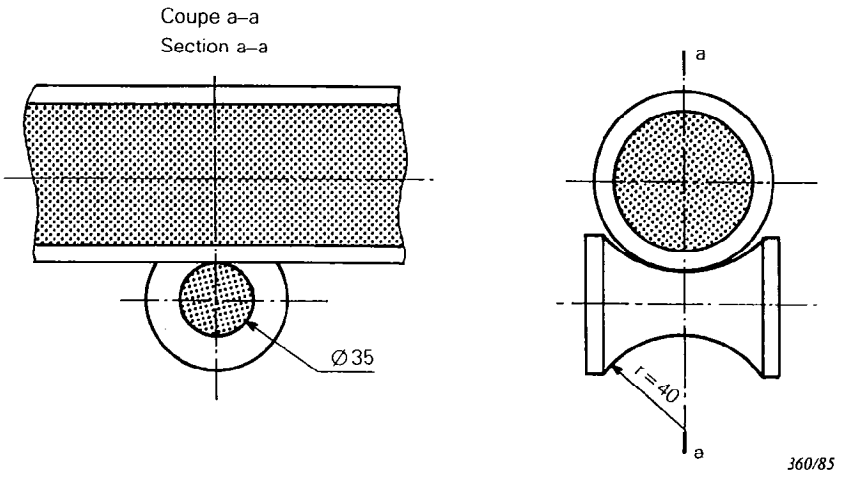
APPENDIX C

MECHANICAL TESTS



Diamètre du tube ou de la tige Diameter of the tube or rod (mm)	Distance entre appuis: *d* Distance between supports: *d* (mm)
10–15 32 39–51–64–77	500 1 500 2 000

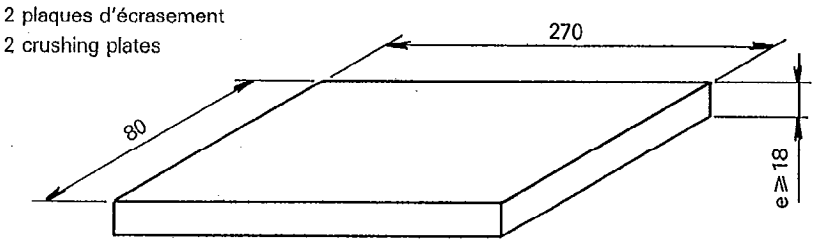
FIG. C1. – Essai de flexion – Montage d'essai.
Bending test – Test assembly.



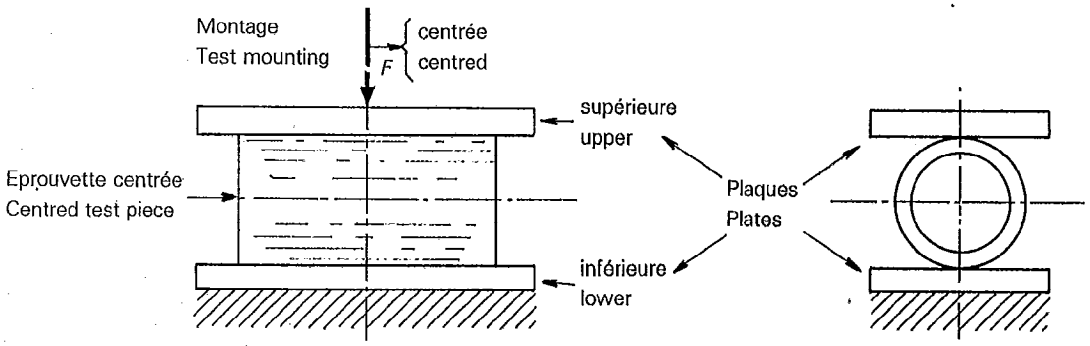
Dimensions en millimètres

Dimensions in millimetres

FIG. C2. – Essai de flexion – Détail des appuis.
Bending test – Detail of supports.



Module d'élasticité du matériau
Young's modulus of material } $E \geq 2{,}2 \cdot 10^{11}\ N \cdot m^2$



La stabilité de la plaque supérieure sera assurée en déplaçant le point d'application de la force *F* vers le bas, à l'aide d'étriers.
Upper plate stability shall be ensured by displacing down application point of force *F*, with the help of stirrups.

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Dimensions en millimètres *Dimensions in millimetres*

FIG. C4. – Essai d'écrasement.
Crushing test.

Publications de la CEI préparées par le Comité d'Etudes n° 78

743 (1983) Terminologie pour l'outillage et le matériel à utiliser dans les travaux sous tension.

855 (1985) Tubes isolants remplis de mousse et tiges isolantes pleines pour travaux sous tension.

IEC publications prepared by Technical Committee No. 78

743 (1983) Terminology for tools and equipment to be used in live working.

855 (1985) Insulating foam-filled tubes and solid rods for live working.