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For Comments Only

भारतीय मानक ब्यूरो

DRAFT FOR WIDE CIRCULATION

भारतीय मानक प्रारूप

Draft Indian Standard

मृदु इस्पात की पानी की पाइप लाइनों के लिए कोल्ड एप्लाइड (पॉलीथीलीन / पॉलीओलफिन) टेप कोटिंग – विशिष्टि

COLD APPLIED (POLYETHYLENE / POLYOLEFIN) TAPE COATING FOR MILD STEEL WATER PIPELINES — SPECIFICATION

ICS 25.220.01

Corrosion Protection and Finishes Sectional Committee, MTD 24

Last date for receipt of comments is **13/04/2023**

FOREWORD

(Formal clauses of the foreword will be added later.)

This draft standard is being formulated to serve as a guide for corrosion protection of underground mild steel pipelines by using cold applied polyethylene/polyolefin tape coating systems with the reasoning and proven performance that if the metal can be isolated with the surrounding earth, corrosion is controlled.

This standard defines cold-applied tape coating systems in terms of its performance or its ability to provide long terms corrosion protection. This standard is intended for use in exterior coating of steel pipelines for underground or underwater installation under normal conditions. This standard is based on best- known experience, but is not intended for unqualified use under all conditions. Cold applied tape coating systems usage for any installation must be reviewed by the purchaser.

If an extended period of aboveground storage of coated pipe is anticipated, the ability of coating to resist degradation by UV light and other atmospheric and environmental conditions should be considered.

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.

Draft Indian Standard

COLD APPLIED (POLYETHYLENE / POLYOLEFIN) TAPE COATING FOR MILD STEEL WATER PIPELINES - SPECIFICATION

1 SCOPE

This standard specifies the requirements for qualification, application, testing, handling of plant applied and constant tension hand wrapped polyethylene / polyolefin tape coating for external corrosion protection of MS water pipeline. Normally prefabricated polyolefin tapes are applied as a three-layer system consisting of:

a) liquid adhesive,
b) corrosion preventive tape (inner layer), and
c) mechanical protective tape (outer layer).

2 REFERENCES

2.1 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 agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
IS 101 (Part 1/Sec 6) : 1987	Method of sampling and test for paints, varnishes and related Products : Part 1 Tests on liquid paints (general and physical) Sec 6 : Flash point (*third revision*)
IS 1954 : 1990	Determination of length and width of woven fabric — Methods (*second revision*)
IS 3589 : 2001	Steel pipes for water and sewage (168.3 to 2 540 mm outside diameter) — Specification (*third revision*)
IS 10810 (Part 6) : 1984	Methods of test for cables : Part 6 Thickness of thermoplastic and elastomeric insulation and sheath

2.2 The technical committee responsible for the preparation of this standard has reviewed the provisions of following International Standards referred in these adopted standards and decided their acceptability for use in conjunction with this standard.

ISO No.	*Title*
ISO 8501-1:2007	Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings

ISO 8502-3 : 2017	Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
ISO 8502-9 : 2020	Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 9: Field method for the conductometric determination of water-soluble salts
ISO 8503-4 : 2012	Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile — Stylus instrument procedure
ISO 8503-5 : 2017	Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 5: Replica tape method for the determination of the surface profile
ISO 11124-1:2018	Preparation of steel substrates before application of paints and related products — Specifications for metallic blast-cleaning abrasives — Part 1: General introduction and classification
ISO 11126-1 : 2018	Preparation of steel substrates before application of paints and related products — Specifications for non-metallic blast-cleaning abrasives — Part 1: General introduction and classification

3 COMPOSITION OF THE COATING SYSTEM

The coating system shall consist of at least three layers.

a) Butyl rubber-based adhesive / primer,
b) Inner layer tape,
c) Intermediate layer tape (for type B coating system), and
d) Outer layer tape (for type A or type B coating system).

4 MINIMUM TOTAL COATING THICKNESS

Type	Specified Outside Diameter	Minimum Coating Thickness (mm)
(1)	(2)	(3)
Type A	Up to 1400 mm	1.17mm
Type B	1400 mm and more	1.85 mm

5 ADHESIVE MATERIAL / PRIMER

The primer shall be butyl rubber-based adhesive, properties of which are given in Table 1.

Table 1 Properties of Adhesive Material

Sl No.	Property	Minimum	Maximum	Test Method
(1)	(2)	(3)	(4)	(5)
i)	Color	Black		
Weight				
ii)	Flammable	0.70kg/l	0.95kg/l	Clause 11.2
iii)	Non flammable	1.2 kg/l	1.40 kg/l	Clause 11.2
Flash Point				
iv)	Flammable	-17°C	-	Clause 11.3
v)	Non flammable	None	-	Clause 11.3

5.1 Inner Layer Tape

5.1.1 Inner layer tape will have single side adhesive layer and will have properties given in Table 2. The inner layer tape shall be applied after the liquid adhesive and before application of the **o**uter layer tape. The purpose of inner layer tape is to provide corrosion protection.

5.1.2 Inner layer tape will have single side adhesive layer and its properties shall conform to the appropriate values stated in Table 2.

Table 2 Property Requirements of Inner Layer Tape

Sl No.	Property	Minimum	Maximum	Test Method
(1)	(2)	(3)	(4)	(5)
i)	Width Deviation	-5%	+5%	Clause 11.4
ii)	Nominal Thickness	480 microns	-	Clause 11.5
iii)	Ratio of adhesive to total inner layer tape thickness ‘ t’	40% of total t	60% of total t	

iv)	Tensile Strength	3500 N/m width	-	Clause 11.7
v)	Elongation	250%	-	Clause 11.7
vi)	Peel force or Adhesion to prepared steel	22N/ cm	-	Clause 11.8
vii)	Water absorption (24 h)	-	0.2% by weight	Clause 11.9
viii)	Water vapour transmission	0	0.10g/hm^2	Clause 11.10
ix)	Dielectric Strength	17kV/mm	-	Clause 11.11
x)	Non polyolefin material % by wt	1%	3.5%	Clause 11.12
xi)	Holiday test voltage	6000 V/ single layer	-	Clause 11.13

6 INTERMEDIATE AND OUTER LAYER TAPE

The outer & intermediate layer tape will have single side adhesive layer and shall be compatible with the inner layer tape. The intermediate layer tape will provide additional mechanical protection. The outer layer tape shall provide mechanical and outdoor weathering protection to the tape system and also overall corrosion protection properties of the system. Physical properties of intermediate & outer layer tape shall conform to values stated in Table 3. The outer wrap must contain UV stabilizers to provide UV stability of minimum 12 months of continuous UV resistance.

Table 3 Property Requirements of Outer Layer Tape

Sl No.	Property	Minimum	Maximum	Test Method
(1)	(2)	(3)	(4)	(5)
i)	Width Deviation	-5%	+5%	Clause 11.4
ii)	Nominal Thickness	722 microns	-	Clause 11.5
iii)	Tensile Strength	7000 N/m width	-	Clause 11.7
iv)	Elongation	100%	-	Clause 11.7
v)	Peel force or Adhesion to inner layer	0.2 N/mm width	-	Clause 11.8
vi)	Non polyolefin material % by wt	3%	7%	Clause 11.12
vii)	UV resistance (outer tape only)	12 months		Clause 11.16

7 TOTAL SYSTEM OF COATING

Properties of total system of coating consisting of primer, inner layer tape and outer layer tape may vary depending on diameter of the pipe on which it is wound. However, it shall conform to the values given in Table 4

Table 4 Property Requirements of Total Coating System

Sl No.	Property	Minimum	Maximum	Test Method
(1)	(2)	(3)	(4)	(5)
i)	Thickness Type A (Primer, 1 layer of inner and 1 layer of outer)	1202 microns	-	Clause 11.5
ii)	Thickness Type B (Primer, 1 layer of inner, one intermediate layer and one layer of outer)	1924 microns	-	Clause 11.5
iii)	Holiday Test Voltage Type A Type B	12000V 12000V	-	Clause 11.13
iv)	Impact resistance Type A Type B	2.8 Nm 2.8 Nm	-	Clause 11.14
v)	Penetration resistance Type A Type B		25% with no holiday 25% with no holiday	Clause 11.15
vi)	Cathodic disbondment	-	12 mm	Clause 11.17

8 DIMENSIONS

The inner layer tape & outer layer tape will be supplied in roll form wound on hollow core. Dimensions of inner layer tape and outer layer tape shall be as given in Table 5.

Table 5 Dimensions of Inner Layer Tape and Outer Layer Tape

Sl No.	Nominal Pipe Diameter, mm	Recommended Tape Width, mm
(1)	(2)	(3)

i)	100 – 150	100
ii)	151 – 300	200
iii)	301 and above	300

9 APPLICATION OF THE COATING SYSTEM

9.1 Initial Preparation

9.1.1 Mud, mill scale, wax, coal tar, asphalt, oil, grease, soluble salt or any other foreign material shall be removed prior to blast cleaning.

9.1.2 After removing foreign materials from the surface, the pipe shall be cleaned by blasting with sand, grit or shot to achieve surface cleanness up to a level of Sa 2½ / NACE 2 / SSPC SP 10 (near white metal). The blasted surface profile shall be 50 to 75 micron and will be measured by Replica Tape as per ISO 8503-5. The abrasive used shall be maintained clean, dry and free from contaminants not to contaminate the substrate.

9.1.3 Blast cleaned pipe surfaces shall be free from high humidity, rainfall or surface moisture. If pipe is flash rusted the same shall be re-blasted. To ensure a dry pipe surface at the time of liquid adhesive application, the minimum steel substrate temperature shall be 7 °C and at least 5 °C above dew point.

9.2 Weld Seam

Weld seam cover tape shall be compatible with liquid adhesive. Before applying the inner layer tape, the weld seams shall be ground flush for a distance of 450 mm along the length on both sides. These weld seams shall be coated with liquid adhesive and then covered with a strip of tape. For more than 1500 mm pipe diameter stripping tape is required. The alternative is to grind the weld seam for the entire length of the pipe.

9.2.1 *Coating Application*

9.2.2 *Liquid Adhesive / Primer Application*

The liquid adhesive shall be thoroughly mixed before application on pipe for 2-3 hours before usage. The liquid primer shall be free from floods, runs, sags, drips or bare spots and shall be applied by spray, roller, or by brushes in a manner so that it makes a uniform thin film. Before application of inner layer tape, the primer shall be touch dry.

9.2.3 *Application of Inner layer Tape*

The inner layer tape shall be applied spirally on dry to touch dry primer by constant tension equipment. Minimum overlap shall be 25 mm or more. The overlap shall be smooth and will maintain continuity of inner layer coating. When splicing the rolls of tape from one roll to the next, the minimum overlap shall be 150mm**.** The inner layer tape should be applied at a minimum roll

temperature of 21 °C. Follow the tape manufacturers guidelines for recommended temperatures for rolls above 21 °C.

9.2.4 *Application of Intermediate and Outer Layer Tape*

Like inner layer tape same constant tension coating equipment can be used for wrapping intermediate and outer layer tape. The overlap of intermediate and outer layer tape shall not coincide with the overlap of the inner layer tape. Minimum overlap shall be 25 mm or more. When splicing the rolls of tape from one roll to the next, the minimum overlap shall be 150mm. The intermediate and outer layer tape shall be applied at a minimum roll temperature of 21 °C.

9.2.5 *Coating Repair in Plant and Field*

Holiday area is repaired by the following steps:

a) Remove outer and inner layers from the damaged area,
b) Apply liquid adhesive primer,
c) Apply inner layer tape by wrapping around the pipe around the damaged area, and
d) Apply a layer of outer wrap by wrapping around the pipe over the inner tape.

9.2.6 Minimum lap at the damaged area is 100 mm all around. The repaired area shall then be tested for holidays. If holidays are not found, the repaired area shall be covered with the outer layer tape with a minimum overlap of 100 mm beyond the inner tape patch.

10 VERIFICATION

10.1 Coating Materials Acceptance Testing

For acceptance of coating materials. one of the following methods shall be used.

a) Manufacturers certified test report submitted by manufacturer / contractor,
b) Getting the material tested by third party or tested by BIS recognized laboratories or NABL approved laboratories, and
c) Acceptance as agreed between purchaser and supplier.

11 COATING SYSTEM TESTS

The physical & electrical properties of the tape will vary with temperature and moisture content. In order that, the test methods yield consistent and reproducible results, control the temperature and moisture content of the sample or specimen as specified in individual tests as described in this standard.

11.1 Conditioning for Room Temperature Measurements

Conditioning – The exposure of a material to the influence of a prescribed atmosphere for a stipulated period of time or until a stipulated relation is reached between material and atmosphere.

Unless otherwise specified, conditioning shall be conducted at 23 ± 5 °C and 50 ± 10 % relative humidity.

11.2 Weight of the Adhesive Primer

Weight of the primer shall be measured in kg/L.

11.3 Flash Point of Adhesive Primer

Flash point of primer shall be measured as per IS 101 (Part 1/Sec 6) : 1987

11.4 Width of Tape

A specimen of inner layer tape and outer layer tape of length at least 0.9 m long shall be removed from each of the 3 randomly selected rolls from each lot. The width of the specimen shall be measured at several points along length of the sample using a standard scale. The width deviation shall not exceed the limits provided in Table 2 and 3 respectively.

11.5 Thickness of Tape

Thickness of inner layer tape and outer layer tape shall be done by calibrated micrometer having least count of 0.01mm at 10 different locations on three randomly selected rolls. The minimum thickness shall be as specified in Table 2 and 3 respectively.

11.6 Length of Coating Material in a Roll

The number of linear metres of tape wound into a roll as measured in accordance with these test methods. Measurement of the length of tape in a roll is necessary to ensure receiving correct quantities.

11.6.1 *Apparatus*

Balance capable of weighing with an accuracy of 1 percent of the weight.

11.6.2 *Test Specimen*

A single thickness of inner layer material, intermediate layer tape or outer layer tape approximately 1 meter long removed from full roll of tape.

11.6.3 *Procedure*

Weigh each roll exactly and to 1 percent accuracy. Remove a specimen of tape approximately 1 m from the roll. After conditioning for 1 hour measure the relaxed length of the specimen to the nearest 2 mm and weigh exactly to 1 percent accuracy. Weigh the core after application exactly and to 1 percent accuracy.

Calculate the meters per roll as follows:

$$Meters\ per\ roll\ (m) = \frac{Weight\ of\ roll\ less\ core\ (kg) \times Length\ of\ specimen\ (m)}{Weight\ of\ specimen\ (kg)}$$

11.7 Tensile Strength and Elongation

11.7.1 Test Specimens - The length of specimen to the nearest 0.1 m. Cut the specimen with a sharp razor blade or scissors, unless otherwise specified. Use test specimens that are the width of the tape as received, if possible. Condition the specimen.

11.7.1 *Testing Machine*

The tensile testing machine should be a constant rate of extension type and should be capable for recording tensile load and amount of separation of grips. The apparatus must be capable of providing smooth, uniform jaw movement during testing and the rate adjustable in increments necessary to produce strain rates that are specified for the materials under test.

***11.7.2** Extension Indicator*

A suitable instrument for determining the distance between two fixed points located within the gauge length of the test specimen at any time during the test. It is desirable, but not essential, that this instrument automatically record this distance as a function of the load on the test specimen, or of the elapsed time for the start of the test, or both. If only the latter is obtained, also take load-time data. The extension indicator will usually have a separation of 25 mm between points and be a minimum of 25 mm from both the top and bottom jaws.

11.7.2 *Holding Fixture*

The holding fixtures may be any of the following types provided that the fixture does not cut the specimen or cause slippage.

a) Air Jaws,
b) Drum Jaws, and
c) Manual Jaws.

11.7.3 *Calculation*

Read the tensile strength directly from recording chart (stress strain cure) or digital readout.

Read or record the distance between benchmarks at the instant of break or rupture and note the jaw separation or the distance between benchmarks at the instant of break or rupture and calculate the percent elongation as follows.

$$\text{Elongation percent} = \frac{d_2 - d_1}{d_1} \times 100$$

where

d_1 = original distance between jaws or benchmarks.

d_2 = distance at instant of break or rupture between jaws and benchmarks.

The tensile strength & elongation of the inner, intermediate and outer tape shall be as specified in Table 2 and Table 3.

11.7.4 *Report*

Following information should be included in the report:

a) Temperature conditions,
b) Average breaking strength expressed in newtons per 10 mm of width plus the maximum and minimum, if specified
c) Average percent elongation, plus the maximum and minimum, if specified

11.8 Adhesion Test

11.8.1 The method for conducting pipe coating adhesion testing to steel surface in a coating plant or on the right-of-way is described below. The tests shall be performed between 21 °C and 24 °C to achieve proper values. Adhesion test will be carried out after 24 hours of application of the coating.

11.8.1 *Adhesion test area*

The adhesion test area shall be prepared in four steps:

a) A circumferential strip measuring 25 mm wide × 375 mm long shall be marked on the coated pipe surface.
b) The marked area shall then be cut to the steel substrate along the marked area on three sides (top and sides).
c) A 25 mm strip shall be pried away from the substrate at the top end and attached with a suitable clamp to a pulling tension scale capable of measuring 0 to 23 kg.
d) The coated pipe shall then be marked at 25 mm increments along the length of a cut side from 0 to 12.

11.8.2 *Adhesion test procedure*

The adhesion test shall be conducted and evaluated in the following manner:

a) Pull the tension scale at an angle of 180° to the pipe surface at a rate of 25 mm per 5 seconds continuously for 1 min.
b) The pull tension value shall be recorded for each 25 mm of pull. A minimum of twelve values shall be recorded.
c) The two highest and two lowest values shall be excluded and the remaining eight values shall be averaged and recorded.

11.8.3 The minimum peel force or adhesion to steel shall be as specified in Table 2. Record the separation mode exhibited during peel test. Primer separation from the steel surface during peel test is not an acceptable separation mode.

11.8.4 *Rejection*

An adhesion value below the requirement shall be considered a non-satisfactory result. In this situation, if the result is at least 90 percent of the requirement, two additional tests shall be made at two different locations on the same pipe. If the initial result is less than 90 percent of the

requirement, or if either of the additional two tests fail to meet the requirement, the coating shall be repaired or rejected. If the coating fails an adhesion test, the test shall be repeated for the pipe coated prior to and after the failed pipe. This process shall be repeated until satisfactory results are obtained. All coated pipe where the requirement is not met shall be repaired or rejected.

11.8.5 The adhesion or peel force of the outer tape to inner tape shall be conducted as above. This test is a laboratory test and not a field test. The minimum peel force or adhesion shall be as specified in Table 3.

11.8.6 Frequency of testing of adhesion shall be performed as agreed between purchaser and manufacturer.

11.9 Water Absorption Test

11.9.1 *Apparatus*

a) *Weighing Scale* — An analytical balance capable of reading 0.0001 g, and
b) *Oven* — Capable of maintaining uniform temperatures of 50 ± 3 °C.

11.9.2 *Test Specimen*

Use only the inner layer for the test. The test specimen size shall be 60 mm x 60 mm. The test specimens shall have smooth edges free from cracks.

11.9.3 *Procedure*

Either of the following two procedures can be used:

a) *Twenty-four-hour immersion* — The conditioned specimens shall be placed in a container of distilled water maintained at a temperature of 23 ± 1 °C and shall rest on edge and be entirely immersed for the period of 24h. At the end of 24 hours, the specimens shall be removed from the water one at a time, all surface water wiped off with a dry cloth, ~~and~~ weigh to the nearest 0.001 g immediately. If the specimen is 1.5mm or less in thickness, it shall be put in a weighing bottle immediately after wiping and weighed in the bottle.
b) *Two-Hour Boiling Water Immersion*—The conditioned specimens shall be placed in a container of boiling distilled water, and shall be supported on edge and be entirely immersed. At the end of 120 ± 4 min, the specimens shall be removed from the water and cooled in distilled water maintained at room temperature. After 15 ± 1 min, the specimens shall be removed from the water, one at a time, all surface water removed with a dry cloth, and the specimens weighed to the nearest 0.001 g immediately. If the specimen is 1.5mm or less in thickness, it shall be weighed in a weighing bottle.

11.9.4 *Calculation*

Percentage increase in weight during immersion, calculated to the nearest 0.01 % as follows.

$$\text{Increase in weight percent} = \frac{Wet\ Weight - Conditioned\ Weight}{Conditioned\ Weight} \times 100$$

11.10 Water Vapor Transmission

11.10.1 *Apparatus*

11.10.1.1 *Test dish*
The test dish shall be of any non-corroding material, impermeable to water or water vapor. The mouth of the test dish shall be as large as practical.

11.10.1.2 Attach the specimen to the test dish in such a manner that the test dish mouth defines the area of the specimen exposed to vapor pressure in the test dish.

11.10.1.3 The sealant used for attaching the specimen to the dish shall be highly resistant to passage of water vapor. It must not affect the vapor pressure in water filled dish. Molten wax /equivalent shall be used as sealant material.

11.10.2 *Test chamber*

The cabinet where the assembled test dishes are to be placed shall have a controlled temperature and relative humidity.

The temperature chosen shall be between 21 and 32 °C and shall be maintained constant within ±1 °C. The temperature of chamber walls facing to the specimen over water should not be cooler than water to avoid condensation on the test specimen.

The relative humidity shall be maintained at 50 ± 2 percent. Both temperature and relative humidity shall be recorded continuously.

Air shall be continuously circulated throughout the chamber, with a velocity sufficient to maintain uniform conditions at all test locations. The air velocity over the specimen shall be between 0.02 and 0.3 m/s.

11.10.3 *Balance and Weights*

Analytical balance shall be used for measuring weight change during the test period and shall be sensitive to a change smaller than 0.001 g of the weight during the period when a steady state is considered to exist.

11.10.4 *Test Specimens*

The sample shall be of uniform thickness. If the material is of nonsymmetrical construction, the two faces shall be designated by distinguishing marks (for example, on a one- side-coated sample, "I" for the coated side and II for the uncoated side). Test specimens shall be representative of the material tested. When a product is designed for use in only one position, three specimens shall be tested by the same method with the vapor flow in the designated direction.

The overall thickness of each specimen shall be measured at the center of each quadrant and the results averaged. Measurement of specimens of 3mm. or less in thickness shall be made to three

decimal digits.

11.10.5 *Test Procedure*

Fill the test dish with distilled water to a level 19 ± 6 mm from the specimen. The air space thus allowed has a small vapor resistance, but it is necessary in order to reduce the risk of water touching the specimen when the dish is handled.

Attach the specimen to the dish and place it in the controlled chamber, specimen up, weighing it immediately.

Weight the dish assembly every hour over the 24 hours test period to provide at least 20 data points during the test. A data point is the weight at a particular time. The time that the weight is made shall be recorded to a precision approximately 1% of the time span between successive weighing. Weighing shall be accomplished without removal of the test dishes from the controlled atmosphere.

Relative humidity and the temperature in the controlled chamber shall also be continuously recorded.

11.10.6 *Calculation for Water Vapor Transmission (WVT) and Permeance (Perms)*

The water vapor transmission (WVT) rate shall be calculated using the following formula.

where

G = weight change (g),

t = time during which G occurred (h),

G/t = slope of the straight line, g/h

A = test area (cup mouth area) m^2 and

WVT = rate of vapor transmission, $g/h.m^2$

$$\text{WVT} = \frac{G}{tA} = \left(\frac{G}{t}\right)/A$$

The permeance (Perms) shall be calculated using the following formula

where:

$$\text{Permeance} = \frac{WVT}{\Delta p} = \frac{WVT}{S(R_1 - R_2)} \times 100$$

Δp = vapor pressure difference in mm Hg (1.333×10^2 Pa)

S = saturation vapor pressure at test temperature, mm Hg (1.333×10^2 Pa)

R_1 = relative humidity at the source (in the test dish) expressed as a fraction

R_2 = relative humidity at the vapor sink (controlled chamber) expressed as a fraction.

11.11 Dielectric Strength

11.11.1 *Apparatus*

11.11.1.1 *Voltage source*

Obtain the test voltage from a step-up transformer supplied from variable sinusoidal low-voltage source. The transformer, its voltage source, and the associated controls shall have the following capabilities: The ratio of crest to root-mean-square (rms) test voltage shall be equal to 1.34 to 1.48, with the test specimen in the circuit, at all voltages greater than 50 percent of the breakdown voltage. The capacity of the source shall be sufficient to maintain the test voltage until dielectric breakdown occurs.

11.11.1.2 *Voltage measurement*

A voltmeter must be provided for measuring the rms test voltage. The overall error of the voltage-measuring circuit shall not exceed 5 % of the measured value. The voltmeter shall be such that its time lag will not be greater than 1 % of full scale at any rate-of-rise used.

11.11.1.3 *Electrodes*

Opposing cylinders; the lower one 75 mm in diameter, 15 mm thick; the upper one 25 mm in diameter, 25 mm thick; with edges of both rounded to 3 mm in radius. The entire flat area of the electrode should be in contact with test specimen. The flatness and surface finish of the electrode faces must be such that the faces are in close contact with the test specimen over the entire area of the electrodes

11.11.2 *Test Specimens*

Take 5 samples from areas that are not immediately adjacent to obvious defects or discontinuities in the material. The outer few layers of roll material, or material immediately next to an edge of a sheet or roll should be avoided. When flat-faced electrodes are to be used, the surfaces of the specimens which will be in contact with the electrodes shall be smooth parallel planes.

The recommended specimen type for this test is a 101 mm plaque or larger. Specimens over 2 mm thick are typically tested in oil to decrease the chance of flashover before breakdown.

11.11.3 *Procedure*

Voltage is applied across the two electrodes and raised from zero to dielectric breakdown at a suitable uniform rate of 100/200/500/1000/2000V/s (generally 500V/s), which will give an average time to breakdown of between 10 and 20 s, until breakdown. Breakdown is when an electrical burn-through punctures the sample, or decomposition occurs in the specimen. The rate

of voltage rise is determined by the time it takes the sample to reach dielectric breakdown. This test is done commonly in air because of adhesive layer at one side.

11.11.4 *Calculation*

a) Calculate for each test the dielectric strength in kV/mm at breakdown;
b) Dielectric strength = Breakdown voltage / Thickness of sample; and
c) Calculate the average dielectric strength of 5 samples.

11.12 Non Polyolefinic Material, Percent by Weight

Polyolefin backing compound contained in a disposable aluminum weighing dish is pyrolyzed in a muffle furnace for a short period. During the pyrolysis of the polymer, the air in the muffle furnace becomes oxygen-deficient to prevent the combustion of the residual non-polyolefin content primarily carbon black.

11.12.1 *Apparatus*

a) Muffle furnace with temperature controller, approximately 100 mm in the three internal dimensions,
b) Desiccator with alumina or equivalent desiccant,
c) Laboratory interval timer with alarm,
d) Disposable aluminum weighing dish, and
e) Analytical balance, capable of measuring up to 0.1 mg.

11.12.2 *Sample and Test Specimen*

Samples may originate from the manufacturers or purchasers sampling regimen.

The test specimens may be in the form of granules or pieces cut from an article such as pipe coating, jacket, film, molding, soiled samples must be washed, and printed articles, such as films, are wiped clean with a suitable solvent.

11.12.3 *Procedure*

a) Set the controller indicator of the muffle furnace to 600 °C and let it stabilize from 600 to 610 °C,
b) Mark an aluminum weighing dish with an identifying impression on the tab,
c) Place the dish on the screen in the muffle furnace and burn off the surface oil for 2 min, as indicated by timer,
d) Transfer the dish to the desiccator and let it cool for at least 2 min,
e) Weigh the dish accurately on the analytical balance. Record the results as W_1,
f) Add about 1 g of specimen and reweigh the dish and contents accurately. Record the results as W_2,
g) Place the weighed dish and contents into the muffle furnace and set the interval timer for 3 min.

h) After the elapsed time, remove the dish from the muffle furnace and place it in the desiccator to cool for at least 2 min,
i) Reweigh the dish and remaining content accurately. Record the results as W_3,
j) If mineral fillers are suspected to be present in the compound, replace the dish and contents into the muffle furnace for a period of 10 min or longer until only light-colored ash remains,
k) Transfer the dish and contents from the muffle furnace to the desiccator and let it cool for 2 min,
l) Re-weigh the dish and ash accurately. Record the results as W_4, and
m) A minimum of two determinations is made for each sample.

11.12.4 *Calculation*

Calculate the percent non-polyolefinic content as follows:

$$\textit{Non-polyolefinic content}\ \% = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

or

$$\textit{Non-polyolefinic content}\ \% = \frac{W_3 - W_4}{W_2 - W_1} \times 100$$

11.13 Holiday Detection

Holiday Test is for locating discontinuities in a coating. The instrument is used for this test is pulse type holiday detector which supplies a high voltage pulse for very short duration.

11.13.1 *Grounding*

Grounding both the pipe metal and the ground terminal of the holiday detector is necessary to complete the circuit.

11.13.2 *Electrode Travel Speed*

Pulse type holiday detector allows higher speed of travel of electrode. The minimum speed shall be 0.3 m/sec.

11.13.3 *Voltage Measurements*

Voltage measurements of pulse type detectors shall be made with kilovolt meter. The electrode must in normal operating position on coated surface in a holiday free area. The voltage shall be measured between the electrode and the pipe.

11.13.4 *Condition of Coating Surface*

If the coated surface has excessive moisture, the coating system can cause appreciable leakage currents and cause erroneous holiday indication. Drying and leaning of the coated surface must be necessary.

11.13.5 Testing Voltage Calculation:

Minimum testing voltage of a coating is given by the formula.

Testing Voltage V = 7900 $\sqrt{T}$ is the target; at ± 20 % of the target is the allowed range.

11.14 Impact Resistance Test

The test consists of verifying the strength of the external coating by the impact of a punch of defined shape falling directly onto the coating from a fixed height and at a fixed temperature. The test shall be carried out on pipes or cut samples.

11.14.1 *Apparatus*

The drop weight testing machine consists of the following:

a) Straight guide made of steel, aluminum or plastic, rigid and non-deformable, with an inside diameter between 40 mm and 60 mm, length at least 1.50 m and incorporating a smooth and even inside surface,

b) Graduated rod, to determine the drop height to an accuracy of 5 mm,

c) Hard steel punch of total fixed weight of 1 kg with a hemispherical nose of dia 16 mm. The designed punch shall be used over a drop range of 0.2 to 1.2 meter,

d) *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, and

e) *Apparatus support* — Both the apparatus and sample shall be firmly supported and secured to a rigid base to optimize energy transfer from the tup to the specimen.

11.14.2 *Preparation of Test Specimens*

The test specimen shall be a 406.4 mm long piece of Schedule 40, 60.325 mm outside diameter coated pipe prepared with its surface preparation and coating procedures equivalent to that of production coated pipe. Three specimens shall be required for the test.

11.14.3 *Conditioning*

The specimen shall be exposed to a room temperature of 23 ± 2 °C for a period of 24 h before beginning the test.

11.14.4 *Procedure*

a) The test shall be carried out at a temperature of 23 ± 3 °C,
b) The coated component shall be placed on a rigid, stable, horizontal support,

c) Before carrying out an impact test, the holiday detection test shall be undertaken to identify defective points and to avoid impact testing at these locations,
d) For each point of impact, the drop weight testing tube shall be placed perpendicular to the coating surface. The loaded punch shall fall freely without friction or resistance,
e) For coating of Type A, 1 kg punch shall be dropped from height of 0.3 m and for coating of Type B, 1 kg punch shall be dropped from height of 0.60 m. Ten impacts shall be carried out. The points of impact shall be at least 50 mm to the side of the weld bead and/or the pipe end and there shall be at least 50 mm between the axis of the impacts, and
f) The holiday detection test shall then be undertaken immediately after each impact.

11.14.5 *Results*

The impact energy and holiday detection results shall be recorded. There will be no failure of the coating during holiday detection for all three samples.

11.15 Penetration test

This accelerated test method is used to determine the relative resistance of steel pipeline coatings to penetration or deformation by a blunt rod under a specified load.

11.15.1 *Apparatus*

Test apparatus shall consist of:

a) Chamber thermostatically controlled to ± 2 °C of the desired test temperature.
b) Penetrometer comprising of: Dead weight tester that can press the flat tip of a rod against the coated pipe. The flat-tipped end of the rod contacting the coating shall have a diameter of 6.350 mm ± 0.0254 mm and together with supplementary weight and any other weight contributing parts shall have a total weight of 4.453 kg resulting in a unit pressure of 14.060 kg/cm^2 against the coating.
c) Dial gauge or any other measurement system accurate to ± 0.01 mm.
d) The test specimens shall be 150 mm long and prepared with its surface preparation and coating procedures equivalent to that of production coated pipe.
e) Thermometer, a temperature measurement device accurate to ± 0.5 °C.

11.15.2 *Procedure*

The specimen shall be exposed to the test temperature for a period of 24 h before beginning the test. If the test temperature is the same as room temperature, it shall be carried out at a temperature of 23 ± 2 °C.

The test shall be performed three times on one coating sample and shall be completed on the installed coating system, as applied on the steel plate or pipe sample. The dimensions of the sample shall be agreed. Prior to conducting the penetration test – holiday test shall be conducted at the required holiday voltage depending on the thickness of the coating sample.

The test sample, held within the penetrometer assembly, shall be placed 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.

The following readings shall be made.

a) t_0 is the reading on the dial gauge placed on an uncovered part of the steel plate or pipe,
b) t_1 is the reading on the dial gauge with the indenter without the mass positioned centrally over the sample, and
c) t_2 is 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.

After the test is completed, the sample shall be subjected to holiday test at the required holiday voltage depending on the thickness of the coating sample.

11.15. 3 *Calculation*

The quantities t_3, the coating thickness; t_4, the residual thickness of the coating; and t_5, the penetration into the coating, can be calculated on the basis of the measurements described in E.3 using Equations (E.1) to (E.3), respectively:

t3 (coating thickness) $= t_1 - t_0$ (E.1)

t_4 (residual coating thickness) $= t_2 - t_0$ (E.2)

t_5 (pénétration) $= t_1 - t_2$ (E.3)

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

The percentage penetration shall be calculated as follows: $\frac{t_5}{t_3} \times 100$

11.15.4 *Result*

The percentage penetration shall be < 25% with no holiday.

11.16 UV Resistance Test

The test method consists of measuring the aging effect of the outer tape when exposed to cyclic irradiation of fluorescent UV light and moisture under fixed temperature and humidity conditions. This test simulates weathering effect when the coating is subjected to sunlight, moisture or rain during the outdoor storage of the coated pipes.

11.16.1 *Apparatus*

UV Weather Resistance test chamber equipped with a fluorescent UV lamp which can completely simulate the UV spectra of sunlight exposes materials to alternating cycles of UV light and moisture at controlled, elevated temperatures.

11.16.2 *Procedure*

The UV resistance test chamber shall be fitted with a Florescent Lamp UVB-313 or equivalent which produces radiation of 0.49 W/m^2/nm at UV wave length of 310nm.

3 samples will be selected. Each sample will be selected to UV cycling as below:

a) 8 h UV at 70 (± 3) °C Black Panel Temperature,
b) 4 h Condensation at 50 (± 3) °C Black Panel Temperature,
c) No of days of cycling: 90 days.

11.16.3 *Result*

There shall be no visual cracks on the surface.

11.17 Cathodic Disbondment Test

The test consists of assessing the resistance to disbondment of damage polyolefin tape coating when exposed to cathodic polarization.

The test shall be performed on a test sample previously subjected to holiday detection and in which an artificial defect of a defined size has been created.

11.17.1 *Apparatus*

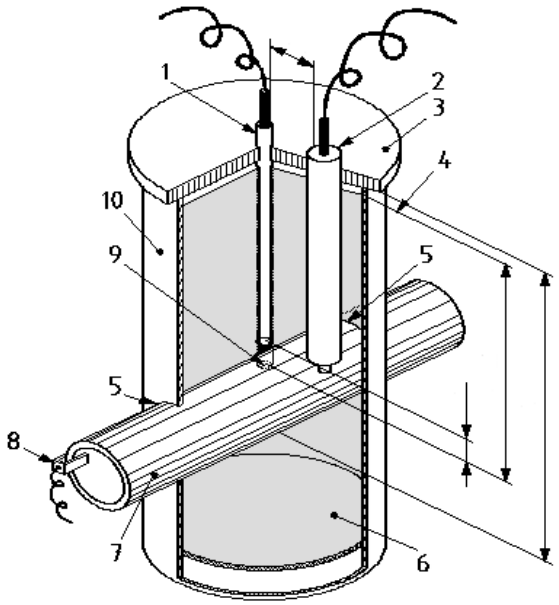
11.17.1.1 Electrical source, consisting of a controlled voltage d.c. power unit **(**potentiostat) capable of supplying 20 mA to each test area simultaneously.

Cathodic polarization potential (E) equivalent to –1500 mV vs. saturated calomel reference electrode shall be maintained. E equals to –1500 mV when a saturated calomel reference electrode is used. The potentials are defined as follows:

11.17.1.2 *Electrolytic cell, having a typical test-cell configuration as shown in figure below***:**

The electrolytic cell shall comprise of

a) a rigid plastic pipe with an internal diameter of minimum 50 mm. The height shall be such that the total volume of the electrolyte is equal to or greater than 150 cm^3 with a minimum height of the electrolyte of 70 mm, and
b) a rigid plastic cover in which holes shall be drilled to allow the passage of the electrodes and any other measuring instruments deemed necessary, and to allow the escape of hydrogen.



Key

1 Anode, platinum wire

2 Reference electrode- calomel

3 Plastic cover

4 Electrolyte level

5 Sealing material

6 Electrolyte

7 Coated pipe

8 Working electrode (cathode)

9 Artificial defect, 6 mm

10 Plastic pipe, minimum internal ∅ 50 mm

FIG. 1 CATHODIC DISBONDMENT MACHINE

11.17.1.3 Reference electrode shall be saturated calomel capable of measuring suitable potential -1500 mV and suitable for the test temperature required, placed in an electrode holder situated in a glass pipe with a porous end diaphragm. The end of this assembly shall be placed approximately 10 mm from the surface of the coating and approximately 20 mm from the coating defect**.**

11.17.1.4 Anode, consisting of an inert material, e.g. platinum wire, 0.8 mm to 1.0 mm in diameter. It shall be immersed in the electrolyte to within approximately 10 mm over the coating defect. The ratio of the surface area of the anode to that of the cathode shall be greater than 1.

11.17.1.5 Cathode, represented by the artificial defect, 6 mm in diameter, with a maximum depth of 0.5 mm in the steel substrate.

11.17.1.6 Electrolyte, consisting of a 3 percent solution of NaCl in distilled or deionized water. The solution shall be made from technical grade sodium chloride. The pH at 23 ± 2 °C during the test shall be in the range of 6 to 9. The height of the electrolyte in the cell shall be at least 70 mm.

11.17.1.7 Heating equipment, suitable to establish and to maintain the test temperature of the sample. If not heated in an oven, the temperature shall be checked on the artificial defect by an appropriate means, for example a temperature sensor.

11.17.2 *Sampling*

The test shall be performed on a on a coated pipe and three cathodic disbondment tests shall be performed. The thickness of the area of the coating subject to the test shall be measured and recorded.

The integrity of the coating on all test samples shall be checked by holiday detection.

A 6 mm diameter hole through the coating shall be obtained by drilling. The depth of the hole in the steel substrate shall not exceed 0.5 mm. At the initiation of the test, the total surface area subject to the test shall be free from residual coating. The test area shall be degreased using a suitable solvent and then rinsed with potable water and subsequently dried.

11.17.3 *Procedure*

The plastic pipe forming the electrolytic cell shall be sealed using a suitable sealant, for example, a chemically inert adhesive. The artificial defect shall be in the centre of the cell.

The cell shall be filled with the NaCl electrolyte. The test temperature shall be controlled within 23 ± 2 °C.

A negative cathodic potential -1500 mV ± 10 mV shall be measured between the reference electrode and cathode (pipe).

The test shall be performed for the test period of 30 days. The level of the electrolyte shall be readjusted with distilled or deionized water, if necessary.

11.17.4 *Investigation Procedure*

After the test, the cell with the electrolyte shall be removed. The test sample shall be rinsed with water and dried. After drying, the area of the coating subjected to the test shall be examined in accordance with the following method.

a) Inspect and assess each coating immediately after the test period,
b) Make about 6 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 60° from each other,
c) Insert the knife point into the center 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,
d) Repeat with each radial segment, and
e) Measure the length from the edge of the holiday area to the furthest extent for each segment.

11.17.5 *Results*

The result of the cathodic disbondment test shall be defined as the arithmetic mean value of the 6 single values. The mean value shall be recorded. The value shall be ≤ 12mm.

12 Inspection and Testing

Inspection and testing are to be carried out as per Table 6.

Table 6 Requirements for Inspection and testing
(*Clause* 12)

Sl No.	Properties	Test Method	Requirements	Frequency For Qualification Test	Frequency During Production
(1)	(2)	(3)	(4)	(5)	(6)
i)	Surface condition before blasting	Visual inspection	Free of contamination from oil, grease and chlorides	Each pipe	Each pipe
	Surface condition after blasting	Conductive measurement	20mg/m^2, *Max* as per ISO 8502-9	Each pipe	5 pipes at start of production and 1 pipe / shift
ii)	Environmental conditions (Dew point)	Calculation	RH 85%, *Max*	Once	Every 4 h
iii)	Pipe temp before blasting	Thermocouple	3 °C, *Min,* above dew point	Once	Every 4 h
iv)	Size, shape and properties of abrasive	Visual + Certification to ISO 11124-1 and ISO 11126-1	Conformity to certificate provided by the manufacturer	Once	1 / day
v)	Water soluble contaminants of abrasives	ISO 11127-6	Salt content 20mg/m^2 , *Max* as per ISO 8502-9	Once	1 / shift

vi)	Surface roughness of blasted steel	ISO 8503-4	50-75 microns	Each pipe	Each pipe
vii)	Visual inspection of blasted surface	ISO 8501-1	Grade Sa 2.5	Each pipe	Each pipe
viii)	Presence of dust after dust removal	ISO 8502-3	class 2, *Max*	5 pipes	Every 1 h
ix)	Elapsed time between blasting and coating	Monitoring	No rust, Pipe temp at least 3 °C above dew point	Continuously	Continuously
x)	Liquid adhesive application	Visual	Total coverage and wetting of pipe surface, without runs and sags (Dry to touch)	Each pipe	Each pipe
xi)	Liquid adhesive thickness	DFT	50-75 microns	10 locations / pipe	5 locations / pipe
xii)	Application of inner tape using manufacturer recommended wrapping machine.	Visual	Coating free of air pocket sand wrinkles	Each pipe	Each pipe
xiii)	Neck-down tension on the inner tape while wrapping	Measurement	2% of tape width	Random; 10 measurement / pipe	Random; 5 measurement / pipe
xiv)	Check overlap of the inner tape	Measurement	25 mm, *Min*	Random; 10 measurement / pipe	Random; 5 measurement / pipe
xv)	Holiday Test on inner tape	Testing by holiday machine	Passes at 6 kV	Each pipe	Each pipe
xvi)	Application of middle layer tape using manufacturer recommended wrapping machine.	Visual	Staggered on the inner layer tape by 25% the width of the tape.	Each pipe	Each pipe

xvii)	Neck-down tension on the middle layer tape while wrapping	Measurement	2% of tape width	Random; 10 measurement / pipe	Random; 5 measurement / pipe
xviii)	Check overlap of the inner pipe	Measurement	25 mm, *Min*	Random; 10 measurement / pipe	Random; 5 measurement / pipe
xix)	Installed coating-Holiday test		Passes at 12 kV	Each pipe	Each pipe
xx)	Installed coating-Adhesion Test of the inner layer to steel	Measurement	2200 N/m width	5 per pipe	One in every 10 pipe
xxi)	Installed coating-Adhesion Test of the outer layer to inner layer	Measurement	200 N/m (600 N/m) width	5 per pipe	One in every 10 pipe
xxii)	Installed coating- Thickness test(minimum)				
	Type A	Measurement	1.17 mm, *Min*	4 locations / pipe	4 locations / pipe
	Type B	Measurement	1.85 mm, *Min*		
xxiii)	Installed coating-coating cutback	Measurement	150 ± 20 mm	Each pipe	Each pipe
xxiv)	Coating repairs	Visual, holiday detection	No holidays	Once for demonstration	Each defect