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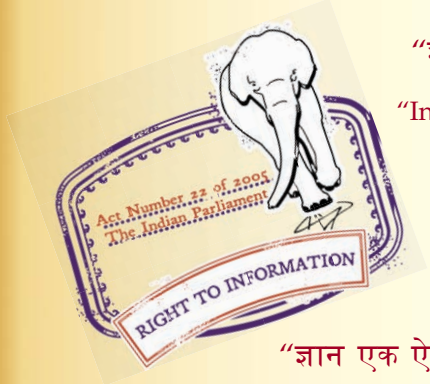

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SPECIFICATION FOR CONDUITS FOR ELECTRICAL INSTALLATIONS

PART I GENERAL REQUIREMENTS

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SPECIFICATION FOR CONDUITS FOR ELECTRICAL INSTALLATIONS

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AMENDMENT NO. 1 JULY 1995
TO
IS 9537 (Part 1) : 1980 SPECIFICATION FOR CONDUITS FOR ELECTRICAL INSTALLATIONS
PART 1 GENERAL REQUIREMENTS

(*Page* 11, *clause* **9.4.2**) — Substitute the following for the existing matter:

'**9.4.2** The sample shall be kept inside the deep freezer the temperature of which is maintained at $-5 \pm 2^{\circ}C$.

When the samples have attained the temperature of the air within the freezer or after 2 h, whichever is longer period, each sample shall be in turn placed in position on the steel base as shown in Fig. 2 immediately within 15 s after the removal from the deep freezer. The hammer is immediately allowed to fall whereby an impact energy *J* according to Table 2 is applied. The mass of the hammer and the height of the fall are also specified in Table 2.'

(ETD 14)

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Indian Standard

SPECIFICATION FOR CONDUITS FOR ELECTRICAL INSTALLATIONS

PART I GENERAL REQUIREMENTS

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 27 June 1980, after the draft finalized by the Electrical Wiring Accessories Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 After examination of the standards covering many types of conduits for electrical installation, it has been observed that many physical, mechanical and electrical properties as well as test methods are similar. Hence it has been felt desirable to formulate a standard covering general requirements of all types of conduits. However, a standard of this kind without reference to any particular type of conduit, cannot possibly cover in detail all the requirements with which the individual type of conduit should comply. Reference to this standard shall be made only after the specifications on individual type of conduits are revised and aligned with this standard.

0.3 This standard (Part I) covers general requirements for various types of conduits. Specific requirements for individual types of conduits are proposed to be covered in subsequent parts of the specification, in which additional or modified requirements including dimensions may be specified.

0.4 To ensure safety in electrical installations use of conduit as earth continuity conductor shall not be permitted.

0.5 While preparing this standard, assistance has been derived from IEC Pub 614-1 (1978) 'Specification for conduits for electrical installations: Part I General requirements', issued by International Electrotechnical Commission.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance

with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part I) applies to conduits of circular cross section for the protection of conductors and/or cables in electrical installations.

NOTE 1 — This standard covers the conduits suitable for temperatures between −5°C to +60°C.

NOTE 2 — Specifications for conduits of other cross sections are under consideration.

2. DEFINITIONS

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Conduit — A part of closed wiring system of circular or noncircular cross section for conductors and/or cables in electrical installations allowing to draw them in and/or to replace them.

NOTE — For the purpose of this standard the word 'conduit' mentioned herein refers to circular cross section only.

Conduits should be sufficiently closed-jointed so that the conductors can only be drawn in and not inserted laterally.

2.2 Plain Conduit — A conduit in which the profile is even in the longitudinal section.

2.3 Corrugated Conduit — A conduit in which the profile is corrugated in the longitudinal section.

2.4 Wall Thickness — The difference between the outside and the inside diameter, divided by two.

2.5 Material Thickness — The average thickness of material measured at any point along the shape of one corrugation of a corrugated conduit.

For plain conduits the material thickness is equal to the wall thickness.

2.6 Rigid Conduit — A conduit which can only be bent with the help of a mechanical aid and with or without special treatment.

*Rules for rounding off numerical values (*revised*).

2.7 Pliable Conduit — A conduit which can be bent by hand with a reasonable force, but without other assistance.

2.8 Flexible Conduit — A pliable conduit which can be bent by hand with a reasonable small force, but without any other assistance, and which is intended to flex frequently throughout its life.

2.9 Metal Conduit — A conduit which consist of metal only.

2.10 Insulating Conduit — A conduit which consist of insulating material and which has no conductive components, neither in the form of an internal lining, nor in the form of external metal braid or coating.

2.11 Composite Conduit — A conduit comprising both conductive and insulating materials.

2.12 Threadable Conduit — A plain conduit the ends of which carry screw threads for connection and on which a thread can be cut manually.

2.13 Non-threadable Conduit — A conduit suitable for connection by means other than screw thread.

2.14 Self-Recovering Conduit — A pliable conduit which deforms when a transverse force is applied for a short time and which after removal of this force returns close to its original shape within a further short time.

2.15 Nonflame-Propagating Conduit — A conduit which is liable to catch fire as a result of applied flame, in which the flame does not propagate and which extinguishes itself within a limited time after the flame is removed.

2.16 External Influences — The presence of water or oil or building materials, low and high temperatures, corrosive or polluting substances and solar radiation.

3. GENERAL REQUIREMENTS

3.1 Conduits shall be so designed and constructed that they ensure reliable mechanical protection to the conductors and/or cables contained therein.

Furthermore the conduit shall withstand the stresses likely to occur during transport, storage, recommended installation practice and usage.

In general, compliance is checked by carrying out all the tests specified.

4. GENERAL NOTES ON TESTS

4.1 Tests specified in this specification are type tests. Type tests on conduits made of insulating materials shall not be commenced before 10 days after manufacture.

4.2 Unless otherwise specified the tests are carried out at an ambient temperature of 27 ± 5°C.

4.3 Unless otherwise specified, each test is made on three new samples.

4.4 The total length and length of the sample to be tested shall be as specified in the individual conduit specification.

4.5 Unless otherwise specified, samples for the various tests shall be taken from conduits delivered in:

a) for rigid conduits, lengths of normally 3 m taken from 3 different manufactured lengths; and

b) for pliable and flexible conduit coils, from places separated by distance of approximately 3 m.

4.6 Unless otherwise specified, conduits are deemed not to comply with the specification if more than one sample fails in any one of the tests. If one sample fails in a test, that test and those preceding, which may have influenced the result of that test, are repeated on another set of samples of the number specified, all of which shall then comply with the repeated tests.

5. CLASSIFICATION

5.1 The conduits are classified as follows:

a) *According to material*:

1) Metal conduits.
2) Insulating conduits.
3) Composite conduits.

b) *According to the method of connection*:

1) Threadable conduits (only plain conduits).
2) Non-threadable conduits.
   i) Plain conduits.
   ii) Corrugated conduits.

c) *According to mechanical properties*:

1) Conduits for very light mechanical stresses.
2) Conduits for light mechanical stresses.
3) Conduits for medium mechanical stresses.
4) Conduits for heavy mechanical stresses.
5) Conduits for very heavy mechanical stresses.

NOTE — Conduits which are designed for higher mechanical stresses can be used for lower mechanical stresses. For example, conduits of classification (c) (5) can be used for any of the conditions covered in (c) (1) to (c) (4).

d) *According to suitability for bending*:

1) Rigid conduits.
2) Flexible conduits.
3) Self-recovering conduits.
4) Pliable conduits.

e) *According to resistance to flame propagation*:

1) Non-flame propagating conduits.
2) Flame propagating conduits.

f) *According to electrical characteristics*:

1) With electrical insulating characteristics.
2) Without electrical insulating characteristics.

g) *According to resistance to external influences*:

1) Resistance against ingress of water:
   i) Unprotected conduits.
   ii) Conduits with protection against sprays, splashes and jets.
   iii) Conduits with protection against waves and immersion.
   iv) Conduits with protection against submersion.

2) Resistance against corrosive or polluting substances.
   i) Conduits with the same protection on the outside and the inside.
   conduits with low protection,
   conduits with medium protection, and
   conduits with high protection.

ii) Conduits with greater protection on the outside than the inside.

conduits with medium protection outside and low protection inside,

conduits with high protection outside and low protection inside, and

conduits with high protection outside and medium protection inside.

h) *According to resistance to solar radiation*:

1) Conduits without protection against solar radiation

2) Conduits with protection against solar radiation.

i) Conduits with low protection against radiation.

ii) Conduits with medium protection against radiation.

iii) Conduits with high protection against radiation.

6. MARKING

6.1 The conduit shall be marked with maker's name, trade-mark or other identifiable symbols, immediately followed by a classification code.

NOTE — A classification code is under consideration.

6.2 Marking of conduits shall be repeated in regular intervals not longer than 3 m but, preferably of 1 m.

Rigid conduits shall be marked at least once on each manufacturing length, preferably 50 mm from one end.

Coils of pliable or flexible conduits shall in addition have an attached label marked with the maker's name or trade-mark immediately followed by the classification code.

6.3 Marking shall be durable and legible.

6.4 Marking according to **6.1** to **6.3** shall be checked by inspection and by rubbing lightly the marking by hand for 15 seconds with a piece of cloth soaked with water and again for 15 seconds with a piece of cloth soaked with petroleum spirit.

NOTE — Marking may be applied by moulding, stamping, printing, adhesive label or water slide transfers.

7. DIMENSIONS

7.1 The dimensions shall be as stated in the relevant conduit specifications and compliance shall be checked by appropriate gauges.

8. CONSTRUCTION

8.1 The inside and the outside surfaces of conduits shall be reasonably smooth and free from burrs, flash and similar defects; in addition, the edges over which the conductors or cables are likely to be drawn shall not damage the cables or conductors.

Compliance is checked by inspection, if necessary, after cutting the samples apart.

8.2 A slight burr resulting from the method of manufacturing is not taken into account if it is not likely to damage insulated conductors.

This requirement does not preclude corrugated conduits.

9. MECHANICAL PROPERTIES

9.1 Conduits shall have adequate mechanical strength.

9.1.1 Conduits according to their types, when bent or compressed, or exposed to extreme specified temperatures, either during or after installation, shall show no cracks and shall not be deformed to such an extent that introduction of the cables becomes difficult, or that the installed conductors or cables are likely to be damaged while being drawn in.

9.1.2 Compliance is checked by the tests specified in **9.2** to **9.5** and in the conduit specification.

9.2 Bending Test

9.2.1 Conduits shall be subjected to a bending test.

9.2.2 Reference to the values and to the tests for conduits are made in the relevant conduit specifications taking into account the manufacturer's instructions for bending, so for as they do not contravene the aims of this specification as a whole.

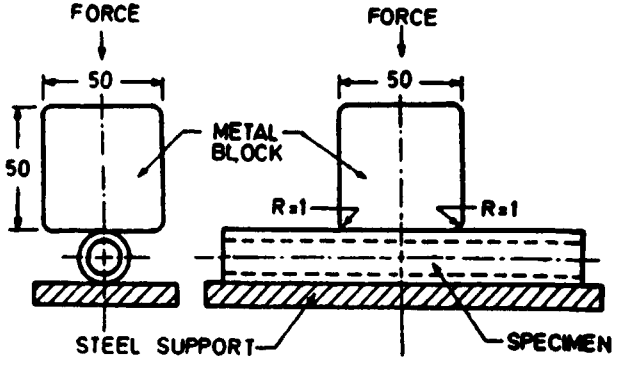
9.3 Compression Test

9.3.1 Samples of conduit, each 200 mm long, shall be subjected to a compression test using the apparatus shown in Fig. 1.

Before the test, the outside diameters of the samples shall be measured. The samples shall then be conditioned at a temperature of $27 \pm 2^{\circ}C$ for at least 10 hours.

9.3.2 Immediately after the conclusion of conditioning period, the samples shall be positioned on a flat steel support and a steel intermediate block as shown in Fig. 1, is placed on the middle of the sample.

A slowly increasing force as shown in Table 1 for different types of conduits shall then be applied to the intermediate piece within 30 seconds.



All dimensions in millimetres.

FIG. 1 ARRANGEMENT FOR COMPRESSION TEST

TABLE 1 FORCE FOR COMPRESSION TEST

(*Clause* 9.3.2)

TYPE OF CONDUIT	COMPRESSION FORCE N
Very light	125
Light	320
Medium	750
Heavy	1 250
Very heavy	4 000

NOTE — The values in the table are subject to modification in relevant conduit specifications.

9.3.3 After the full force has been applied for 1 minute, the outside diameter of the sample shall be measured where flattening has taken place, without removing the force.

The difference between the initial diameter and the diameter of the flattened sample shall not exceed a specific percentage of the outside diameter measured before the test. The values are given in the relevant conduit specifications.

The force and the intermediate piece are then removed and, 1 minute after removal, the outside diameter of the samples, where they have flattened, is again measured. The difference between the initial diameter and the diameter of the flattened samples shall not exceed 10 percent of the outside diameter measured before the test.

9.4 Impact Test

9.4.1 Twelve samples of conduits, each 200 mm long, shall be subjected to an impact test by means of the apparatus shown in Fig. 2.

Before the test, the samples shall be conditioned at a temperature of 60 $\pm$ 2°C for 10 days (240 hours).

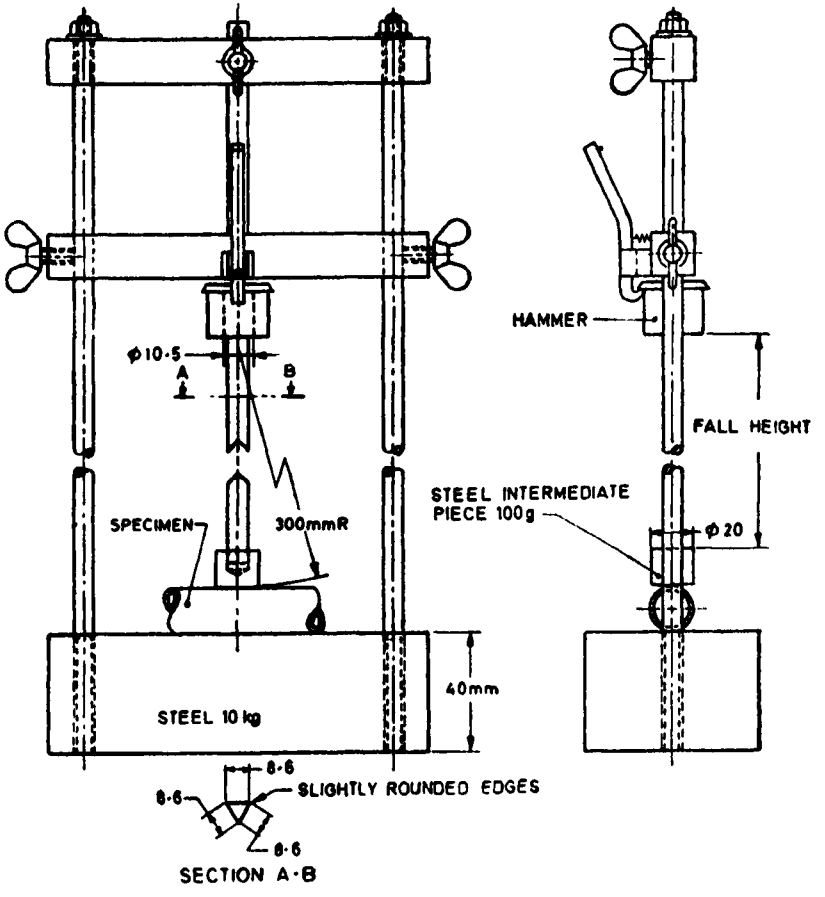
9.4.2 The test apparatus shall be placed on a pad of sponge rubber 40 mm thick, and this together with the samples, shall be placed in a freezer, the temperature within which is maintained at -5 ± 2°C.

When the samples have attained the temperature of the air within the freezer or after 2 hours, whichever is longer period, each sample shall be in turn placed in position on the steel base as shown in Fig. 2 and the hammer is allowed to fall whereby an impact energy J according to Table 2 is applied. The mass of the hammer and the fall height are also specified in Table 2.

TABLE 2 FORCES FOR IMPACT TEST

(*Clause* 9.4.2)

Conduit	Impact Energy (J)	Mass of the Hammer	Fall Height
(1)	(2)	(3)	(4)
		kg	mm
Very light	0·5	0·5	100 $\pm$ 1
Light	1·0	1·0	100 $\pm$ 1
Medium	2·0	2·0	100 $\pm$ 1
Heavy	6·0	2·0	300 $\pm$ 1
Very heavy	20·0	6·8	300 $\pm$ 1



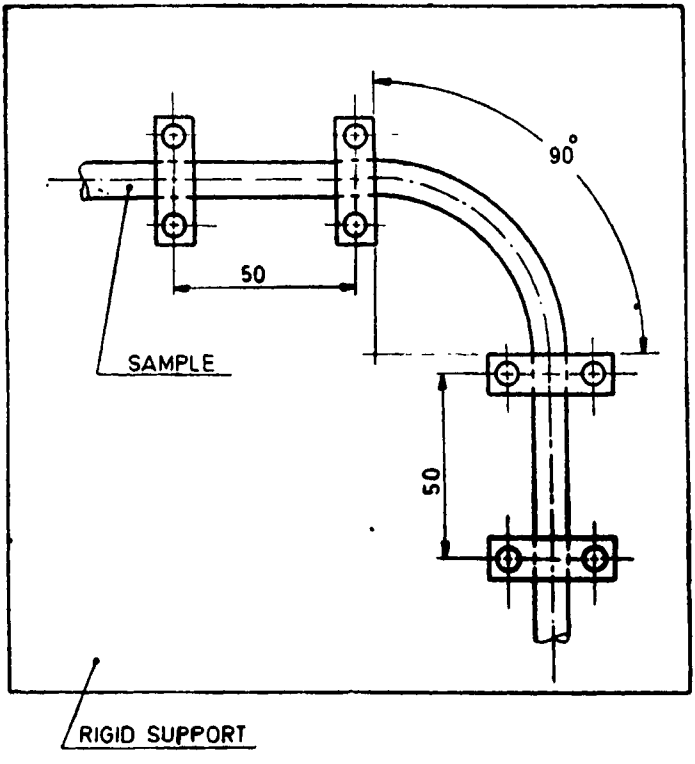
All dimensions in millimetres.

FIG. 2 IMPACT-TEST APPARATUS

9.4.3 After the test, there shall be no sign of disintegration, neither shall there be any crack visible to the naked eye in at least nine of the twelve samples.

9.5 Collapse Test

9.5.1 Samples of conduits made of insulating materials of length as specified in Table 3 shall be bent at room temperature, the bending radius being as given in relevant conduit specifications. The samples are then fixed to a rigid support by means of four straps as shown in Fig. 3.



All dimensions in millimetres.

FIG. 3 ARRANGEMENT FOR COLLAPSE TEST

TABLE 3 LENGTH OF SAMPLES FOR COLLAPSE TEST

(*Clause* 9.5.1)

SIZE mm	LENGTH mm
16	340
20	370
25	450
32	590
40	740
50	900
63	1 130

If mechanical bending aids recommended by the manufacturer are used for rigid conduits, the mechanical aids shall be removed. The support with the sample in position is kept for 24 hours in a heating cabinet at a temperature of 60 $\pm$ 2°C unless specified otherwise in the relevant conduit specification.

After the period, the sample still being secured to the support, the minimum internal diameter is checked as specified in the relevant conduit specifications.

10. RESISTANCE TO HEAT

10.1 Conduits of insulating material shall be adequately resistant to heat.

10.2 Compliance is checked by tests as specified in the relevant conduit specifications.

11. RESISTANCE TO BURNING

11.1 Non-flame-propagating insulating conduits shall not ignite or, if ignited, not continue to burn, when the source of ignition is removed.

11.1.1 Compliance is checked by the following test, which is made on three samples, each having a length of 600 mm.

11.2 The test is made in still air with a bunsen burner, having a nozzle with an internal diameter of 9 mm.

While the burner is in the verticle position, the flame is adjusted so that the overall length is 100 mm. The intensity of the flame shall meet the following requirements.

> A bare copper wire, 0·71 mm in diameter and at least 10 cm long, is held horizontally, so that it passes through the middle of the flame, 5 cm above the top of the burner, its free end being vertically above the edge of the burner. The wire should melt within 6 seconds.

For testing the conduits the burner is supported so that its axis is at an angle of 45° to the vertical.

The sample is held in such a position that the part above the flame is vertical and that the tip of the inner cone of the flame touches the surface of the sample at a distance of approximately 100 mm from its lower end, as far as practicable.

11.3 The time of exposure of the sample to the flame shall be as specified in the relevant conduit specifications for the different types of conduits. The burner is then removed.

If the sample burns it shall do so slowly and the flame shall not spread appreciably; any flame shall have died out in less than 30 seconds after removal of the burner.

12. ELECTRICAL CHARACTERISTICS

12.1 Insulating conduits shall have adequate electrical strength and insulation resistance.

Compliance is checked by the test given in **12.1.1** and **12.1.2** which is made on three samples of appropriate length.

The end of each sample is provided with a conductive coating at least of 10 mm length.

12.1.1 *Electrical Strength* — The samples are bent and immersed over a length of 1 m in water at a temperature of 27 $\pm$ 5°C, as shown in Fig. 4, a length of about 100 mm at each end being kept above the water level. Water is then poured into the sample so that the levels inside and outside are approximately the same and one electrode is immersed in the water inside each sample and another electrode in the water outside.

After 24 hours, a voltage of 2 000 V, of substantially sine-wave form and having a frequency of 50 Hz, is applied for 15 minutes between the electrodes.

No breakdown shall occur during the test.

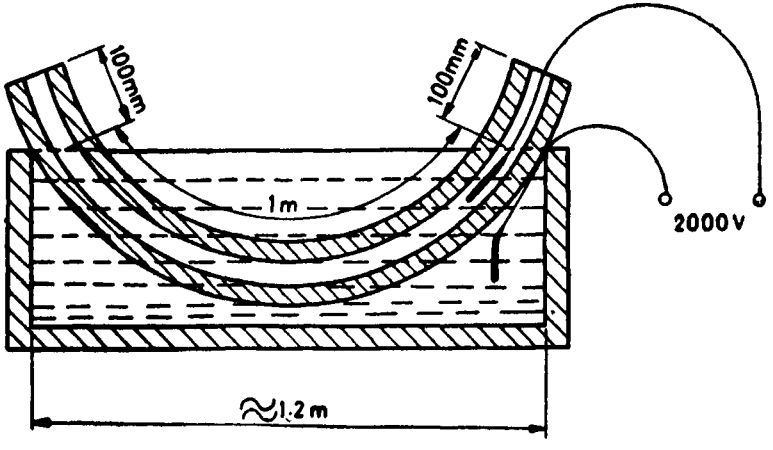


FIG. 4 ARRANGEMENT FOR INSULATION RESISTANCE AND ELECTRIC STRENGTH TEST

12.1.2 *Insulation Resistance* — Immediately afterwards, the samples are immersed, as described in **12.1.1** in water maintained at a temperature of 60 ± 2°C, and the electrodes are again placed in position.

After 2 hours, the insulation resistance of each sample is measured by applying a dc voltage of approximately 500 V between the electrodes, the conductive coating also being connected to the voltage source, but not included in the measuring circuit.

The measurements are made 1 minute after application of the voltage.

The insulation resistance shall not be less than 100 MΩ.

NOTE — The voltage is applied to the conductive coating in order to exclude any leakage current along the exposed surface.

13. EXTERNAL INFLUENCES

13.1 Conduits shall have adequate protection against external influences. The influences included here are ingress of water or oil or building materials, low or high temperatures, corrosive and polluting substances and solar radiation.

NOTE — Tests for low and high temperatures are covered in **9.4**, **9.5** and **10**.

13.2 Ingress of Water — under consideration.

13.3 Ingress of Solid Foreign Bodies — under consideration.

13.4 Corrosion and Polluting Substances

13.4.1 Metal conduits shall be adequately protected against corrosion both outside and inside.

13.4.2 Compliance shall be checked:

a) for conduits with low protection outside and inside by the test given in **13.4.3**,
b) for conduits with medium protection outside and inside by the test given in **13.4.4**, and
c) for conduits with high protection outside and inside by the test given in **13.4.5**.

13.4.3 Samples with conduits of low protection shall be slowly bent round a smooth cylindrical steel mandrel, having a radius of:

10 times the nominal size, for conduits of nominal size not exceeding 25 mm,

12 times the nominal size, for other conduits.

A sheet of cardboard or the like, about 3 mm thick, shall be placed between the conduit and the mandrel.

After the test, the coating of the conduit shall show no damage.

13.4.4 Samples of conduits with medium protection shall be bent as described in **9.2.2** cleaned with a piece of wadding soaked in benzene and then dried.

The bent part of each sample shall be immersed in a solution of 0·75 percent potassium ferricyanide [$K_3Fe(CN)_6$] and 0·25 percent ammonium persulphate [$(NH_4)_2S_2O_8$] in water; a quantity of about 0·1 percent of a suitable wetting agent, for instance a sodium salt of an alkylnaphthaline sulphonic acid, shall be added to the solution.

The solution and the samples be maintained at a temperature of 27 ± 1°C.

Each sample shall be tested separately, a fresh solution being used each time.

After immersion for 5 minutes, the samples shall be removed from the solution and left to dry in air at room temperature.

After the test, the samples shall show not more than two blue coloured spots on each square centimetre of the surface and no spot shall have a dimension larger than 1·5 mm.

Traces of rust on sharp edges and screw threads and any yellowish film removable by rubbing, shall be ignored.

For conduits, the test may be made on the samples which have been subjected to the test of **9.2.**

13.4.5 Samples of conduits with high protection shall be bent as described in **9.2.2**, degreased by immersion in carbon tetrachloride for 10 minutes and wiped dry with a piece of clean soft cloth.

They shall then be immersed in a 2 percent solution of sulphuric acid (H_2SO_4) in water for 15 seconds, thoroughly cleaned in running water and again wiped dry with a piece of clean soft cloth. The bent part of each sample shall be immersed in a solution of copper sulphate ($CuSO_4$, $5H_2O$) in distilled water, having a specific gravity of 1·186 at 20°C. The solution and the samples shall be maintained at a temperature of 27 ± 1°C without stirring.

The solution shall be made by dissolving 360 g of crystalline copper sulphate ($CuSO_4,5H_2O$) in 1 litre of distilled water and neutralizing with copper carbonate or copper hydroxide (about 1 g/l). The specific gravity shall then be checked and adjusted, if necessary.

The container shall be such that it will not react with the solution and shall be of such size that there is a clearance of at least 25 mm between the walls and the sample.

Each sample shall be immersed 4 times in succession in the same solution, each time for 1 minute, a fresh solution being used for each sample.

After each immersion, the sample shall immediately be cleaned in running water with a brush to remove any black deposit.

The sample shall then again be wiped dry with a piece of clean soft cloth and, except after the fourth immersion, returned immediately into the solution.

Care shall be taken to clean out all holes and pockets.

After the test, the samples shall show no precipitation of copper which cannot the scrubbed off in running water, if necessary after immersion in a 10 percent solution of hydrochloric acid (HCl) in water for 15 seconds.

Traces of copper precipitation on screw threads shall be ignored.

For conduits, the test may be made on the samples which have been subjected to the test of **9.2.2**.

13.5 Solar Radiation — under consideration.

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