*भारतीय मानक*

***Indian Standard***

**IS 16676 : 2024**

# पानी के लिए स्टील पाइप-लाईन के आंतरिक एवं बाहरी सतहों पर उपयोग के लिए सॉल्वेंटलेस लिक्विड एपॉक्सी सिस्टम — विशिष्टि

( *पहला पुनरीक्षण* )

# Solventless Liquid Epoxy System for Application on Interior and Exterior Surfaces of Steel Water Pipeline — Specification

( *First Revision* )

ICS 87.040



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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 first published in 2017, provides guidance to the water industry in selecting and evaluating liquid epoxy coatings for use in water service and sets optimum requirements for linings and coatings used on steel water pipe. Users of this standard are advised to consider additional lining thickness for pipe that handles water containing higher than normal levels of particulates or that operates at higher than normal velocities and also specify the required finished coating. The specified thickness should not exceed the maximum thickness recommended by the coating manufacturer. Consideration should be given to the ability of the coating to resist degradation by ultraviolet light and other atmospheric environmental conditions. It is advisable that the purchaser should consult the manufacturer for specific conditions and limitations of this product.

In recognition of the substantial consequences of volatile organic compounds (VOC) on the environment and human health, this first revision has been taken up to limit the VOC content in paint products. This revision aims to promote the usage of low VOC or VOC-free products, marking a significant step towards fostering a healthier and more sustainable environment. The prescribed limits have been carefully established, taking into account the current capabilities of small, medium, and large-scale manufacturers to produce compliant products. The ultimate goal of these measures is the complete elimination of VOC from paint products. These initial limits are expected to serve as the foundation for future reductions, encouraging manufacturers to develop and adopt innovative technologies and processes that facilitate the production of VOC-free paints.

In addition, the following changes have been made:

a) The maximum limit for lead has been specified considering its adverse impact on human health; and
b) References of Indian Standards have been updated wherever required.

The composition of the Committee, responsible for the formulation of this standard is given in Annex M.

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.

*Indian Standard*

# SOLVENTLESS LIQUID EPOXY SYSTEM FOR APPLICATION ON INTERIOR AND EXTERIOR SURFACES OF STEEL WATER PIPELINE — SPECIFICATION

( *First Revision* )

## 1 SCOPE

**1.1** This standard specifies the requirements for application, method of sampling and test and handling of materials of solventless liquid epoxy system for application on interior and exterior surfaces of steel water pipelines, installed underground or underwater, under normal construction conditions, for corrosion protection.

**1.2** It is suitable for application by airless spray or plural component system machine. It is not intended for use on pipes that will be bent after coating.

**1.3** Solventless system consists of two components; epoxy resin and hardener mainly amide/amines.

## 2 REFERENCES

The standards listed in Annex A 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 edition of these standards.

## 3 TERMINOLOGY

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

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

**3.2 Batch** — Maximum quantity manufactured from the same set of raw materials under the same conditions of manufacturing by the same manufacturer.

**3.3 Batch Certificate** — Certificate of analysis issued by the manufacturer.

**3.4 Component** — Parts of primer and/or finished coating when mixed together form epoxy coating.

**3.5 Coating System** — Mixture of the two components in the proportion recommended by the manufacturer.

**3.6 Holiday** — Coating discontinuity that exhibits electrical conductivity when exposed to a specific voltage.

**3.7 Manufacturer** — Organization responsible for manufacture of coating materials.

**3.8 Volatile Organic Compounds (VOC)** — Is any organic compound having an initial boiling point less than or equal to 250 °C measured at a Standard atmospheric pressure of 101.3 kPa.

## 4 TYPES

**4.1** Solventless liquid epoxy coating system is categorised into the following two types on the basis of nature of the product:

a) *Type* I — Polyamide based; and
b) *Type* II — Amine based.

**4.2** The material used in both, primer and finishing coat(s) shall be produced by the same manufacturer.

**4.3** Polyamide based epoxy coating system shall be used for internal lining of drinking water pipeline. Drinking water shall conform to the requirements specified in Table 2 of Annex K when tested in accordance with the method of test prescribed therein.

## 5 FINISH

The material may either be in mat finish or glossy finish, as agreed between the purchaser and the manufacturer.

## 6 REQUIREMENTS

### 6.1 Condition

The material shall be free from lumps, skins and shall become homogeneous on stirring. The components of the epoxy coating system shall be stored in original sealed containers under the conditions prescribed by the manufacturer.

### 6.2 Thinning

For ease of spray coating application of the product, it is recommended that the coating material may be thinned by adding thinner, as recommended by the manufacturer.

### 6.3 Application Properties

Solventless liquid epoxy coating system shall be suitable for application by airless spray machine or plural component machine.

### 6.4 Recoating Properties

The solventless liquid epoxy coating system shall be applied in accordance with the manufacturer's recommendations. If more than one coat is applied, the second coat shall be applied within the prescribed time limits, surface conditions and temperature recommended by the manufacturer. After application, the coating shall be tested for cure in accordance with solvent rub test prescribed in Annex J. The coating shall not exhibit colour separation, sagging, pitting, flaking or cracking and also confirm to the observations of **J-4**.

### 6.5 Consistency

Insert a clean metal rod or palette knife in the original container and examine the nature of settling. The material shall not cake hard inside the container and shall be in such condition that stirring using mechanical device/power stirrer easily produces a smooth uniform paint suitable for application by appropriate method.

### 6.6 Lead Restriction

The material shall not contain lead or compounds of lead or mixtures of both, as metallic lead more than 90 ppm, when tested for restriction from lead in accordance with IS 101 (Part 8/Sec 5).

### 6.7 Keeping Properties

The material shall confirm to all the requirements specified **6.1** to **6.5** and **6.8,** when tested immediate after expiry of shelf life period declared by the manufacturer. The material shall be stored in original sealed container under normal atmospheric conditions.

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

## 7 PACKING AND MARKING

### 7.1 Packing

Unless otherwise specified, the material shall be packed in suitable metal container in dual pack (base and hardener).

### 7.2 Marking

**7.2.1** Each container shall be marked with the following

a) Name of the material;

b) Manufacturer name and his recognised trademark, if any;

c) Lead content, *Max*;

d) The maximum content of VOC in g/l of the product as supplied in container;

e) Net mass or volume of material;

f) Batch number or lot number in code or otherwise;

g) Month and year of manufacture;

h) Shelf life of the material;

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; and

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

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(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed there under, and the products may be marked with the Standard Mark.

## 8 SAMPLING

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

## 9 TESTS

**9.1** Tests shall be conducted according to the methods prescribed in Annexes B to Annex J.

**Table 1 Requirements of Solventless Liquid Epoxy Coating System**

(*Clause* 6.8)

| Sl No. | Characteristic | Requirement | Methods of Test, Ref to |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | Thickness, dry film, micron , *Min* | 400 | Annex B |
| ii) | Electrical insulation (holidays) | Passes the test | Annex C |
| iii) | Adhesion test | | |
| | a) Tape test | Passes the test | Annex D |
| | b) Pull off test, MPa , *Min* | 5 | Annex E |
| iv) | Immersion and vapour phase, 30 days<br>a) De-ionized water pass<br>b) Sulphuric acid pass 1 percent by weight.<br>c) Sodium hydroxide pass 1 percent by weight | No blistering, peeling or detaching of coated film from substrate | Annex F |
| v) | Abrasion resistance, mg , *Max* | 125 | Annex G |
| vi) | Cathodic disbondment test, mm radius, *Max* | 6.0 | Annex H |
| vii) | Solvent rub test, *Max* | Thickness reduction 25 percent | Annex J |
| viii) | Drinking water test | Passes the tests for requirements prescribed at Table 2 of Annex K | Annex K |
| ix) | Volatile organic compound, gm/litre, *Max* (*see* Notes) | 50 | IS 101 (Part 2/Sec 4) |

NOTES

**1** It is In-can VOC as supplied by manufacturer, without including any thinner. Since the amount of thinner used on-site can vary depending on the application method (brushing, spraying, etc), it can be challenging to precisely track the extent of thinning during application.

**2** VOCs of colorant added at Point of Sale- The VOC content of product including the colorant added at the point-of-sale shall not exceed 50 grams per litre over and above the allowed VOC limit of product without colorant.

**3** For the calculation of the VOC content, for solvent and water-based paints, Method 2 and Method 3 may be employed respectively as given in the IS 101 (Part 2/Sec 3) or IS 101 (Part 2/Sec 4).

### 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

### 10.1 General

The solventless liquid epoxy coating system shall be applied in accordance with manufacturer's recommendations. Application by airless spray or plural component machine is recommended.

### 10.2 Pipe Preparation

**10.2.1** *Initial Preparation*

All dirt, contaminants, defect, irregularities shall be removed prior to blasting.

**10.2.2** *Blast Cleaning*

Pipe shall be blast cleaned with mineral abrasives, slag abrasives, steel shot or steel grit. Minimum Sa 2.5 grade of blast to be followed (*see* IS 9954 and ISO 8501-1). The anchor profile depth should not be less than 50 microns.

**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 the inside and outside 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 metal temperature is more than 3 °C above the dew point temperature. The temperature of the mixed coating material and the pipe at the time of application shall not be lower than 10 °C. Pre-heating of coating material and use of online heaters to heat the coating material may be done on the recommendations of the manufacturer.

**10.2.3.4** *Application of epoxy coating system*

The solventless liquid epoxy coating system shall be applied as per recommendations of the manufacturer. If more than one coat is applied, the second coat shall be applied within the time limits recommended by the manufacturer. If the period between coats is exceeded, a repair procedure shall be obtained from the coating manufacturer and recommendations followed.

**10.2.3.5** *Coating thickness*

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

**10.2.3.6** *Electrical inspection*

After curing but prior to installation, the coating system applied to the pipe shall be tested for holidays as per the method prescribed in Annex C. 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 (cross-cut) test as prescribed in Annex D, followed by adhesion pull-off test as prescribed in Annex E. The frequency of test shall be one in every ten pipes.

**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 coating repairs shall be cleaned to remove 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 C.

**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 C. Holidays indicated shall be marked to identify the area of repair.

**10.5 Bedding and Trench Back-filling**

Back-filling shall be done in a manner that avoids abrasion or other damage to both factory 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

(*Clause 2*)

## LIST OF REFERRED STANDARDS

| *IS No.* | *Title* | *IS No.* | *Title* |
|---|---|---|---|
| IS 101 | Methods of sampling and test for paints, varnishes and related products: | IS 9954 : 1981 | Pictorial surface preparation standards for painting of steel surfaces |
| (Part 1/Sec 1) : 2023 | Test on liquid paints (general and physical), Section 1 Sampling (*fourth revision*) | IS 10163 (Part 1) : 1982 | Recommended methods of tests for the determination of dielectric properties of insulating materials at frequencies above 300 MHz: Part 1 General |
| (Part 3/Sec 2) : 1989 | Tests on paint film formation, Section 2 Film thickness (*third revision*) | IS 10221 : 2008 | Coating and wrapping of underground mild steel pipelines — Code of practice (*first revision*) |
| (Part 8/Sec 5) : 2022 | Tests for pigments and other solids, Section 5 Lead restriction test (*fourth revision*) | IS 10500 : 2012 | Drinking water — Specification (*second revision*) |
| IS 1070 : 2023 | Reagent grade water specification (*fourth revision*) | IS 11755 : 1986 | Methods of test for the determination of electrical resistance and resistivity of insulating materials at elevated temperatures |
| IS 1303 : 1983 | Glossary of terms relating to paints (*second revision*) | IS 15337 : 2003 | Coal tar based anticorrosion tape for protection of underground mild steel pipelines — Specification |
| IS 3589 : 2001 | Steel pipes for water and sewage — Specification (*third revision*) | | |
| IS 5083 : 2023 | Knifing stopper for railway coaches — Specification (*third revision*) | | |

## ANNEX B

[*Clauses* 9.1 *and* 10.2.3.5 and *Table* 1, *Sl No.* (i)]

## MEASUREMENT OF DRY FILM THICKNESS

### B-1 GENERAL

Prescribes method for checking whether thickness of a dried film of coating on a test panel lies within the specified limits.

### B-2 EQUIPMENT

Magnetically induced thickness measuring gauge.

### B-3 PROCEDURE

#### B-3.1 Number of Measurements

For 9.29 $m^2$ test area, five spots per test area (each spot of 3.8 cm) in diameter shall be selected. Three gauge readings per spot shall be taken. If the structure is less than 27.87 $m^2$, each 9.29 $m^2$ should be measured. If the structure is between 27.87 and 90.29 $m^2$, three 9.29 $m^2$ test areas shall be selected randomly and measured. For structures exceeding 90.29 $m^2$, three 9.29 $m^2$ test areas shall be selected randomly for the first 90.29 $m^2$ and one test area of 9.29 $m^2$ area for each additional 90.29 $m^2$ 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

[*Clauses* 9.1, 10.2.3.6, 10.3.2 *and* 10.4.2 and *Table* 1, *Sl No.* (ii) ]

## ELECTRICAL INSULATION (HOLIDAY) TEST

### C-1 GENERAL

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

### C-2 PROCEDURE

**C-2.1** The applied output voltage of holiday detector shall have a spark discharge of thickness equal to at least twice the thickness of the coating to assure adequate inspection voltage and compensate for any variation in coating thickness. 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 m/min 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.

**C-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.

### C-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.

### C-4 RESULT

Any audio visual sound or spark indicates pinhole, break or presence of conductive particle.

## ANNEX D

[*Clauses* 9.1 *and* 10.2.3.7 and *Table* 1, *Sl No.* (iii)(a)]

## ADHESION TAPE TEST

### D-1 GENERAL

This method is used to evaluate adequacy of adhesion of coating to a substrate.

### D-2 APPARATUS

**D-2.1 Cutting Tool** — sharp razor blade, scalpel, knife or other cutting devices. It is of particular importance that the cutting edges be in good condition.

**D-2.2 Cutting Guide** — steel or other hard metal straightedge to ensure straight cuts

**D-2.3 Tape** — twenty five mm wide, semi-transparent pressure-sensitive tape with an adhesion strength of (44.6 ± 2.8) g/mm. The backing of the tape may consist of fibre-reinforced cellulose acetate, unplasticized poly vinyl chloride or polyester film.

**D-2.4 Rubber Eraser** — on the end of a pencil

**D-2.5 Illumination** — a light source is helpful in determining whether the cuts have been made through the film to the substrate.

### D-3 TEST SPECIMEN

The surface of the substrate shall be cleaned either by shot or grit blasting. One coat of epoxy primer (red oxide) shall be applied by brush/airless spray machine and allowed to dry for at least 12 h. Solventless epoxy coating shall be applied by brush or by airless spray in one coat or multiple coats, depending on the thickness required. Recoating time shall be min 12 h.

### D-4 PROCEDURE

Select an area free of blemishes and minor surface imperfections. Make two cuts in the film, each about 40 mm long, that intersect near the middle with an angle between 30° and 45°. Inspect the incisions for reflection of light from the metal substrate to establish that the coating film has been penetrated. Smooth the tape into place by finger in the area of the incisions and then rub firmly with the eraser on the end of a pencil.

### D-5 OBSERVATION

The material shall be deemed to have passed the test if the coating does not separate from the substrate cleanly and the coating remains attached to the substrate.

## ANNEX E

[*Clauses* 9.1 *and* 10.2.3.7 and *Table* 1 *Sl No.* (iii)(b)]

## ADHESION PULL-OFF TEST

### E-1 PRINCIPLE

The general pull-off test is performed by securing a loading fixture (dolly, stud) normal (perpendicular) to the surface of the coating with an adhesive. After the adhesive is cured, a testing apparatus is attached to the loading fixture and aligned to apply tension normal to the test surface. The force applied to the loading fixture is then gradually increased and monitored until either a plug of material is detached, or a specified value is reached. When a plug of material is detached, the exposed surface represents the plane of limiting strength within the system. The pull-off strength is computed based on the maximum indicated load.

### E-2 APPARATUS/INSTRUMENT

#### E-2.1 Adhesion Tester

It consists of three basic components, a hand wheel; a black column containing a dragging indicator pin and scale in the middle, a base containing three legs and a pulling jaw at the bottom; and dollies (test pull studs).

### E-3 PROCEDURE

#### E-3.1 Preparation of Test Surface

Once test area is selected, it shall be free of grease, oil, dirt and water. The area should be flat and large enough to accommodate the specified number of replicate tests.

#### E-3.2 Prepare of Dolly (Test Pull Stud)

The dolly is a round, two-sided aluminium fixture. Both sides of the dolly look the same. However, one side is sloped on top surface while being flat on bottom surface. As the surface of the dolly is polished aluminium, roughen the same using a coarse sand paper.

**E-3.3 Selection of Adhesive**

Use 100 percent solid epoxy adhesive. This adhesive requires curing of at least 24 h at room temperature.

**E-3.4** Attach the dolly to the surface. Using a wooden stick, apply an even layer of adhesive to the entire contact surface area of the dolly. Carefully remove the excessive adhesive by using cotton swab. Allow the adhesive to fully cure before performing the adhesion test. Attach the dolly to the coated surface and gently push downward to displace any excessive adhesive. Push the dolly inward against the surface and apply tape across the head of the dolly.

**E-3.5 Scoring**

Tape of scoring around the base of dolly prior to testing is not recommend. Scoring may produce tiny factures in the coating or may generate friction heat, which can change the properties of coating and result in lower adhesion values.

**E-3.6 Adhesion Test**

Attach the adhesion tester to the dolly by rotating the hand wheel counter clockwise to lower the jaw of the device. Slide the jaw completely under the head of the dolly. Position three legs of the instruments so that they are sitting flat on the coated surface. Slide the dragging indicator pin on the black column to zero by pushing it downward. Firmly hold the base of the instrument in one hand and rotate the hand wheel anti-clockwise to raise the jaw of the device that is attached to the head of the dolly. The dragging indicator pin will move upward on the black column as the force is increased and will hold the reading. Apply tension at moderate speed. Continue to increase tension on the head of the dolly until (a) the minimum tension required as per the purchase specification is exceeded and the test is discontinued; (b) the maximum tension of adhesion tester has been achieved and dolly is still attached; and (c) the force applied by the adhesion tester causes the dolly to dislodge.

**E-4 RESULT**

The black column near the middle of the adhesion tester contains two scales and a dragging indicator pin in between. The dragging indicator pin will hold the reading until pushed back to zero. When the end point of the test is achieved, read the scale across the bottom of the dragging pin and record the adhesion value.

## ANNEX F

[*Clause* 9.1 and *Table* 1, *Sl No.* (iv)]

## TEST FOR IMMERSION IN VAPOUR PHASE 30 DAYS

Steel panels of dimensions (50 mm × 150 mm × 3.2 mm) shall be prepared, coated and cured as prescribed in **10.2**. The uncoated side and edges shall be sealed with hot wax or other resistant material. Suitable containers shall be filled to a depth of (100 mm), one with de-ionized water, one with 1 percent (*w*/*v*) solution of sulfuric acid and one with 1 percent (*w*/*v*) solution of sodium hydroxide. The panels shall be placed in the containers to allow exposure to both the liquid and vapour phases of the fluids. If multiple panels are placed in the same container, a distance of at least (25 mm) shall be maintained between panels. The containers shall be covered, but not sealed, and allowed to stand at (27 ± 2) °C for 30 days, maintaining liquid levels as required. The panels shall be removed, rinsed, and allowed to dry for 24 h. The occurrence of any blistering, peeling or disbondment shall be considered as failure in the test.

## ANNEX G

[*Clause* 9.1 and *Table* 1, *Sl No.* (v)]

## ABRASION RESISTANCE OF EPOXY COATING BY THE TABER ABRASER

### G-1 APPARATUS

Wheel number CS–10 or CS–17, as required, shall be used. Acceptable hardness for both types of wheel is (81 ± 5) shore D. A vacuum pick-up assembly, consisting of vacuum unit, variable transformer suction regulator, nozzle with bracket attachment and connecting hose with adaptor, shall be used.

### G-2 PREPARATION OF TEST SPECIMEN

Apply uniform coating of material to be tested. Specimens shall be a 4" × 4" square panel with rounded corner and ¼" (6.3 mm) hole centrally located on each panel. Prepare minimum two coated panels of the material.

### G-3 STANDARDIZATION

Mount the CS wheels on their respective flange holders. Adjust load on the wheels to 1 000 g.

### G-4 CONDITIONING

Condition the coated panels for at least 24 h at (27 ± 2) °C and (65 ± 5) percent RH.

### G-5 PROCEDURE

Weigh the test specimen to the nearest 0.1 mg and record the weight. Mount the test specimen on the turntable. Place the CS wheel on the test film and the vacuum pick up nozzle. Set the counter and suction regulator. Start the vacuum pick-up and turntable of CS wheel. Subject the test specimen to abrasion for 1 000 cycles. Remove any loose abrasions remaining by light brushing. Reweigh the test specimen. Repeat the test for additional test specimen.

### G-6 CALCULATION

Weight loss is calculated by the formula, $L = A - B$

where

$A$ = mass of test specimen before abrasion in mg; and

$B$ = mass of test specimen after abrasion in mg.

## ANNEX H

[*Clause* 9.1 and *Table* 1, *Sl No.* (vi)]

## CATHODIC DISBONDMENT TEST

### H-1 APPARATUS

#### H-1.1 Instrument

The instrument shall have stable DC power unit, having controlled voltage output between 0 and 10 V and a current capacity sufficient to supply 20 mA simultaneously to each 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.

**H-1.2** Variable resistor shall be of 5 kΩ ± 10 percent, 1 W for each test site.

**H-1.3** Flaw detector to detect any flaw like pinholes prior to start of the test.

**H-1.4** Reference electrode of saturated calomel type having formed plug of diameter less than 10 mm for measurement of voltage.

**H-1.5** Platinum wire of diameter 0.8 mm and 75 mm of length to act as anode at each site.

**H-1.6** Rigid plastic tube of 50 mm nominal bore and 60 mm length at each site of coating forming the test cell.

**H-1.7** Twist drill for making a 6 mm hole at the middle of the test cell.

### H-2 REAGENTS

**H-2.1 Electrolyte** — sodium chloride, 3 percent solution (*m*/*v*).

**H-2.2 Indicator** — phenolphthalein indicator for measurement of extent of corrosion at the end of the test.

### H-3 PROCEDURE

Test samples of solventless liquid epoxy coating

systems shall be subjected to cathodic disbondment test for 28 days at – 1.5 V potential and at (30 ± 5) °C. For cathodic disbondment test, two individual cells shall be made having electrolyte concentration of sodium chloride solution, 3 percent. A hole of 6 mm diameter shall be drilled at the centre of each cell to remove the coating material upto 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 each test cell to measure continuous potential for 28 days.

### H-4 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 two parallel incisions through the coating, 12.5 mm apart across the panel, so as to include the pre-damaged area. The cuts should extend 50 mm on each side of the pre-damaged area. Using a square ended pellet knife, insert it in the centre portion of the pre-damaged area, between the parallel cuts, down to the metal. Using a gentle levering action, lift the strip of coating, if possible, with a slow peeling action and grip the coating between the blade and thumb and continue the peeling action until the coating breaks. Repeat the peeling test in the opposite direction and then repeat the procedure at an angle of 90° to the first test. Apply one spot of phenolphthalein indicator to the exposed metal surface at the outside edge and allow it to flow towards the pre-damaged area. The purple boundary indicates the extent of disbonding.

### H-5 REPORTING

Report the extent of disbonding as the radius in millimetres from the edges of the pre-damaged areas. Alternatively, if the coating is strongly adhering to the steel substrate, take the average distance at which the coating breaks as the extent of disbonding. The extent of disbonding shall not be more than 6.0 mm radius from the edge of the 6 mm holiday.

## ANNEX J

[*Clause* 6.4 *and Table* 1, *Sl No.* (vii)]

## ASSESSING SOLVENT RESISTANCE OF ORGANIC COATING BY SOLVENT RUB

### J-1 SAMPLE PREPARATION

Take mild steel pipe of 6" dia and 12" length, coat the same with solventless liquid epoxy system to minimum 400 micron. Cure the pipe for minimum 15 days.

### J-2 CHEESE CLOTH

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

### J-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 × 25 mm rectangular test area by pencil or marker pen. Fold cotton 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 is one double rub and should be completed in 1 s. Continue rubbing the test area for 25 double rubs. 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.

### J-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 K

[*Clauses* 4.3 *and* 9.1 and *Table* 1, *Sl No.* (viii)]

## REQUIREMENT FOR DRINKING WATER

### K-1 SAMPLE PREPARATION

Take mild steel pipe of 63 diameter and 123 length and coat the same with solventless liquid epoxy system to minimum 400 micron. Cure the same for minimum 15 days. Wash the pipes with drinking water and dry the same.

### K-2 PROCEDURE

Pass drinking water (*see* IS 10500) through the pipe for 30 days continuously or otherwise hold drinking water inside the coated pipe for 30 days at ambient temperature. After 30 days, collect the water and test the same for the requirements prescribed in Table 2 as per the method of test prescribed in IS 10500.

**Table 2 Requirement for Drinking water**

[*Clause* 4.3 *Table* 1, *Sl No.* (viii)]

| Sl No. | Parameter | Desirable Limit | Permissible Limit |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | *p*H | 6.5 to 8.5 | No relaxation |
| ii) | Turbidity (NTU) | 1 | 5 |
| iii) | Total hardness (as $CaCO_3$), mg/l | 200 | 600 |
| iv) | Chloride (Cl) mg/l | 250 | 1 000 |
| v) | Nitrate (as $NO_3$), mg/l | 45 | 100 |
| vi) | Iron (as Fe), mg/l | 0.3 | 1.0 |
| vii) | Arsenic (as As), mg/l | 0.05 | No relaxation |
| viii) | Fluoride (as F), mg/l | 1.0 | 1.50 |
| ix) | Total coliform (CFU/100 ml) | Absent | Absent |
| x) | Faecal streptococci CFU/100 ml) | Absent | Absent |
| xi) | Odour | Agreeable | Agreeable |
| xii) | Taste | Agreeable | Agreeable |

## ANNEX M

(*Foreword*)

## COMMITTEE COMPOSITION

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