भारतीय मानक
Indian Standard

IS 16719 : 2022

स्टील पाइप और फिटिंग के बाहरी हिस्से के लिए सॉल्वेंट फ्री पॉलीयूरेथेन कोटिंग्स — विशिष्टि

(पहला पुनरीक्षण)

Solvent Free Polyurethane Coatings for Exterior of Steel Pipe and Fittings — Specification

(First Revision)

ICS 87.040

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Paints, Varnishes and Related Products Sectional Committee, CHD 20

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Paints, Varnishes and Related Products Sectional Committee had been approved by the Chemical Division Council.

This Standard was originally published in 2018 by the title "Polyurethane coatings for the interior and exterior of steel pipe and fittings-Specification". This Standard is being revised, in order to specify the requirements for Polyurethane (PU) coatings for external purpose only in line with international standard EN 10290-2002. For covering the specification of Polyurethane coatings for internal use a separate Standard would be formulated.

This Standard is for the product – Solvent free Polyurethane coatings for exterior of the steel pipe, buried pipes, mounded bullets and fittings. This Standard provides guidance to the industry in selecting and evaluating Polyurethane coatings for steel pipes (for exterior coating of steel pipe transmitting various fluids and gases) and sets optimum requirements for shops or field-applied polyurethane external coating. Consideration should be given to the ability of the coating to resist degradation against weathering in natural sun light (except slight change of colour) and attack by other environmental agents. It is advisable that the purchaser and manufacturer should consult each other for compliance of this standard with reference to their intended use. Other specific tests outside the tests mentioned in the requirement table may be adopted depending on the actual use condition or use environment of the coated pipes based on the mutual agreement between the supplier and the user.

In addition, the following additional requirements have been incorporated in the requirement table 6.6 of the Standard.

1. Pot life/ Gel time
2. Specific electrical Insulation resistance
3. Indentation resistance
4. Infrared scan of cured film
5. Elongation (in free film up to 1.0 mm Dry film thickness (DFT))

Assistance has also been derived from the following international standards in formulation of this standard :

ASTM D 16 Type V — Thermoset, aromatic polyurethane plastic polymer that is the reaction product of diphenyl methane di-isocyanate (M.D.I) resin and polyol resin, polyamine resin or a mixture of polyol and polyamine resin.

(*Continued to third cover*)

Indian Standard

SOLVENT FREE POLYURETHANE COATINGS FOR EXTERIOR OF STEEL PIPE AND FITTINGS — SPECIFICATION

(First Revision)

1 SCOPE

1.1 The standard specifies the requirement of Solvent free Polyurethane coatings method of sampling, test, and handling of materials of solvent free two component, fast curing polyurethane coatings used for external corrosion protection of steel pipeline, mounded bullets and fittings.

1.2 This standard does not deal with the requirements of internal coatings of pipelines carrying various fluids and gases.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

IS No.	*Title*
IS 101 (Part 1/Sec 1) : 1986	Methods of sampling and test for paints, varnishes, and related products — Part 8 Test on liquid paints (General and Physical) Sec 1 Sampling (*third revision*)
IS 101 (Part 8/Sec 5) : 1993	Methods of sampling and test for paints, varnishes, and related products — Part 8: tests for pigments and other solids : Sec 5 Lead restriction test (*third revision*)
IS 1070 : 1992	Reagent grade water — Specification (*third revision*)
IS 9954 : 1981	Pictorial surface preparation standards for painting of steel surfaces

3 TERMINOLOGY

For the purpose of this standard, the following definitions and the definitions given in IS 1303 shall apply.

3.1 Applicator

The organization which undertakes the task of coating application in accordance with the provisions of this standard.

3.2 Manufacturer

Organization responsible for manufacturing of polyurethane coating materials.

3.3 Holiday

The coating imperfections such as pinholes, porosity etc**.** that exhibit electrical continuity to the substrate when measured by a scanning electrode attached to high arc voltage.

3.4 Coating System

The cured solvent free Polyurethane coating film with or without primer applied on a blast cleaned steel surface as per recommended Dry film thickness (DFT) for a specific end use.

4 TYPES

Polyurethane Coating mentioned in the Standard shall be two component, fast setting solvent free coating. The product when mixed as per recommended ratio of base and hardener must have minimum 98 percent non-volatile by weight when checked by as per Annex R (air drying method).

5 COMPOSITION

5.1 The coating and lining system shall consist of thermoset polyurethane prepared from two components :

5.1.1 *Resin/Base Component*

Various kind of polyol or polyamine or mixture of these polyol and polyamine resins together with additives, pigments, catalysts, etc. as per requirement.

5.1.2 *Activator/Hardener Component*

Polymethylene, Polyphenylene Diisocyanate (Polymeric MDI), various pre-polymers as well as mixtures of the two products.

5.2 The mix ratio and pot life should be as per manufacturer's technical data sheet (TDS).

5.3 Exact composition shall vary from product to product and is usually a proprietary formulation of the coating manufacturer.

5.4 Use of Primer

Solvent free Polyurethane coating is applied either directly or over primer on the blast cleaned steel surface. Maximum DFT of primer, if applied, should not be more than 40 μm.

5.6 Class A and class B coating :

The pipe manufacturer shall ensure that the total DFT of applied system must confirm to 1 000 μm for class A category and 1 500 μm for class B category as per the requirement of customer. Both categories must conform to all the test parameters of requirement given in Table 1.

In general class A coating is recommended service temperature varies from -20°C to 40°C and class B is recommended when service temperature varies from -20°C to 60°C. However, the ultimate choice will remain with user.

6. REQUIREMENT

6.1 Application Procedure

The content of both packs should be stirred, unless specified otherwise by the manufacturer, using a suitable device to a homogeneous state prior to mixing or application.

Polyurethane coating system (PUC-system) shall be suitable for application by airless spray machine or plural component airless spray machine at ambient or hot condition as recommended by paint supplier. It should be applied using the method and equipment prescribed by the product manufacturer within the specified pot life/ gel time of the product. Weld joint coatings or repair coatings for touch up may be mixed and applied as per manufacturer's instructions using spray, brush, rollers, or putty knives, as applicable.

In case of field or site application the coating shall not be applied during rain, fog, high humid condition and under condition of condensing moisture on the surface (preferably 5°C above dew point). Erection of suitable canopies, use of heaters, dehumidifiers may be considered to control the application environment during adverse weather conditions. Coated components should not be backfilled until the desired hardness, as recommended by the product manufacturer, is achieved.

The coating layer shall be uniform in appearance and ensure complete coverage of the area to be coated.

6.2 Recoating Properties

Solvent free high reactive Polyurethane coatings applied by plural feed spray should be finished preferably in single step using multiple wet on wet passes. Recoating should be avoided, as far as possible, to mitigate the risk of adhesion failure. If more than one coat has to be applied for reasons of localized damage or touch up, then the identified area should be abraded sufficiently before application of touch up material. The second coat shall be applied within the prescribed specified overcoating time limits and temperature as recommended by the manufacturer. After application of final coat, the coating shall be tested for DFT and degree of cure in accordance with solvent rub test, as prescribed in Annex Q. Necessary care must be taken in the handling of the components prior to the attainment of minimum hardness as recommended by the product manufacturer.

6.3 Consistency

Insert a clean metal rod into the original container and examine the nature of settling, if any. The material shall not be cake hard inside the container. The material shall be in such condition that manual stirring or agitation using mechanical device/power stirrer, produces easily a smooth, homogeneous mass suitable for application by recommended method.

6.4 Keeping Properties

The material shall confirm to all the requirements prescribed at **6.1, 6.2, 6.3, 6.5** and **6.6**, when tested immediately after expiry of shelf-life period declared by the manufacturer. The material shall be stored in original sealed container under shade at ambient atmospheric conditions.

6.5 Lead Restriction

The material shall be tested for restriction from lead in accordance with IS 101 (Part 8/Sec 5). When thus tested the material shall not contain lead or compounds of lead or mixtures of both, exceeding 90 ppm, calculated as Metallic lead.

6.6 The material shall also comply with the requirement given in Table 1.

Table 1 Requirements of Polyurethane Coating System

(Clause 6.6*)*

Sl No.	Characteristics	Requirement	Test Method Annex
(1)	(2)	(3)	(4)
i)	Gel Time, at 27 ± 2°C, min, *Max*	30	A
ii)	Dry Film Thickness, 27 ± 2°C, μm, *Min*		
	(a) For class A coating	1 000	B
	(b) For class B coating	1 500	
iii)	Hardness Shore "D", at 27 ± 2°C, *Min*	65	C
iv)	Electrical continuity	No holidays by spark insulation tester	D
	a) For class A coating, at 8 kV		
	b) For class B coating, at 12 kV		

Sl No.	Characteristics	Requirement	Test Method Annex
(1)	(2)	(3)	(4)
v)	Adhesion Test		
	(a) Pull Off adhesion on 20 mm dolly	To pass 7 MPa	E
	(b) X cut adhesion, rating less than equal to	4	F
vi)	Immersion Test : Tap water, Rating, Max	5	G
vii)	Specific Electrical Insulation Resistance ($\Omega.M^2$) on coated panel, after 100 days , at 50 V		H
	a) For class A coating	$Rs(100d) \geq 10^6$	
	b) For class B coating	$Rs(100d) \geq 10^7$	
viii)	Taber Abrasion Resistance, gm loss, *Max*	100	J
ix)	Impact Resistance at 5 J	No perforation	K
x)	Cathodic disbondment, mm disbondment from incision point, *Max*	8	L
xi)	Indentation resistance, at 25 N, percent, *Max*	30	M
xii)	Flexibility- mandrel test, at 76 mm mandrel	No crack or detachment	N
xiii)	Infrared Scan of cured film, Fourier-transform infrared spectroscopy (FTIR)	Close match to the reference scan	Supplier to provide reference scan at the time of approval
xiv)	Elongation (in free film up to 1.0 mm DFT), percent, *Min*	10	P

Note —

1 All test panels must be prepared on 5 mm thick blast cleaned steel panel with 150 mm X 100 mm dimension. Other dimensions may be used for specific tests as described in text annexure.

2 After applications test panels are to be matured for 7 days at ambient condition prior to commencement of test

3 All tests should be done in duplicate

7 PACKING AND MARKING

7.1 Packing

Unless otherwise specified, the material shall be packed in suitable metal container in two separate packs (base and hardener).

7.2 Marking

7.2.1 Each container shall be marked with the following :

a) Name of the material;

b) Manufacturer's name, logo and recognised trade-mark, if any;

c) Lead content (Max);

d) Net mass or volume of material;

e) Batch number or Lot number in code or otherwise;

f) Month and year of manufacture; and

g) Shelf life of the material.

h) Use of suitable hand gloves, PPE, masks etc. during handling and application

j) A cautionary note as given below :

1) Keep out of reach of children.

2) Dried film of this paint may be harmful if eaten or chewed.

3) This product may be harmful if swallowed or inhaled.

k) Additional information- Manufacturer should also provide all necessary information, instructions and recommended condition for coating application of product along with each consignment of product for bulk supply or individual packaging as applicable.

7.2.2 *BIS Certification Marking*

The product may also be marked with the Standard Mark.

7.2.2.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations made thereunder and as amended time to time. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

8 SAMPLING

Representative samples of the material shall be drawn, as prescribed in IS 101 (Part 1 / Sec 1).

9 TESTS

9.1 Tests shall be conducted according to the methods prescribed in Annex A to Q.

9.2 Quality of Reagents

Unless specified otherwise, pure chemicals and distilled water (*see* IS 1070) shall be used.

NOTE — Pure chemicals shall mean chemical that do not contain impurities which affect the results of analysis

10 COATING APPLICATION ON PIPES

10.1 General

The polyurethane coating system shall be applied in accordance with manufacturer's recommendations. Application by plural component machine is recommended.

10.2 Pipe preparation, Painting and Inspection

10.2.1 *Initial Preparation* — All dirt, contaminants, defect, irregularities shall be removed from the steel surface prior to blasting.

10.2.2 *Blast Cleaning* — Pipe shall be blast cleaned with mineral abrasives, slag abrasives, steel shot or steel grit. The degree of cleanliness shall be minimum Sa 2.5 grade (*See* IS 9954). The anchor profile depth shall not be less than 50 μm.

10.2.3 *Coating Application*

10.2.3.1 Material preparation shall be in accordance with manufacturer's recommendations.

10.2.3.2 *Holdback for field welds*

When pipe sections are to be joined together by field welding, a band, free from lining and coating, shall be left on both side of surfaces at the end of sections. This band shall be of sufficient width as specified by the purchaser to permit making of field joints without damage to lining and coating. The manufacturer shall be consulted for holdback width.

10.2.3.3 *Application temperature*

Coating shall be applied when the component metal temperature is more than 3°C above the dew point temperature. The temperature of the coating material and the pipe at the time of application shall not be lower than 15°C. Preheating of coating material may be carried out using online heaters as per recommendations of the manufacturer. If the ambient temperature goes below 15° C, base/hardener or both is required to be heated when applied by airless spray or plural component machine.

10.2.3.4 *Application of polyurethane coating system*

The polyurethane coating system shall be applied as per recommendations of the manufacturer. If application of more than one coat is required, the subsequent coat shall be applied within the time limits recommended by the manufacturer. If time gap between application of coats exceeded, a repair procedure shall be obtained from the coating manufacturer and recommendations should be followed. Ensure that the temperature and holding time of component prior to coating shall not result in oxidation of the blast cleaned surface leading to visible rust.

10.2.3.5 *Coating Thickness*

Coating thickness shall be in the range of ± 20 percent when tested as per method prescribed in Annex B.

10.2.3.6 *Electrical inspection*

After curing but prior to installation, the coating system applied on the pipe shall be tested for holidays as per the method prescribed in Annex D. Any holiday, indicated by the detector, shall be marked with chalk to identify the area to be repaired. The entire area shall be subjected to electrical inspection.

10.2.3.7 *Adhesion test*

After electrical inspection (*see* **10.2.3.6**), the coated surface is subjected to adhesion (X-cut) test as prescribed in Annex F, followed by adhesion pull-off test either on painted pipe or on painted steel plate painted in the same production line as prescribed in Annex E. The frequency of test shall be one in every 300 square meters.

10.3 Coating Repair

10.3.1 *Defective Coating* — Coating shall be repaired as specified in **10.3.1.1** to **10.3.1.2.**

10.3.1.1 *Surface preparation*

Accessible areas of pipe requiring repair of coating shall be cleaned by removing debris and damaged coating using surface grinders or other means. The adjacent coating shall be feathered by sanding, grinding or other method. Accumulated debris shall be removed by blowing with contaminant free air or wiping with clean rags. Areas not accessible for coating repair, such as interior surfaces of small diameter pipe, shall be reprocessed and recoated as specified in **10.2.3**.

10.3.1.2 *Coating application*

The coating system shall be applied to as specified in **10.2.3** on the prepared surface areas.

10.3.2 *Repair Inspection* — Repaired portion shall be electrically inspected using a holiday detector as prescribed in Annex D.

10.4 Welded Field Joints

10.4.1 *Preparation*

Weld joints shall be cleaned so as to be free from mud, oil, grease, welding flux, weld spatter and other foreign contaminants. Cleaned metal surfaces of weld joints shall be blasted or abraded using rotary abrading pads. The adjacent coating shall be feathered by abrading the coating surface for a distance of 25 mm.

10.4.2 *Electrical Inspection*

After curing, the coating system applied to welding joints shall be tested for holiday as prescribed in Annex D. Holidays indicated shall be marked to identify the area of repair. For factory and site control holiday test should be conducted on every painted pipe.

10.5 Bedding and Trench Back-filling

Back-filling shall be done in a manner that avoids abrasion or other damages to both shop floor and field applied coatings. Where the trench traverses rocky ground containing hard objects that could penetrate the protective coating, a layer of screened earth, sand or rounded river run gravel not less than 150 mm thick with a maximum particle size of 20 mm shall be placed in the bottom of the trench prior to installation of the coated pipe.

ANNEX A

[*Table* 1, *Sl. No.* (i)]

DETERMINATION OF GEL TIME

A-1 GENERAL

This test aims at measuring the length of time from the mixing of two components (base and activator) together of a 2 K thermoset system to the point at which the mixed paint is no longer flowable or usable due to sharp rise in viscosity. During gel time determination the mixed material undergoes cross linking leading to transition from liquid state to semi-solid state or 'gel' state due to chemical reaction. The exothermic nature of this reaction further catalyzes the crosslinking process leading to sharp rise in viscosity. Gel time determination is required for specifying the speed of curing that is required for various application techniques such as handheld twin feed spray or rolling bed spray, snap set spray on screw conveyor and hand mix kits for field joint coating. Temperature of the coating materials, amount of sample taken for testing and room temperature play an important role in Gel time determination and hence must be clearly specified.

A-2 APPARATUS

A-2.1 Disposable mixing cup

A-2.2 Mixing stick or plastic beaker

A-2.3 Mixing rod

A-2.4 Stopwatch

A-2.5 Spatula

A-2.6 Digital Pyrometer/thermometer

A-3 PROCEDURE

Keep both base and activator component in the lab at 27℃ for few hours for conditioning. Ensure temperature of both packs has attained 27 ± 1°C. Cool the packs if temperature is higher. Weigh out accurately requisite quantities of base and hardener as per recommended mixing ratio into a plastic beaker or metal can. The quantities should be adequate to produce 100 gm of mixed material. Pour the base component first into the metal can/ beaker and then the activator. Start the stop watch and mix the two components vigorously with the spatula for 20 s taking care to scrape the sides and the bottom. Viscosity starts rising up rapidly as reaction exotherm begins. After 20 s mixing, lift the flat end of the spatula from the surface of the material about 75 mm. Initially the mixed coating will lift with the spatula and form a liquid vertical 'string'. Gel time is achieved when the coating no longer makes a string and breaks when lifted. Stop the stopwatch and note the time interval in s or min. Record this as the gel time. If mixed material is unable to form string after 20 s then report gel time as below 20 s.

A-4 REPORT

Report the following:

a. Resin and activator temperature in degree Celsius.

b. Surface temperature in degree Celsius.

c. Gel time in seconds.

ANNEX B

[*Table* 1, *Sl. No.* (ii) and *Clause* 10.2.3.5]

MEASUREMENT OF DRY FILM THICKNESS

B-1 GENERAL

The prescribed test method is for checking the thickness of a dried film of coating on a test panel.

B-2 APPARATUS

Magnetically induced thickness measuring gauge.

B-3 PROCEDURE

B-3.1 Number of Measurements

For 9 m^2 test area, five spots per test area (each spot of 4 cm) in diameter shall be selected. Three-gauge readings per spot shall be taken. If the structure is less than 28 m^2, each 9 m^2 should be measured. If the structure is between 28 m^2 and 90 m^2, three 9 m^2 test areas shall be selected randomly and measured. For structures exceeding 90 m^2, three 9 square meter test areas shall be selected randomly for the first 90 m^2 and one test area of 9 m^2 area for each additional 90 m^2 area or less.

B-3.2 OBSERVATIONS

Individual readings taken to get representative measurement shall be unrestricted, but abnormally low or high readings shall be discarded. Spot measurements (average of three readings) shall be within 80 percent of the minimum thickness and 120 percent of the maximum thickness.

ANNEX C

[*Table* 1, *Sl. No.* (iii)]

HARDNESS BY DUROMETER - SHORE "D"

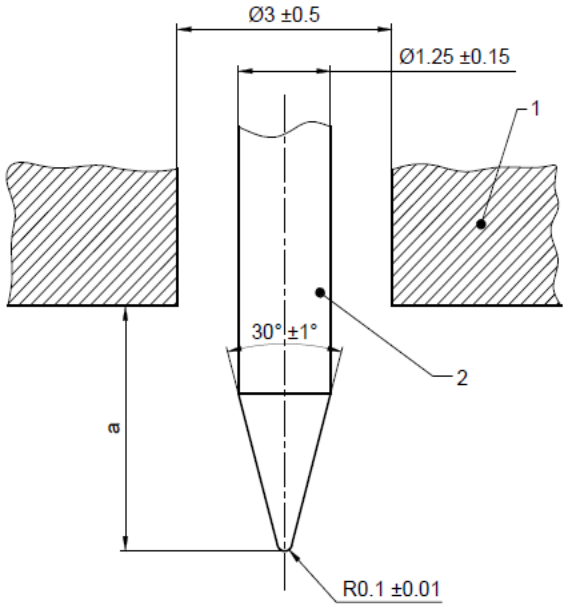
C-1 GENERAL

The prescribed test method is meant for checking indentation hardness of dried paint films applied on a steel substrate with the help of durometer. The Durometer recommended for this test is Type D shore Durometer. A specified indenter is forced into the coated panel under specified conditions and the depth of penetration is measured. Indentation hardness is inversely related to the depth of penetration of indenter into the coated test panel which, in turn, is dependent on the modulus of elasticity and viscoelastic properties of the coating material. This is an empirical test method intended primarily for control purpose. There is no direct relationship between the indentation hardness determined by this method with the fundamental properties of the material being tested.

C-2 APPARATUS

C-2.1 Type D durometer, *see Fig.* 1

Consists of presser foot having hole diameter 3 mm ± 0.5 mm centered at least 6 mm from any edge of the foot and an indenter which is hardened steel rod of diameter 1.25 mm ± 0.15 mm. Indicating device of durometer reads extent of protrusion in terms of unit ranging from 0 to 100



Key

1 presser foot

2 indenter

a full protrusion: 2.5mm ± 0.04 mm

Dimensions in millimetres

Fig. 1

C-3 TEST SPECIMEN

Testing should be carried out on coated MS panel having total thickness of at least 4 mm or above. Ideally the thickness of test panel and applied film should be 5 mm and 1 mm respectively. Coating must be full cured at 30 ºC for 7 days prior to testing.

C-4 : CALIBRATION

The spring of durometer should be calibrated from time to time by the manufacturer.

C-5 : PROCEDURE

Place the test specimen on a hard, horizontal, plane surface. Hold the durometer in a vertical position with the point of the indenter at least 9 mm from any edge of the test specimen. Apply the presser foot to the test specimen as rapidly as possible, without shock, keeping the foot parallel to the surface of the test specimen. Apply just sufficient pressure to obtain firm contact between presser foot and test specimen. Observe reading on indicating device within 15 ± 5 s after presser foot is in firm contact with test specimen. Maximum reading shall be recorded from the gauge. Take 5 measurements of hardness at different position on the test specimen at least 6 mm apart. Determine mean value of reading.

C-6 Results

Average value of indentation hardness should be reported along with coating thickness, temperature, type of durometer used.

ANNEX D

[*Table* 1, *Sl. No.* (iv), 10.2.3.6, 10.3.2 *and* 10.4.2]

ELECTRICAL CONTINUITY (HOLIDAY) TEST

D-1 GENERAL

All the lined / coated pipes shall be tested with an approved high voltage holiday detector, preferably equipped with an audio-visual signalling device, to indicate any faults, holes, breaks or conducting particles in the protective coating.

D- 2 PROCEDURE

D-2.1 The applied output voltage of holiday detector shall have a spark discharge for thickness equal to at least twice the thickness of the coating to assure adequate inspection voltage and compensate for any variation in coating thickness and calculated according to formula prescribed in **D-3**. The electrode shall be passed over the coated surface at approximately half the spark discharge distance from the coated surface only one time at the rate of approximately 10 to 20 m/min. The edge effect shall be ignored. Excessive voltage shall be avoided as it tends to induce holiday in the coated surface, thereby, giving erroneous readings.

D-2.2 While selecting test voltages, consideration should be given to the tolerance on coating thickness and voltage should be selected on the basis of maximum coating thickness likely to be encountered during testing of a particular pipe.

D-3 CALCULATION

The testing voltage shall be calculated by using following formula :

Testing Voltage $V = 7\ 900\ \sqrt{T} \pm 10$ percent, where T is the average coating thickness in mm.

D- 4 RESULT

Record any audio visual sound or spark indicates pinhole, break or presence of conducting particle.

ANNEX E

[*Table* 1, *Sl. No.* (v) (a) and 10.2.3.7]

PULL OFF ADHESION USING PORTABLE ADHESION TESTER

E-1 GENERAL

The test aims to measure the adhesion of a coating to the steel surface by application of a perpendicular negative force to a dolly bonded to the surface of the coating having uniform thickness. Although the aim is to test the tensile stress necessary to break the weakest interface (adhesive failure to the base), failures may take place within the coating (cohesive failure) or interface between the dolly and surface (glue failure) or a mix of these failures. Readings with adhesive failure to the base may be considered as the true adhesion. The pull off load is computed based on maximum indicated load from a calibrated pull off tester and the area stressed. The result may vary between different devices depending on the instrumental parameters.

E-2 APPARATUS

Apparatus shall comprise of the following:

E-2.1 Adhesion (Tensile) Tester

Preferably automatic with self-aligning aluminum dolly, centering device and hydraulically operated. Hand-driven instrument may be used for site testing.

E-2.2 Loading fixtures / test dollies

Usually, aluminum make cylindrical test dollies having a flat surface on one end and a means of attachment to the tensile tester on the other end. Dolly diameter shall be 20 mm for this test standard. If the dolly surface is highly polished roughen the same lightly using an emery paper.

E-2.3 Core cutter or a sharp knife

E-2.4 Adhesives

For securing the fixture to the coating. Adhesive should not affect the coating properties. The most suitable adhesives recommended for this test are two component solvent free epoxies, cyanoacrylates and peroxide-catalyzed polyester adhesives.

E-2.5 Fine scouring pad or fine sandpaper, (400 grit or finer), clean cloth.

E-3 PREPARATION OF TEST SPECIMENS

Apply the coating on a sand blasted steel plate of at least 4 mm thickness having dimension approximately 100 mm X 150 mm. Ensure there is no oil, grease or dust on the blasted test specimen. The coating thickness must be 1000 ± 200 µm and fully cured at the time of testing. Unless a faster cure is specified by the manufacturer, cure the applied film for 7 days at 27 ± 2°C. The test must be conducted at 27 ± 2°C, relative humidity of 50 ± 5 percent.

E-4 PROCEDURE

Very lightly abrade the surface of the dried coating and the surface of the test dolly with scouring pad (preferred) or fine sandpaper and wipe with cloth. Prepare and apply the adhesive in accordance with the manufacturer's instructions. Use the minimum quantity of adhesive required to produce a firm, continuous and even bond between the surface and the test dolly. Remove any excess adhesive immediately if possible. Allow the adhesive to cure for at least 24 h or as specified by the manufacturer.

Use the core cutter or sharp knife for cutting through cured adhesive and the paint coating to the substrate, round the

circumference of the dolly. This is essential when testing thick coatings of this nature. Adhesion test shall be carried on fully cured coating at 20-30 °C temperature. Use standard 20 mm dolly to obtain direct reading from the analogue dial gauge of the self-aligning, Type V adhesion tester. For the 20 mm dolly the pressure reacted by the dolly is the same as pressure in the actuator and is transmitted directly to the pressure gauge. When using digital version of the tester, enter the correct dolly size being used that is 20 mm. When using hand plunger pump type manual machine, apply stress at a rate not greater than 1 MPa/s such that failure of the assembly takes place within 90 s of the initial application of the stress. If the surface curvature causes error in readings, the adhesion will be tested on reference flat steel coupons. Average reading from three randomly selected spots shall constitute one test. Test to be pass if pull of adhesion value is minimum 7 MPa for both class A and class B.

E-5 REPORT

Report the following :

a) Coating thickness.

b) Diameter of dolly

c) Make and model of Pull Off Gauge.

d) Individual readings in MPa and nature of failure (cohesive or adhesive failure)

The following protocol shall be used for determining adhesion test failure / success.

Sl No.	Gauge Reading	Type of Failure	Result / Conclusion
(1)	(2)	(3)	(4)
i)	≥ 7.0 MPa	A/B, B, Y, Y/Z	Coating meets adhesion criteria. Take actual reading of bond strength and record type of failure and percent area to the nearest 10 percent for each failure.
ii)	≤ 7.0 MPa	A/B (> 90 percent adhesive failure between substrate and first coat)	Coating fails adhesion criteria. Remove coating and re-coat.
iii)	≤ 7.0 MPa	B (cohesive failure of first coat)	Allow coating to cure for additional 4 days and re-test.
iv)	≤ 7.0 MPa	Y (cohesive failure of adhesive)	Replace the adhesive and re-test.
v)	≤ 7.0 MPa	Y/Z (adhesive failure between adhesive and dolly)	Roughen, clean dolly and re-test.

ANNEX F

[*Table* 1, *Sl. No.* (v) (b) *and* 10.2.3.7]

X-CUT ADHESION – RESISTANCE TO REMOVAL

F-1 GENERAL

The test consists of determining the adhesion of coating by destructive process. This test is carried out on a painted test specimen applied at approximately 1 mm DFT on a 5 mm Mild steel (MS) panel which has been matured for 7 days at 27 ± 2°C post application.

F-2 APPARATUS

F-2.1 Utility knife, with a stiff straight blade

F-2.2 Steel ruler

F-2.3 Steel rod

F-2.4 Oven

F-3 PROCEDURE

The test area shall consist of any coated area on the component or test piece that is free from all defects and with the correct dry film thickness.

F-3.1 Using a sharp-bladed utility knife against a steel rule if necessary, straight 30 mm to 50 mm cuts shall be made in the coating through to the metal surface to form an X with an angle of approximately 30° at the intersection point.

F-3.2 The point of the utility knife shall be inserted horizontally (that is the flat of the blade) under the coating at the point of intersection of the cuts such that the blade point is at the metal surface.

F-3.3 A levering action against a fulcrum (such as steel rod) shall be used to force the flat point of the blade up from the metal surface describing a single, vertical (that is at 90° to the surface) motion in an attempt to prise the coating off.

F-3.4 The same procedure (from F.3.1 to F.3.3) shall be applied to test the coating at the maximum service temperature. A sample shall be conditioned in an oven for 4 h. Immediately after the removal from the oven, an adhesion test shall be carried out in accordance with the procedure mentioned above. Then the sample shall be maintained at 23 ± 2 °C for 24 h and the adhesion test shall be repeated.

F-4 RESULTS

The adhesion of the coating shall be determined by the following rating system (*see Fig*. 2).

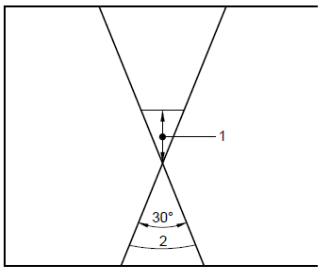


Fig. 2

1 Adhesive loss of coating (rating 1 to 5)

Rating 1 : No removal of coating other than that caused by insertion of the flat point of the knife blade at the intersection point (nominally less than 1 mm).

Rating 2 : Not more than 2 mm of adhesive loss of coating from the metal surface.

Rating 3 : Not more than 3 mm of adhesive loss of coating from the metal surface.

Rating 4 : Not more than 5 mm of adhesive loss of coating from the metal surface.

Rating 5 : More than 5 mm of adhesive loss of coating from the metal surface.

2 Cuts

The rating of the coating adhesion is determined by adhesive failure. Limited cohesive rupture within the coating shall be considered a pass if there is satisfactory adhesion. Cohesive rupture caused by excessive interface or cross-section porosity leaving a noticeable honeycomb structure on the specimen surface shall constitute a failure. For the test at the maximum operating temperature the adhesive loss in millimetres, measured vertically from the intersection point of X-cuts to the adherent coating, not along the X-cuts, shall be recorded (*see Fig*. 2).

ANNEX G

[*Table* 1, *Sl. No.* (vi)]

IMMERSION TEST IN TAP WATER (LOSS OF ADHESION)

F-1 GENERAL

The test consists of determining the resistance to loss of adhesion of the coating by water absorption, a measure of wet adhesion. This test is carried out on a painted test specimen applied at approximately 1 mm DFT on a 5 mm MS steel panel which has been matured for 7 days at ambient condition post application. All sides and edges of the panel shall be coated.

F-2 APPARATUS

F-2.1 Utility knife, e.g.; with a stiff straight blade

F-2.2 Steel rule

F-2.3 Steel rod

F-2.4 Oven

F-3 PROCEDURE

Immerse the sample in tap water for 100 h at 27 ±2°C. Remove, wipe clean and proceed with the test. The test area shall consist of any coated area on the component or test piece that is free from all defects and with the correct dry film thickness. Using a sharp-bladed utility knife against a steel rule if necessary, straight 30 mm to 50 mm cuts shall be made in the coating through to the metal surface to form an X with an angle of approximately 30° at the intersection point. The point of the utility knife shall be inserted horizontally (i.e. the flat of the blade) under the coating at the point of intersection of the cuts such that the blade point is at the metal surface. A levering action against a fulcrum (such as steel rod) shall be used to force the flat point of the blade up from the metal surface describing a single, vertical (that is 90 to the surface) motion in an attempt to prise the coating off.

F-4 RESULTS

The adhesion of the coating shall be determined by the following rating system (*see Fig* 3).

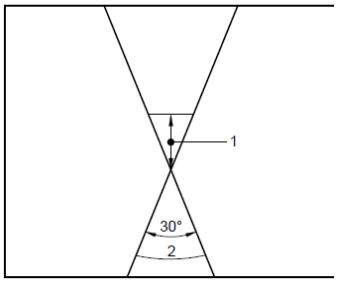


Fig. 3

1 Adhesive loss of coating (rating 1 to 5)

Rating 1 : No removal of coating other than that caused by insertion of the flat point of the knife blade at the intersection point (nominally less than 1 mm).

Rating 2 : Not more than 2 mm of adhesive loss of coating from the metal surface.

Rating 3 : Not more than 3 mm of adhesive loss of coating from the metal surface.

Rating 4 : Not more than 5 mm of adhesive loss of coating from the metal surface.

Rating 5 : More than 5 mm of adhesive loss of coating from the metal surface.

2 Cuts

The rating of the coating adhesion is determined by adhesive failure. Limited cohesive rupture within the coating shall be considered a pass if there is satisfactory adhesion. Cohesive rupture caused by excessive interface or cross-section porosity leaving a noticeable honeycomb structure on the specimen surface shall constitute a failure.For the test at the maximum operating temperature the adhesive loss in millimetres, measured vertically from the intersection point of X-cuts to the adherent coating, not along the X-cuts, shall be recorded (*see Fig* 3).

ANNEX H

[*Table* 1, *Sl. No.* (vii)]

SPECIFIC ELECTRICAL INSULATION RESISTANCE

H-1 GENERAL

The test consists of measuring the specific electrical insulation resistance (electrical resistance of the coating in relation to the surface area of the coated pipe) by exposure to a sodium chloride solution over a period of 100 days.

H-2 APPARATUS

The equipment consists of the following :

a) Supply, direct current (DC) ≥ 50 V

b) Voltmeter, with an accuracy of 0.1 V, and ammeter, with an accuracy of 5 percent, or DC-ohmmeter, with equivalent accuracy

c) Counter electrode (copper), inert, with an area of at least 10 cm^2 and conducting leads for connecting the pipe and electrode to the power supply.

H-3 PREPERATION OF TEST SPECIMEN

Three 0.5 m lengths of pipe of at least 50 mm diameter prepared by blast cleaning the surface to SA 2 ½ with > 50 Microns Anchor Profile, shall be coated in accordance with the manufacturer's instructions. Sprayed sample must be allowed to cure for at least 7 days at minimum 27 °C. The coated area shall be at least 0.03 m^2.

Prepare a 0.1 mol/l sodium chloride (NaCl) solution. Immerse the pipe in one of the two following ways.

a) Place the coated sample horizontally in a plastic container through appropriate holes in the opposite faces of the side walls. Seal the entry of the pipes with a suitable nonconductive sealant. *(See Fig.* 4*).*

b) Seal the coated sample at one end with a suitable non-conductive sealant, ensuring that the metal pipe is prevented from contacting the sodium chloride (NaCl) solution. Place the pipes vertically in the plastic container. *(See Fig.* 5*).*

Alternately, for large diameter pipes, a tank can be attached to the pipe *(See Fig.* 6*).*

H-4 PROCEDURE

Fill the container with the sodium chloride (NaCl) solution. Immerse at least 10 cm^2 of the counter electrode into the solution. Carry out the test at 27 ± 2 °C. For each measurement, connect the positive pole of the direct current supply to the end of the pipe that is not immersed and the negative pole to the counter electrode.

Apply the voltage during measurements only. Measure the resistance using an ohmmeter or record voltage (*U*) and current (*I*) after 1 min. The first measurement shall be taken after three days. Thereafter continue to monitor the measurement at weekly intervals for a total of 100 days.

If the resistance of any one sample falls below the specified value, repeat the test with three new samples. The measured value of the resistance or current is that due only to the current passing through the submersed coating. If this requirement is not met, check for possible current leakage.

H-5 EVALUATION

Calculate the specific electrical resistance, R_S, expressed in ohm square metres, using formula :

$$R_S = U \times A/I = R_1 \times A$$

Where

R_1 is the measured electrical resistance of the submerged sample, expressed in ohms;

U is the voltage between counter electrode and pipe, expressed in volts;

A is the submerged surface area of coating, expressed in square metres;

I is the measured current, expressed in amperes.

Plot a graph of specific electrical resistance against time. Between the 70th day (R_S70) and the 100th day (R_S100), a linear, straight regression line shall be calculated from the measured values. Using the regression line, calculate the ratio of the specific electrical resistance, R_S100/R_S70.

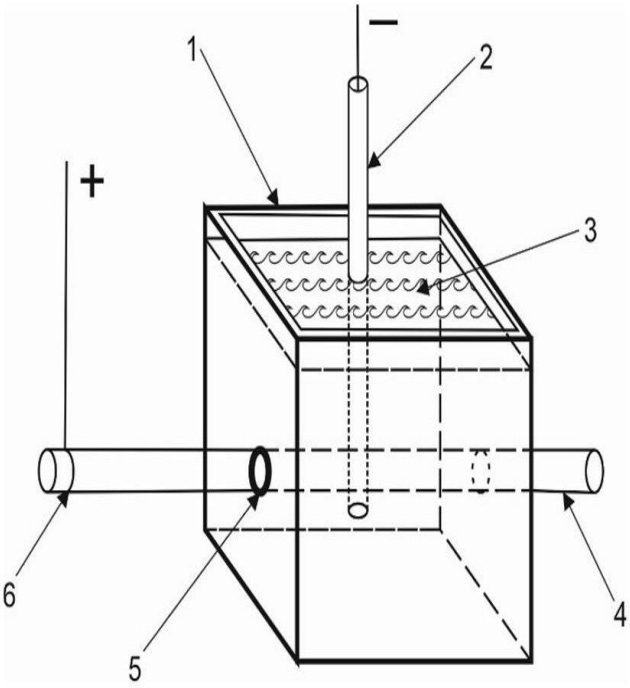


FIG. 4 – HORIZONTAL PIPE PLACEMENT

Key

1	Tank in non-conductive material
2	Copper electrode introduced only at the time of measurement
3	NaCl solution
4	Pipe with Polyurethane Coating
5	Sealing
6	Exposed Steel Pipe

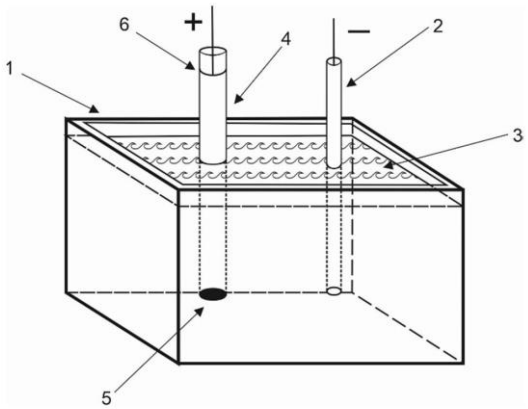


FIG. 5– VERTICAL PIPE PLACEMENT

Key	
1	Tank in non-conductive material
2	Copper electrode introduced only at the time of measurement
3	NaCl solution
4	Pipe with Polyurethane Coating
5	Sealing
6	Exposed Steel Pipe

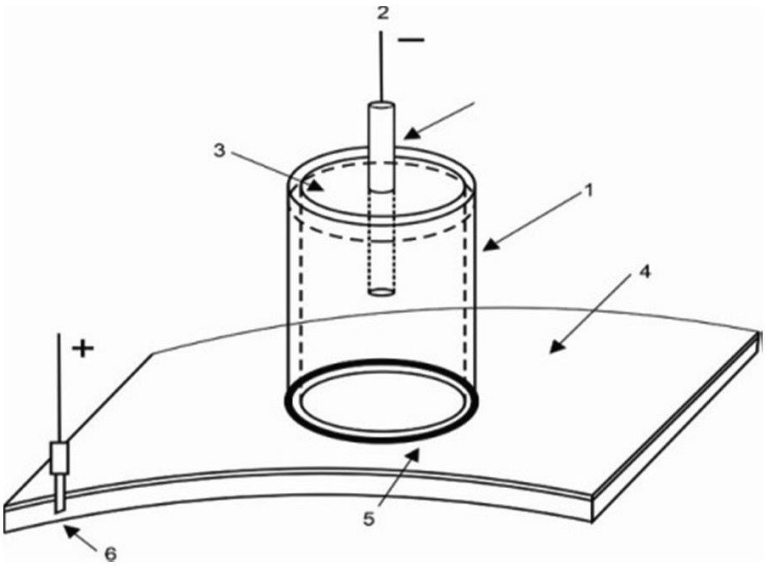


FIG. 6 – LARGE DIAMETER PIPE WITH ATTACHED CELL

Key	
1	Tank in non-conductive material
2	Copper electrode introduced only at the time of measurement
3	NaCl solution
4	Pipe with Polyurethane Coating
5	Sealing
6	Exposed Steel Pipe

ANNEX J

[*Table* 1, *Sl. No.* (viii)]

ABRASION RESISTANCE BY TURNTABLE ABRASION TESTER (TABER ABRASION)

J-1 GENERAL

This test method covers the determination of the resistance of Polyurethane Coating to abrasion produced by the Taber Abraser on coatings applied to a plane, rigid metal surface.

J-2 APPARATUS

J-2.1 Turntable abrasion tester

Consist vacuum suction system and adjustable height vacuum pick-up nozzle of 8 mm diameter to remove debris and abrasive particles from the specimen surface during testing.

J-2.2 Abrasive Wheels, Calibrase CS-17

J-2.3 Resurfacing medium, P 150 abrasive paper disc

J.2.4 Weighing scale, with minimum 200 gm capacity and least count of 0.1 mg.

J-3 PREPERATION OF TEST SPECIMEN

The test panels shall be of steel measuring 100 mm X 150 mm and thickness of 1.00 mm, spray coated with Polyurethane Coating of 900-1100 µm DFT after blast cleaning the surface to SA 2 ½ with > 50 Microns Anchor Profile. The panel shall have a centre hole of 6.5 mm diameter. The test panels shall be flat and free from distortion, and both the front and the back shall be free from any visible ridges.

J-4 CONDITIONING

Sprayed sample must be allowed to cure for at least 7 days at minimum 27 °C. Condition the test specimens for at least 24 h at 27 ± 2°C and 50 ± 5 percent relative humidity, and test in the same environment or immediately on removal therefrom.

J-5 PROCEDURE

Weigh the test specimen to nearest 0.1 mg and record the weight. Mount the test specimen on the abraser with coting side up. Secure using clamp plate and nut. Place the abrading head on the test specimen and the vacuum pick up nozzle. Resurface the CS-17 wheels with P 150 abrasive paper disk by running them 50 cycles against the resurfacing medium. Install the wheels. Add weight totalling 1,000 gm per arm (including weight of arm). Start the vacuum and subject the specimen to 500 cycles, resurface wheel and then another 500 cycles. Remove any loose abrading remaining on the test specimen by light brushing. Reweight the test specimen. Perform three tests on three coated specimens.

J-6 EVALUATION

Evaluate weight loss, L, of the test specimen as follows :

$$L = A - B$$

where

A = Weight of test specimen before abrasion, mg, and

B = Weight of test specimen after abrasion, mg.

Calculate the arithmetic mean of the three specimen and report the value.

ANNEX K

[*Table*1, *Sl. no.* (ix)]

IMPACT RESISTANCE

K-1 GENERAL

The prescribed test method is for determination of energy required to rupture coatings applied to pipe under specified condition of impact from a falling weight.

K-2 APPARATUS

K-2.1 Striker

The apparatus shall consist of a drop weight testing machine comprising : Option 1 : The striker shall consists of body and nose having a combined fixed weight of 1.361 kg and shall be used over a drop range of 0.61 to 1.22 m. The striker nose shall have a 15.87 mm hemispherical head. Option 2 : The striker shall consists of body and nose having a combined fixed weight of 1 ± 0.005 kg and shall be used over a drop height of 0.5 m. The striker nose shall have a 25 mm hemispherical head.

K-2.2 Drop Tube

A tube 1.52 m long shall be used to guide the striker during free fall.

K-2.3 Specimen Holder

The base plate of the apparatus shall include a device for positioning and holding the pipe specimen on line with the axis of the vertical drop tube.

K-2.4 Thickness Gauge, for measurement of coating thickness of test specimen.

K-2.5 Holding Detector, for locating breaks in coating film.

K-3 TEST SPECIMEN

Test specimen shall be coated pipe of 406.4 mm (16 inch) length with 60.325 mm outside diameter

K-4 PROCEDURE

Perform the test at a room temperature of 27 ± 2°C. Use a suitable detector to determine penetration. If the coating film is penetrated on the initial drop, perform the subsequent test at the next lower height increment. If the first specimen does not fail, perform the second test at next higher increment. Calculate the impact resistance as follows :

Impact resistance = weight of striker x falling height

ANNEX L

[*Table* 1, *Sl. No.* (x)]

CATHODIC DISBONDMENT TEST

L-1 General

This test method aims at measuring the extent of disbondment of applied coating layer from the steel substrate of painted pipes or panels which are made cathodically active. The purpose is to simulate the resistance of coated pipes to mitigate corrosion and loss of adhesion (disbondment) under buried /immersed condition which are protected by cathodic current. Cathodic disbondment (CD) is measured by the longitudinal distance between the edge of intentional holiday to the point up till which coating layer can be removed easily with the help of knife due to under film corrosion creep.

L-2 APPARATU

L-2.1 Cathodic disbondment Instrument, *(see Fig.* 7*)*

Instrument shall have stable direct current (DC) power unit, having controlled voltage output between 0 and 10 V and a current capacity sufficient to supply 20 mA to site in circuit. The digital voltmeter shall be capable of reading up to third decimal place and the maximum effective input current shall not be greater than 11 A.

L-2.2 Variable resistor, shall be of 5 KΩ ± 10 percent, 1 W for each test site.

L-2.3 Flaw detector, to detect any flaw like pinholes prior to start of the test.

L-2.4 Reference electrode, of saturated calomel type having formed plug of diameter less than 10 mm for measurement of voltage.

L-2.5 Platinum wire, of diameter 0.8 mm and 75 mm of length to act as anode at each site.

L-2.6 Rigid plastic tube, of 50 mm nominal bore and 60 mm length at each site of coating forming the test cell

L-2.7 Twist drill, for making a 6 mm hole at the middle of the test cell.

L-3 REAGENTS

3.1 Electrolyte — Sodium chloride, 3 percent solution (m/v).

3.2 Indicator — Phenolphthalein indicator for measurement of extent of corrosion at the end of the test.

L-4 PREPARATION OF TEST SPECIMEN

Specimens shall be a 150 mm X 100 mm x 6 mm MS steel panel. Apply uniform coating of polyurethane coating system. Cure the panels for 7 days at 27 ± 2°C before testing.

L-5 PROCEDURE

Test specimens as prepared at L-3 shall be subjected to cathodic disbondment test for 28 days at -1.5 V potential and at 30 ±5°C. For cathodic disbondment test, individual cells shall be made having electrolyte of sodium chloride solution, 3 percent. A hole of 6 mm diameter shall be drilled at the centre of cell to remove the coating material up to the base metal substrate as a pre-damaged area, which acts as a cathode. Platinum electrode shall be used as anode and reference calomel electrode shall be immersed in test cell to measure continuous potential for 28 days.

L-6 ASSESSMENT

Remove plastics tube from each test site and wipe along the surface of the coating using a lint free paper towel and cathode

area material. Make about 8 radial incisions using a sharp knife through the coating to the substrate extending outwards from the holiday for a distance of at least 40 mm. Make these incisions at an angle of approximately 45° from each other. Insert the knife point into the centre portion of the holiday down to the metal substrate. Using a gentle levering action, peel away slowly a radial section of coating continuing until firm adhesion is encountered. As adhesion loss is not always obvious, carefully examine the substrate for sign of residual coating which indicates that disbonding has not occurred. Repeat the same procedure for each radial segment.

L-7 REPORTING

Report the extent of disbonding as average distance between the edge of holiday area and positions of firm adhesion. If the coating is strongly adherent to the substrate, take the average distance at which the coating breaks as the extent of disbonding. The cathodic disbondment test is defined as the arithmetical mean value of the 8 single values. The maximum single value of disbondment and the arithmetical mean value shall not exceed the values given in Table 1.

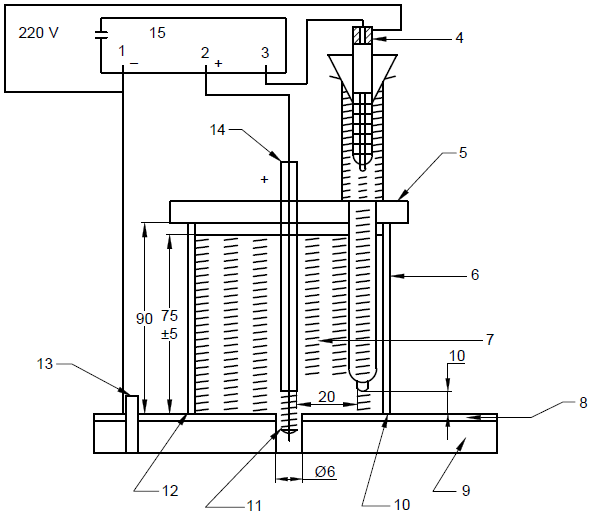


FIG. 7 -CATHODIC DISBONDMENT TEST ASSEMBLY

Key

1.Working electrode

2. Electrode (anode)

3. Electrode (reference)

4. Reference electrode

5. Plastic cover

6. Plastic pipe, minimum internal diameter 50 mm

7. Electrolyte > 150 ml

8. Coating

9. Steel test piece

10.Sealing material

11.Artificial defect

12.Sealing material

13.Electrode (cathode)

14.Platinum electrode of diameter 0.8 mm to 1.0 mm (anode)

15.Potentiostat

ANNEX M

[*Table* 1, *Sl. No.* (xi)]

INDENTATION RESISTANCE

M-1 GENERAL

The test consists of measuring the indentation of a punch into the coating under fixed conditions of temperature and load.

M-2 APPARATUS

M-2.1 Chamber or bath, thermostatically controlled to ± 2°C.

M-2.2 Penetrometer, comprised of the following :

a) A cylindrical punch of 1.8 mm (cross sectional area of 2.5 mm^2) on the top of which is mounted a weight. The assembly, punch plus weight, shall produce a force of 25 N.

b) Dial gauge or any other measurement system, accurate to ± 0.01 mm.

M-3 PREPERATION OF TEST SPECIMEN

The test panels shall be of steel measuring 100 mm X 150 mm and thickness of 4.00 mm, spray coated with Polyurethane Coating of 900-1100 µm DFT after blast cleaning the surface to SA 2 ½ with > 50 Microns Anchor Profile. Measure the DFT at five spots on each panel and record the same to ensure that the panels meet the DFT requirements.

M-4 CONDITIONING

Sprayed sample must be allowed to cure for at least 7 days at minimum 27°C. Condition the test specimens for at least 24 h at 27 ± 2°C and 50 ± 5 percent relative humidity, and test in the same environment or immediately on removal therefrom.

M-5 PROCEDURE

Perform three tests on the coated specimen. Place the test sample, held within the penetrometer assembly, in the thermostatically controlled chamber and set to the test temperature (± 2°C). The test sample shall be kept in the chamber for 1 h.

Make the following readings :

a) t_0 — the reading on the dial gauge placed on an uncovered part of the steel plate or pipe.

b) t_1 — the reading on the dial gauge with the indenter without the mass positioned centrally over the sample.

c) t_2 — the reading of the dial gauge after the mass has been applied, giving the total desired pressure on the indenter for a minimum duration of 24 h.

M-6 EVALUATION

Calculate indentation as under :

Coating Thickness : $t_3 = t_1 - t_0$

Residual Thickness : $t_4 = t_2 - t_0$

Indentation : $t_5 = t_1 - t_2$

The arithmetic mean of the three individual determinations of each of the thicknesses t_3, t_4 and t_5 shall be calculated and reported.

Percentage indentation shall be calculated as under :

$$\frac{t_5}{t_3} \times 100$$

The arithmetic mean shall be calculated and reported.

ANNEX N

[*Table* 1, *Sl. No.* (xii)]

FLEXIBILITY – BEND TEST USING CYLINDRICAL MANDREL

N-1 GENERAL

This test method covers the determination of the resistance to cracking (flexibility) and/ or detachment of the Polyurethane Coating to metal when subjected to bending around a cylindrical mandrel under standard conditions. This is a pass and fail test, by carrying out the test with a 76 mm diameter mandrel to assess compliance with this standard.

N-2 APPARATUS

N-2.1 3 inch diameter pipe (76.2 mm OD) of 60 cm length, firmly affixed on a vice

N.2.2 Safety gloves

N-2.3 Safety goggles

N-3 PREPERATION OF TEST SPECIMEN

The test panels shall be of steel, tinplate, or soft aluminium measuring 100 mm X 150 mm and thickness of 0.80 mm, spray coated with Polyurethane Coating of 500-900 µm DFT after abrading the surface to shiny metal with a coarse grade 40-60 sandpaper. The test panels shall be flat and free from distortion, and both the front and the back shall be free from any visible ridges or cracks. Measure the DFT at five spots on each panel and record the same to ensure that the panels meet the DFT requirements.

N-4 CONDITIONING

Sprayed sample must be allowed to cure for at least 7 days at minimum 27°C. Condition the test specimens for at least 24 hr at 27 ± 2°C and 50 ± 5 % relative humidity, and test in the same environment or immediately on removal therefrom. Test at least three specimens at the specified mandrel diameter and for passing this test readings of two specimens should meet the requirement.

N-5 PROCEDURE

Place the test panel over the mandrel with the uncoated side in contact with the mandrel. Using a steady pressure of the hand, bend the panel approximately 180° around the mandrel at a uniform velocity in a time of around 1-2 seconds. Do not allow ‘tenting’ of the specimen in the middle. Gently remove and evaluate.

N-6 EVALUATION

Use normal corrected vision examines the coating for cracking or detachment from the substrate, ignoring the surface of the coating less than 10 mm from the edge of the panel. Panels showing cracking or detachment shall be deemed to have failed.

ANNEX P

[*Table* 1, *Sl. No.* (xiv)]

DETERMINATION OF PERCENT ELONGATION IN FREE FILM

P-1 GENERAL

The test method is prescribed specifically for determining percent elongation of free film prepared from a coating material under defined conditions. Depending on the tensile strength and tensile modulus of the material (rigid, plastic or composite materials) under test different types of test specimen may be used. In this test method, specimen is extended in universal tensile machine (UTM) along its major longitudinal axis using force at constant speed until specimen fractures or until the stress load or elongation reaches to a predetermined value. During this test the load sustained by the specimen and the elongation at break are measured.

P-2 APPARATUS

P-2.1 Universal testing machine (UTM)

Testing machine should be capable of maintaining testing speed of 1 mm/min to 100 mm/min. Average thickness of the film shall be taken as per test specimen thickness.

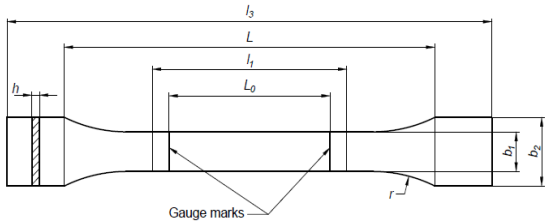
P-2.2 Silicone release paper

P-3 PREPERATION OF TEST SPECIMEN

Cast a free film having average thickness in the range of 1000 ± 200 µm on a silicone release paper using drawdown. The cast length should be more than 150 mm long and 50 mm wide. Allow the film to dry at ambient conditions. For elongation testing cut out a test strip from the casted film as per the dimension indicated below. It is advisable to cut the strip after overnight drying of casted film and then condition the cut out strip.

Specimen Dimension:

The test strip should be dumbbell shaped as per dimensions indicated in the Fig. 8. Make sure the edges are smooth and free from notches.



b_1	Width of narrow parallel-sided portion: 10mm ± 0.2 mm
b_2	Width at ends: 20 mm ± 0.5mm
h	Thickness: ⩽ 1mm
L_0	Gauge length: 50 mm ± 0.5 mm
l_1	Length of narrow parallel-sided portion: 60 mm ± 0.5 mm
L	Initial distance between grips: 115 mm ± 5 mm
l_3	Overall length: ⩾ 150 mm
r	Radius: ⩾ 60 mm

Fig. 8

P-4 CONDITIONING

Free film cut strip must be allowed to cure for at 7 days prior to testing. Condition the test specimens at 27± 2 °C and 50 ± 5 % relative humidity, and then subject it to test. Test at least three specimens of free film test strips for evaluation and for passing this test readings of two specimens should meet the requirement.

P-5 PROCEDURE

Conduct the test at same atmosphere used for conditioning of specimen.

Place the test specimen in the grips and align longitudinal axis of specimen with axis of testing machine. Tighten grips evenly and firmly to avoid slippage of test specimen and movement of grips during test. Set the pull rate to a uniform test speed of 10 mm/min. It is preferable to

unload the test specimen before testing at a different speed, but it is also acceptable to change the speed without unloading after the tensile modulus has been determined. When changing the speed during the test, make sure that the change in speed occurs at strains $\varepsilon \leq 0.3$ percent.

P-6 OBSERVATION

Record increase of gauge length and of the distance between the grips during test

P-7 CALCULATION

Record the displacement between the grips of the machine from the beginning of the test. Calculate nominal strain (Elongation) using :

$$E_t\ (\%) = \frac{L_t}{L} \times 100$$

where

Et is the nominal strain (Elongation), expressed as a dimensionless ratio or percentage;

L is the gripping distance, expressed in millimetres (mm)

L_t is the increase of the gripping distance occurring from the beginning of the test, expressed in millimetres (mm).

ANNEX Q

[*Clause* 6.2]

ASSESSING SOLVENT RESISTANCE OF ORGANIC COATING BY SOLVENT RUB

Q-1 SAMPLE PREPARATION

Take mild steel pipe of 152.4 mm diameter and 304.8 mm length, apply a coat of Polyurethane system and dry the coating to surface dry. Apply another coat of Polyurethane coating. The final coating thickness should be minimum 400 µm. Cure the pipe for minimum 15 days.

Q-2 CHESSECLOTH

100 percent cotton mesh, grade 28 x 24 and size 300 mm x 300 mm and contrasting in colour to the coating being evaluated.

Q-3 PROCEDURE

Select areas on coated surface of at least 150 mm long on which to run the test. Clean the surface with tap water to remove any loose material and allow to dry. Measure dry film thickness of coating in the selected area. Mark 150 mm x 25 mm rectangular test area by pencil or marker pen. Fold cheese cloth into a pad of double thickness and saturate it to dripping wet with methyl ethyl ketone. Place properly protected index finger in the centre of the pad while holding excess cloth with thumb and remaining fingers of the same hand. With the index finger at 45° angle to the test surface, rub the rectangular test area with moderate pressure, first away from operator and then back towards operator. One forward and backward motion (width wise) is one cycle of rubbing and should be completed in 1 second. Continue rubbing the test area for 25 cycles of rubbing. Impact the middle 125 mm of the rubbed area, disregarding 12.5 mm at each end with fingernail. Check for any visual changes in appearance.

Q-4 OBSERVATIONS

Compare the rubbed area with an adjacent area which is not under test. Measure the film thickness of the rubbed area and visually examine the cloth for indications of coating removal. The coating thickness shall not decrease by more than 25 percent of the original film thickness. There shall be no sign of blistering or any other visual defect.

ANNEX R

[*Clause* 4]

DETERMINATION OF NON- VOLATILE CONTENT OF MIX PAINT BY AIR DRYING METHOD

R-1 GENERAL

This method is used to determine the non-volatile content of highly reactive two component material where the one or both the reactive components might tend to evaporate if subjected to NVM measurement at higher temperature before the expiry of pot life.

R-2 APPARATUS

R-2.1 Aluminium Foil

R-2.2 Petri dish

R-2.3 Can lid

R-2.4 Lab Oven

R-3 PROCEDURE

Weigh out an empty clean lid along with a cut out aluminium foil to cover the lid and a glass rod or a metallic pin for mixing. Note this reading (W_1). Weigh out accurately calculated quantity of base and hardener material as per recommended ratio so as to ensure total sample weight of approximately 2-4 gm mix in the can lid. Mix 1 min with the clip and immediately cover the lid with the aluminium foil. Take the weight and record reading (W_2). Keep it at 27 ± 2°C temperature for 1 hr to ensure thorough curing. After 1 hr open the aluminium foil cover carefully and place it in the oven for 1 h at 110 °C Take out the assembly from the oven and cool to room temperature. Then take the second weight (W_3).

R-4 CALCULATION

Percent of Non-Volatile by weight

$$= \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

ANNEX S

(*Foreword*)

COMMITTEE COMPOSITION

Paints, Varnishes and Related Products Sectional Committee**, CHD 20**

Organization	*Representative(s)*
Institute of Chemical Technology, Mumbai	PROF. P A MAHANWAR, ***(Chairman, Chd 20)***
Central Public Works Dept., New Delhi,	SHRI AMAR SINGH SHRI M L PRASAD *(Alternate)*
Ministry of Defence (DGQA)	DR GURBACHAN SINGH SHRI B S TOMAR (*Alternate)*
Ministry of Industry, New Delhi	SHRI NAND LAL
Ministry of Defence, Department of Standardization, New Delhi	LT COL PRAVEEN DEO SHRI V.K.CHHABRA, (*Alternate)*
Office of the Micro Small & Medium Enterprises (MSME), New Delhi	SHRIMATI M ANNABACKIAM SHRIMATI M S RAMMIYA (*Alternate)*
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Harcourt Butler Technical University, Kanpur	PROF. P K KAMANI PROF. ARUN MAITHANI (*Alternate)*
Institute of Chem. Technology, Mumbai	PROF. V. V. SHERTUKADE
Indian Institute of Technology, Mumbai	PROF. SMRUTIRANJAN PARIDA
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Shriram Institute for Indl. Research, Delhi	SHRI A. K. MAJUMDAR

Organization	*Representative(s)*
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Kansai Nerolac Paints Ltd., Mumbai	SHRI LAXMAN NIKAM SHRI MANOJ KUMAR SOMANI (*Alternate)*
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Indian Paints Association, Kolkata	SHRI SUBROTO BANERJEE DR M B GUHA (*Alternate*)
Indian Small Scale Paint Association	SHRI MUKUND HULVALKAR SHRI ASHOK-SHREYAS PATHARE (*Alternate)* (SHRI NIRAV RAVESHIA) (*Alternate)*
Paint and Coating Technologists Association, Kanpur	MR. USHENDRA SINGH MR. VIVEK KUMAR SAXENA (*Alternate)*
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Consumer VOICE	SHRI M A U KHAN
In Personal Capacity	DR. SUNIL KUMAR SAHA
In Personal Capacity	DR. B P MALLIK
Director General, BIS	A K LAL Scientist 'E' And Head (Chd) [Representing Director General, Bis (*Ex-Officio)]*

Secretary

SHRI PUSHPENDRA KUMAR

Scientist 'B', CHD, BIS

Panel responsible for revision IS 16719 CHD 20 : P10

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(*Continued from second cover*)

AWWA C222-2018 PU Coatings and Linings for Steel Water Pipe and Fittings issued by American Water Works Association of America (ANSI/AWWA C222-18).

ISO 21809-3 Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 3: Field joint coatings

The Committee responsible for formulation of this standard is given in Annex S.

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 or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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