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Underground Mild Steel Pipe Corrosion Protection by Applying Heat Shrinkable Sleeves

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Abstract: Mild steel pipelines are extensively used in various industrial sectors for transporting water, oil, gas, and other fluids. When buried underground, these pipelines are constantly exposed to corrosive environments due to the presence of moisture, oxygen, salts, and microorganisms in the soil. Corrosion not only weakens the structural integrity of the pipeline but also leads to potential leakage, safety hazards, and high maintenance costs. Therefore, effective corrosion protection methods are essential to ensure the long-term performance and safety of underground pipeline systems.

This thesis investigates the use of heat shrinkable sleeves as a corrosion protection method for underground mild steel pipes. Heat shrinkable sleeves are thermoplastic materials that shrink upon heating and tightly conform to the pipe surface, forming a continuous, water-tight, and corrosion-resistant barrier. The research covers the materials and construction of heat shrink sleeves, the preparation and application process, and the effectiveness of the sleeves in various soil and environmental conditions.

Through literature review, field application studies, and performance evaluation, the study demonstrates that heat shrinkable sleeves provide a durable, cost-effective, and easy-to-apply solution for protecting buried mild steel pipelines. The findings suggest that this method significantly reduces corrosion rates and extends the service life of underground piping infrastructure, making it a viable alternative or complement to traditional protection systems such as coatings and cathodic protection.

Index Terms - Surface Preparation, Primer Application, Heat Shrinkable Sleeves Application, Inspection and Corrosion Prevention.

I. INTRODUCTION

Underground pipe corrosion protection through heat shrinkage sleeves should encapsulate the significance of corrosion management in urban infrastructure. As underground pipelines serve as critical conduits for essential services, their integrity is paramount. Corrosion poses a significant threat, leading to potential leaks and hazardous situations, such as gas explosions or sewage spills. This thesis explores the application of heat shrinkage sleeves, a promising solution designed to enhance the durability and reliability of these pipelines. By employing a layered structure that includes a polyolefin substrate and a hot melt adhesive, heat shrinkage sleeves provide robust protection against various corrosive elements. The following sections will delve into the mechanisms of corrosion, the design and functionality of heat shrinkage sleeves, and their effectiveness in prolonging the service life of underground pipelines.

1.1 Corrosion Protection of Underground Pipes Using Heat Shrinkable Sleeves

Underground pipelines, especially those made of steel, are highly susceptible to corrosion due to continuous exposure to moisture, soil chemicals, and stray currents. One effective method for protecting these pipelines is the application of heat shrinkable sleeves**,** a type of protective coating system designed to provide long-lasting corrosion resistance and mechanical protection.

1.2 What is a Heat Shrinkable Sleeve?

A heat shrinkable sleeve is a factory-produced wrap made from cross-linked polyethylene or polyolefin backing with a corrosion-resistant adhesive layer (such as mastic or epoxy). When heated, the sleeve shrinks tightly around the pipe surface, forming a seamless, waterproof, and corrosion-resistant barrier.

II. METHODOLOGY

2.1 Selection of Materials

- **Pipe Material**: Mild steel pipes commonly used in industrial underground applications are selected based on standard dimensions and grades (e.g., IS 1239 or ASTM A106).
- **Heat Shrinkable Sleeves**: Commercially available cross-linked polyolefin sleeves with a thermoplastic adhesive backing are procured. Specifications such as thickness, shrink ratio, and adhesive type are documented.
- The Heat-Shrink Sleeve shall consist of an expanded, irradiated, cross-linked polyolefin backing coated with a uniform thickness of semi-crystalline (hot-melt) thermoplastic adhesive having high shear strength and melting temperature greater than 60º C.
- The Heat-Shrink Sleeve system shall be resistant to UV light degradation, chemical attack and shall be resistant to physical damage during construction works. It shall also be resistant to soil stresses, moisture absorption and cathodic disbandment. The sleeve shall withstand the weather conditions of environment and the pipe operating temperature. It shall be compatible with the pipeline plant-applied coating.
- The thickness of the expanded backing and the adhesive shall be at least 1.0 mm for each, such that an average thickness of 2.0 mm is guaranteed on the complete finished coating. The minimum permissible thickness at the apex of weld seam shall, however, be 1.6 mm. The minimum width of the sleeve shall be such that it provides at least 75 mm overlap with the plant-applied coating on each side of the girth weld. The size and width of the sleeve shall be suitable to suit the pipe diameter.
- The primer shall be solvent-free fast-setting 100%-solid, two-component epoxy. It shall be thermally resistant to steel pre-heat, sleeve shrinking temperature and weather conditions during application, as specified by project data sheets.

2.2 Surface Preparation

2.2.1 The pipe surface is cleaned using mechanical methods (wire brushing or sand blasting) to achieve a near-white metal finish (as per SSPC-SP10 / NACE No. 2 standard).

2.2.2 Imperfections/ Damage Removal

- Before starting any surface preparation, steel surface to be coated shall be inspected for general conditions, weld condition and the presence of defects/damage, which should be referred to the client representative to establish whether they can be satisfactorily removed.
- All surface imperfections/defects that may have arisen in the weld area during installation/welding and/or handling/transportation/storage such as weld spatter, slivers, dents, gouges, flattening, etc, shall be removed by suitable methods approved by client and in accordance with SSPC-SP2, SSPC-SP3 or SSPC-SP11.
- The steel surface to be coated shall be smooth, free of porosity, undercuts, cracks and cavities. All sharp edges of weld beads or any raised portion of the weld crown shall be smoothed by suitable method approved by client. If client-approved grinding method was used to remove imperfections, the pipe wall thickness shall be checked to ensure that the pipe wall thickness is not reduced.

2.2.3 Contaminants Removal

- Prior to surface preparation, tar, oil, grease and other contaminants shall be removed from the steel surface to be coated by a suitable method approved by client in accordance with SSPC-SP-1. Heavy deposits of oil, grease and other fatty matter should initially be broken up by means of an appropriate solvent using clean rags before the above procedure is adopted. Solvent cleaning shall be in accordance with SSPC-SP1. Only solvents that do not leave any residues on the surface shall be used.
- Pipe joints that have been contaminated with salt, soil, dust or other atmospheric contamination shall be washed with high-pressure (minimum 3000 psi) fresh water. The surface shall then be allowed to dry before further surface preparation activities are carried out. Air blast can be used for drying. All compressed air shall be free of oil and water.

- The ends of existing plant-applied coating shall be inspected and feathered prior to sleeve application. Any frayed or loosened coating at the edge of the shop coating cutback shall be removed. All grease, oil, mud, dirt or other contaminant shall be removed from the pipe within a 300 mm wide band adjacent to the weld area, prior to blast cleaning. The pipe joints external surface shall be cleaned to a finish in accordance with the degree specified for plant- applied coatings.

2.2.4 Abrasive Blast Cleaning

- The abrasive material used for blast cleaning operations shall be client approved type, brand and size of grit abrasives selected in accordance with ISO11124 parts 1 – 4. The particle size range of the abrasive shall be selected to achieve the required standard surface cleanliness and surface profile height specified in Sub-clauses 3.3.4.5 and 3.3.4.6 respectively. Abrasive blasting materials shall be clean, dry and suitably stored to maintain excellent condition prior to use. It shall be continually checked and sieved to maintain it free of contamination. In case of oil/grease contamination, the abrasive material shall be completely replaced. Under no circumstances shall sand, contaminated and/or recycled abrasives be allowed for blast cleaning. The grit shall be kept dry at all times. Particle size and abrasive type shall be regularly checked.
- Equipment for grit blasting shall be of a suitable type to obtain the degree of cleanliness and surface profile specified. It must be in a good working order and shall be kept in a sufficiently clean condition to avoid surface and/or coating contamination.
- The compressed air supply used for surface preparation must be of sufficient pressure and volume to prepare the surface to the degree specified and shall be free of water and oil. The air pressure measured at the blasting nozzle shall be 7 bars minimum. Adequate separators and traps for water and oil shall be provided and these shall be kept emptied by regular purging.
- Each side of weld joint, the bare metal Cutback and the strip of plant-applied coating shall be prepared by abrasive blasting. The plant-applied coating shall not be removed during abrasive blasting but cleaned and roughened/etched and feathered by the blasting operation to a minimum distance required for overlapping, such that no sharp shoulders exist at the edge of the plant coating and the bare steel. Swept blasting should extend over to both sides of the plant-applied coating to a distance equal to the overlap with HSS. This is to roughen the surrounding plant-applied coating and to provide a key for overlapping with the HSS coating. Sweep blasting shall be in accordance with NACE 4/SSPC-SP7 or as recommended by HSS manufacturer. Adjacent plant-applied coating shall be protected; a canopy and covers shall be fixed during blast cleaning so that blasting does not contaminate powder application or any welding operations on the adjacent joints.
- The bare metal of the girth weld shall be blast cleaned to achieve a standard of surface cleanliness conforming to ISO 8501-1- SA 2 ½ or SSPC equivalent SP10 standard (NACE No. 2). A photographic or visual standard such as SSPC-VIS1 shall be used to verify that a near-white finish has been achieved.
- The abrasive blast cleaning shall produce a surface profile height (anchor pattern) of 50 – 100 microns. The profile shall be inspected using a replica film-type tape in accordance with ASTM D4417 or NACE RP0287. The test tape shall be attached to the daily report (for record purpose) submitted to client.
- After blast-cleaning, all residual particulate matter, metal particles dust and blasting materials shall be removed from the blast-cleaned surface area by vacuum cleaning or using clean, dry, oil and moisture free compressed air before proceeding to further operations. The external surface shall be tested for residual dust particles using transparent self-adhesive tape as per ISO 8502-3. A minimum acceptance standard of class 2 rating 2 shall apply. At the discretion of client, a Potassium Ferricyanide test may be carried out to confirm a contamination free surface.
- Abrasive blast-cleaned surface area shall be protected from wet, rain or humid conditions. The cleaned surface shall be tested for condensation as per ISO 8502-4. Weld area prepared surface shall be checked for rust blooming prior to coating application. If rust blooming occurs, the pipe surface must be blast cleaned as explained in Clause 3.3.4.4. All prepared weld joint surface area, in any case, shall be coated within maximum 4 hours of blast cleaning.
- Abrasive blast-cleaned surface shall be protected from salt/chloride contamination. The blast-cleaned surface shall be tested for chloride contamination. The agency shall submit a salt contamination test procedure for client approval. The acceptance criteria shall be maximum 20 mg NaCl/m² or as recommended by coating manufacturer. Any level of chloride in excess of this value shall result in new washing and drying in accordance with Sub-clause 3.3.4.2 until the chloride level becomes below this value.
- Abrasive blast-cleaned pipe surface shall be inspected immediately for defects after blast cleaning. All slivers, scabs, slag, etc., made visible by blast cleaning shall be referred to client representative to establish

whether they can be satisfactorily removed by a suitable method within the corrosion allowance of the pipe. This cleaning operation shall not burnish or completely destroy the anchor pattern. If required, abrasive blast cleaning should be used to reinstate anchor pattern. The Agency shall submit a procedure to client for checking wall thickness.

- At no time shall the blast-cleaning be performed when the relative humidity exceeds 85% or when the steel temperature is less than 3°C higher than the dew point. It shall be checked for dryness and temperature using suitable client-approved instrument. Dew point measurements shall be taken before, during and after blasting operations. The pipe surface may be heated prior to blasting, utilizing a uniform pre-heating of the steel pipe to a minimum temperature as required to remove condensation and to ensure that the pipe temperature is at least 3ºC above the ambient dew point. This is to maintain dry steel surface prior to blast cleaning. The pre-heating equipment and procedure are subject to client approval, prior to commencement of blast cleaning.

2.3 Application of Heat Shrinkable Sleeves

- The Heat sleeve shall be of a size such that a minimum overlap of 75 mm is ensured (after shrinking) on both sides of the plant-applied coating of pipe.
- Just prior to sleeve application, the area to be coated shall be blown clean of all dust, sand, etc., using clean, dry, high-pressure air. It is recommended that this area be brush- cleaned with a clean, soft, dry, animal bristle hair paintbrush, No man-made fibre brushes shall be permitted.
- Before centring the HSS, the bare steel shall be preheated over the surface to remove the moisture. Preheating shall be done using propane gas torch or induction heater suitable for the pipe diameter. The minimum preheat temperature shall be as recommended by sleeve manufacturer and shall be checked by pyrometers; temperature crayons shall not be used. In no case shall the abrasive blasted weld joints be allowed to rust bloom before they are coated. The surface cleanliness of the weld joint shall be checked for conformance with the standard requirement specified in Sub-clause 3.3.4.5 before any coating application begins.
- The epoxy primer shall be applied prior to the sleeve application. The application method shall be as per the manufacturer's recommendations. It shall be applied uniformly and free of runs, sags, drips, bare spots, and other defects. The primer shall be applied as early as possible as but not later than 2 hours after blast cleaning. Prior to primer application, the steel surface temperature shall be at least 3º C above the dew point. The minimum DFT of the applied primer shall be 50 - 60 micron unless otherwise specified.
- After the primer has cured as specified by the manufacturer, the HSS shall be applied (entirely wrapped around the pipe) in accordance with the manufacturer's instructions. The agency shall ensure that the sleeve is centred over the weld and the closer patch on wrap-around sleeve is attached in position. The closer shall not slip more than 6mm during or after sleeve application.
- Immediately after wrapping the sleeve, it should be shrunk using propane gas torch or induction heater for16" and larger pipeline diameters. The heating equipment and temperature shall be as per the manufacturer's recommendations. Adequately applied heat to sleeve will be verified by visually observing the adhesive oozing at all exposed sleeve edges.
- The sleeve heat shrinking process shall be performed using a suitable method recommended by the sleeve manufacturer and in such a manner that all entrapped air is removed. The complete shrinking of the entire sleeve shall be affected without undue heating of the plant applied pipe coating and shall provide requisite bonding between pipe, sleeve and pipe coating. Resulting coating shall be free of wrinkles and cold spots. The girth weld profile shall be clearly visible on the sleeve.
- The coated field joints/pipeline shall be buried within 48 hours of application completion. This duration may be extended based on the manufacturer recommendation and client approval.
- A primer may be applied to the cleaned surface if recommended by the manufacturer.
- The HSS is wrapped around the pipe with the overlap positioned correctly and centered on the joint or test area.
- Controlled heat is applied using a propane torch or industrial heat gun. The sleeve is evenly shrunk until it conforms tightly to the pipe and adhesive bonding is visibly uniform.
- The sleeve is allowed to cool and is inspected for air pockets, wrinkles, or incomplete shrinkage.

2.4 Inspection and Testing

- Visual Inspection

a) The coated field joint area shall be visually inspected to ensure that the HSS has been applied in a manner representing high quality workmanship and that the sleeve is firmly bonded to the bare steel and the plant applied pipe coating. The mastic extrusion on either ends of the sleeve shall be examined. The girth weld bead and the overlap profiles shall be visible on the sleeve

b) The applied HSS shall be inspected for surface imperfections. The surface shall be smooth, there shall be no sign of puncture, dimples, voids, bubbles, bend failures, cold spots, burn holes, holidays or any other defects or apparent irregularities. Any visually detected defects shall be marked and brought to the attention of Client. Failure to satisfy Client as to the integrity of the coating shall be grounds for rejection and replacement of all defective applied HSS.

- Peel (Adhesion) Strength Test

a) Peel (adhesion) strength test shall be performed on the applied sleeve to ensure that the adhesion is satisfactory. The test shall initially be done on one joint per shift or one in twenty whichever is more frequent.

b) The testing shall be made at a sleeve temperature of 25º C (for both the sleeve and steel substrate), slight heating or cooling may be utilized.

c) The Peel Strength shall not be less than 12 N/cm with the bulk of the adhesive remaining on the pipe surface. Failure to satisfy the said test result shall be grounds for rejection by client. The agency shall recoat all rejected coated weld joints.

- Thickness Measurement

a) The thickness measurements of the applied primer and the HSS shall be made at ambient temperature using a non-destructive thickness gauge, or suitable approved instrument. The gauge shall be calibrated at least twice per shift. There shall be at least four equally spaced measurements performed around the circumference of the joint and across the width of the joint.

b) The thickness measurements shall be in accordance with the method described.

c) The DFT of the primer shall be minimum 50-60 micron, and the average thickness of completed finished coating shall be 2.0 mm. The minimum permissible thickness at the apex of weld seam shall be 1.6 mm. Thickness average shall be recorded and included in the Agency's inspection report. Should the actual thickness be less than the minimum specified value, the coating shall be rejected and new sleeve shall be applied.

- Holiday Detection

a) Upon complete cooling of the applied shrink sleeve, all surface area of the applied field joint shall be subjected to100% holiday detection prior to lowering in the trench. The detector shall be a pulse-type recommended by the coating manufacturer and approved by client. The test voltage shall be set to a value depending upon coating thickness, in accordance with NACE RP 0274. Calibration of the detector shall be at least twice per 8 hours.

b) The electrode used for locating holidays shall be designed to ensure direct contact with the coating, (with no visible gaps) and provide complete coverage of the whole coated surface area. The travel rate of the detector electrode shall not exceed 0.30 m/s and shall not be allowed to remain stationary while the power is on.

c) The allowable holiday acceptance criteria, to avoid complete rejection, will be specified by the project specification and agreed by client and the agency. The maximum number of holidays that can be repaired per field joint shall be two (2). All joints having more than two (2) holidays shall be stripped, re-blasted and recoated in accordance with this specification.

d) All holidays detected shall be marked. Sleeves with unacceptable holidays shall be removed and replaced with new ones. The defective sleeves within the acceptance criteria can be repaired and then tested for holiday free status. Repairs shall be carried out in accordance with the manufacturer's recommended repair procedure.

- Quality Control Table

Table 2.1: HSS Material Properties – Backing

Sr. No.	Property	Requirement	Test Method
1	Adhesion Test	450 Kg/m	ASTM D 100
2	Impact Test at 25º C	10 J/mm (Min)	ASTM G14
3	Cathodic Disbondment at 23º C	10 mm (Max)	ASTM G8
4	Cathodic Disbondment at 60º C (30 days)	30 mm (Max)	ASTM G42
5	Peel Strength at 25º C With metal surface With plant coating Peel Strength at 50º C With metal surface With plant coating	 20 N/cm (Min) 12 N/cm (Min) 5 N/cm (Min) 3 N/cm (Min)	 ASTM 1000 or DIN 30672
6	Indentation Resistance at 50º C	Pass	DIN 30672
7	Hot Water Immersion	Visual Test – Pass	ASTM 870
8	Water Absorption	0.1 % Max	ASTM D 2671
9	Lab Shear Strength between Wrapping and metal surface and plant Coating	5 N/cm^2 (Min)	DIN 30672

Table 2.2: HSS Material Properties –As Applied

Sr. No.	Property	Requirement	Test Method
1	Softening Point	90º C (Min)	ASTM E 28
2	Shear Strength at 50º C	60 N/cm^2 (Min)	ASTM D1002 or DIN 30672

Table 2.3: HSS Material Properties – Adhesive

Sr. No.	Property	Requirement	Test Method
1	Tensile Strength at 25º C	17 N/mm^2 (Min)	ASTM 638
2	Elongation at 25º C	400% (Min)	ASTM 638
3	Dielectric Strength (1000 Volts/s) at 25º C	30 KV (Min)	ASTM 638
4	Water Absorption (24 Hours) at 25º C	0.05% (Min)	ASTM 570
5	Volume Resistivity at 25º C	10^{15} Ohm-cm	ASTM 257
6	Resistance to Thermal Aging at 100º C	300% Elongation	ASTM 638
7	Hardness	45-55 Shore D	ASTM D2240

Table 2.4: Inspection/Testing of Surface Preparation

Sr. No.	Item/Property	Requirement	Test Method	Frequency
1	Initial steel surface condition	Dry and free from contamination, rust and weld spatters/defects.	Visual inspection	Every joint
2	Steel temperature and RH	Temperature minimum 3º c above dew point. RH less than 85%.	As per agency procedure	Start of each shift and then every 4 hours (Min)
3	Surface cleanliness (salt/chloride contamination)	Surface free of salt/chloride	Agency's approved procedure	First 10, then one joint/shift
4	Surface cleanliness (visual standard)	SA 2.5- SSPC-Vsi 1	Visual examination ISO 8501-1/SPC10	Every joint
5	Surface cleanliness (residual dust particles)	Class 2 Rating 2	ISO 8502-3	First 10, then one joint/shift
6	Surface Profile	50-100 Micron	ASTM D4417 or NACE RP0287	First 10, then one joint/shift
7	Final Surface Condition	Free from surface defects, dust, rust blooming	Visual examination	Every joint

Table 2.5: Testing of Applied HSS

Sr. No.	Item/Property	Requirement	Test Method	Frequency
1	Joint coating – Visual	Smooth surface. No sign of dimples, cold spots, bubbles, punctures, burn holes or holidays.	Visual examination Approved procedure	Every Joint
2	Thickness Primer HSS Applied	50-60 Micron (Min) 2 mm (average)	SSPC PA2 or Approved Procedure	Every Joint
3	Peel Strength at 25 C	12 N/cm (Min)	DIN 30670	One joint/shift or one/twenty
4	Holiday Detection	100% Holiday Free	NACE RP 0274	Every Joint

III. Sample Practice – Underground Pipe Heat Shrinkable Sleeve (HSS) Application

The practical work involved the application of heat shrinkable sleeves (HSS) on mild steel pipes to protect them from underground corrosion. The procedure was carried out under controlled conditions to simulate actual field application. The following steps were followed during the process:

3.1 Surface Preparation

The surface of the mild steel pipe was cleaned thoroughly to remove all rust, scale, oil, and dirt. This was done using the Air Blast Cleaning process. The cleaned surface ensured better adhesion of the sleeve and prevented corrosion under the wrap.

Fig 3.1 – Surface Preparation by Air Blast Cleaning Process

Fig 3.2 – Surface Profile Gauge

Fig 3.3 – Measure Surface Profile

3.2 Drying

The pipe surface dried completely to eliminate moisture, which could affect bonding and lead to corrosion beneath the sleeve.

Fig 3.4 – Pipe Surface Drying by Heating Process and Drying

Fig 3.5 – Pipe Surface Temperature after Heating

3.3 Primer Application

Epoxy primer was applied evenly over the prepared pipe surface and allowed to dry for a few minutes as per the manufacturer's guidelines.

Fig 3.6 – Primer Application

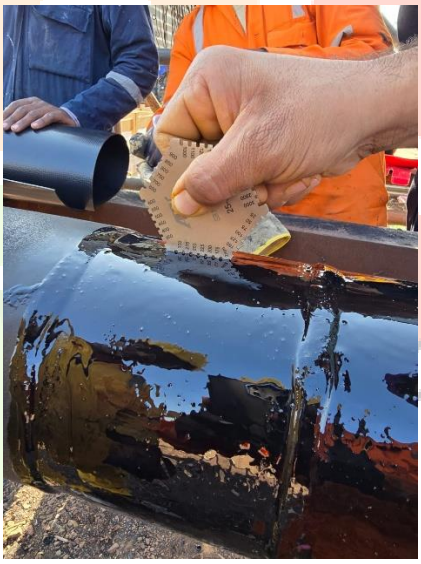


Fig 3.7 – Thickness Measure by Wet Film Thickness Gauge

3.4 Positioning The Sleeve

The heat shrink sleeve was then wrapped around the pipe, centered over the area to be protected. Care was taken to ensure proper overlap and alignment. The adhesive side of the sleeve was placed directly against the pipe surface.

Fig 3.8 – Positioning the Sleeve

3.5 Heating and Shrinking

A propane torch was used to apply heat uniformly over the surface of the sleeve. Heating started from the center and gradually moved towards the ends, ensuring even shrinkage and avoiding the formation of air pockets. The sleeve was observed to shrink tightly around the pipe, and the adhesive melted and bonded to the pipe surface.

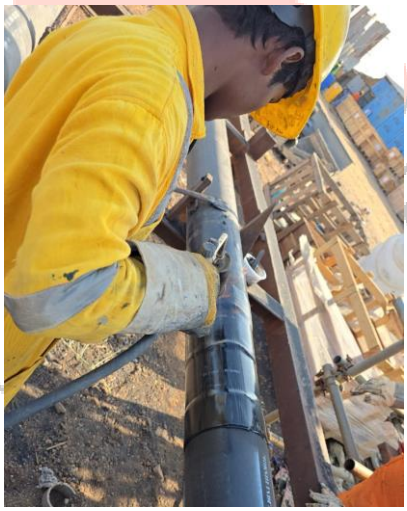


Fig 3.9 – Heating and Shrinkage

3.6 Cooling and Inspection

After heating, the sleeve was allowed to cool naturally. A visual inspection was carried out to confirm proper adhesion, full shrinkage, and the absence of wrinkles, gaps, or bubbles. The sleeve formed a smooth, tight, and sealed coating over the pipe surface.

Fig 3.10 – Cooling Temp after Shrinking

Fig 3.11 – Peel Test for proper Adhesion

3.7 Holiday Detection

a) No holidays (defects) were detected across the tested sleeve surface.
b) The sleeve demonstrated a continuous, defect-free protective layer, confirming correct application and material integrity.
c) The absence of pinholes or voids ensures effective corrosion protection in underground conditions.

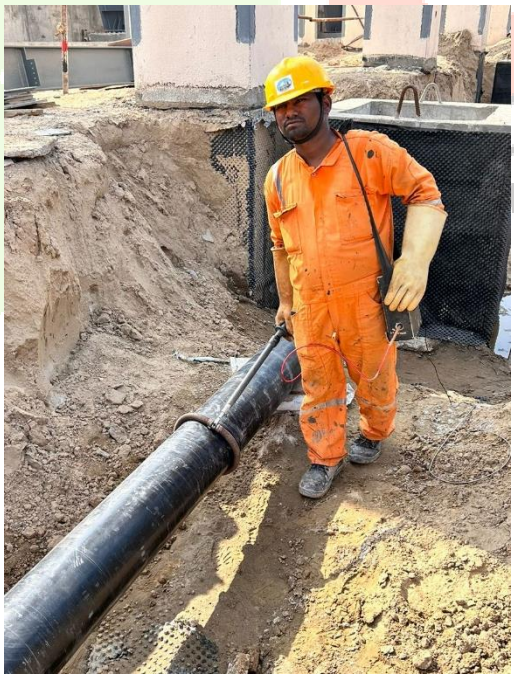


Fig 3.12 – Holiday Inspection

3.8 Backfilling Simulation

Once the application was complete, the pipe section was placed in a soil-filled container to simulate underground burial conditions. Soft backfill was used around the sleeve area to prevent mechanical damage. This practical exercise demonstrated the ease of application, strong adhesion, and effective sealing properties of heat shrinkable sleeves when used for underground corrosion protection. The results confirmed the reliability of HSS as a protective coating for mild steel pipelines in buried conditions.

IV. RESULT AND DISCUSSION

The practical application of heat shrinkable sleeves (HSS) on underground mild steel pipes was carried out to assess the effectiveness of this method in protecting buried pipelines from corrosion. This section presents the outcomes of the application process, evaluates the performance of the sleeves in simulated underground conditions, and compares the protected samples with uncoated controls. The results are analyzed based on visual inspection, physical integrity, sealing performance, and early-stage corrosion behavior. By interpreting these findings, the objective is to understand the real-world effectiveness of HSS in mitigating underground corrosion and to validate its suitability for industrial pipeline protection.

4.1 EXPERIMENT RESULT

4.1.1 Adhesion and Sealing

- The heat shrinkable sleeve bonded firmly to the prepared pipe surface.
- The adhesive layer spread evenly upon heating and provided a continuous, water-tight seal.
- No gaps, wrinkles, or air pockets were observed upon inspection, indicating correct application.

4.1.2 Mechanical Integrity

- After cooling, the sleeve formed a tight, rigid layer that was resistant to manual peeling or deformation.
- The sleeve maintained its shape and adhesion even after simulated underground burial.

4.1.3 Corrosion Resistance (Short-Term Observation)

- After a few weeks of exposure in the soil environment, there were no visible signs of corrosion or rusting beneath the sleeve.
- The sleeve effectively prevented moisture and soil contact with the metal surface.

4.1.4 Comparison with Unprotected Sample

- In contrast, the unprotected mild steel pipe (control sample) buried under similar conditions exhibited early signs of surface corrosion and rust formation.

4.2 OBSERVATION

PROCEDUREQUALIFICATION REPORT FOR HTLP80-HP FIELD JOINT COATING

Project : Product Ware House and Work shop Pkg-14
Client : HPCL Rajasthan Refinery Limited (HRRL)
PMC : Engineers India Limited
Contractor : Montecarlo Limited
Specification Number : EIL Specification Number 6-71-0044 Rev.4
Field joint coating material : Covalence Heat Shrink SleeveHTLP80-HP withS1301M Epoxy
Repair Material : PERP 80, S1137 Filler Mastic & Melt Stick.
Location : HRRL Refinery - Rajasthan – India
Date : 15-12-2024 To 17-12-2024

OFFICIALS PRESENT

HRRL / EIL	MONTECORLA	ISK SERVICES
Mr. Binay Kumar (DM)	Mr. Saroj Kumar Gupta	Mr. Rushikesh Prajapati
+91 8982252545	+91 8553218585	+91 7575810088

OBSERVATIONS:

- **PIPE & JOINT DETAILS:**

1	Pipe Dia	Various Dia	8.625"
2	Type of Main Line Coating	3LPE to 3LPE	SJ-07
3	Coating cut back	140 mm	140 mm
4	Pipe Wall thickness	7.11 mm	7.11 mm
5	No. of HTLP 80 Joints Coated	01	01
6	No. of applicators on each joint	01	01
7	Number of Heating Torches used	01	01 Numbers of BN 80

- **BATCH NUMBERS:**

1	Batch number of HTLP80-HP	Visual	V24213
2	Batch no of S1301M Epoxy Part A		B24264A
3	Batch no of S1301M Epoxy Part B		B24290A1

- **CHAMFERING:**

1	Chamfering of 3LPE coating at angle 30° with horizontal	SLF Recommendation	Yard coating from factory was chamfered at site.

- **ATMOSPHERIC CONDITION:**

1	Relative Humidity	Visual	49.0%
2	Dew point		21.0°C
3	Ambient temperature		33.6°C

- **SURFACE PREPARATION:**

1	Cleaning & moisture removal	ISO – 8501 -1	Satisfactory
2	Free from oil & grease		Satisfactory
3	Visual comparison using comparator	ISO – 8503 -1	Satisfactory
4	Blast Cleaning to SA 2½ - Sweep blasting – 100mm sleeve overlap area on 3LPE mill coating	ISO 8501-1	Satisfactory
5	Surface roughness 50-70microns using Micro Meter and Press 'O' film	SIS - 055900	60µ
6	Dust Contamination test	ISO 8502 - 3	Level – 2

APPLICATION OF HTLP80-HP WRAP AROUND THE SLEEVE

(A) – APPLICATION OF LIQUID EPOXY LAYER – S1301M

1	S1301 M Epoxy Mixing Ratio Part A & Part B	By Volume 3:1

- **MIXING TIME OF PART-A & PART-B**

1	Part A & Part B to be mixed thoroughly for 30 secs.	SFL Recommendation	Satisfactory

- **PRE HEAT TEMPERATURE**

1	Steel – 70 to 80° C	SFL Recommendation	Satisfactory
2	Yard coating – 70 to 80° C		Satisfactory

- **EPOXY APPLICATION**

1	Primer Application only on steel.	SFL Recommendation	Satisfactory
2	Primer Thickness (WFT) ≥ 200 Microns		Satisfactory

APPLICATION OF HTLP 80HP HEAT SHRINK SLEEVE

- **INITIAL CHECKS**

1	Epoxy primer prior to application	SFL Recommendation	Wet
2	Chamfering of inside edge of the sleeve (2" x ⅛")		Done at site
3	Position of sleeve overlap 10 or 2 O'clock		Satisfactory
4	Upper end of the sleeve facing downward		Satisfactory

- **CLOSURE PATCH**

1	Application with pre-heating on inner surface of closure patch	SFL Recommendation	Satisfactory
2	Heating after application and patting down		Satisfactory

- **HEAT SHRINKING OF HTLP-80 HP SLEEVE**

1	Direction of flame movement	SFL Recommendation	Circular and one end to another end
2	Post heating to the entire sleeve		Satisfactory
3	Dimples on the backing		Heating continued till dimples on the backing vanished
4	Check of adhesive flow with finger		Satisfactory
5	Removal of wrinkles & air by rolling		Satisfactory
6	Pressing down of edges		Satisfactory
7	Roller movement		Satisfactory
8	Final post heating to the entire sleeve		Satisfactory

INSPECTION & TESTING:

- **VISUAL INSPECTION**

1	Adhesive flow evident over the entire circumference on both edges	SFL Recommendation	Satisfactory
2	Sleeve fully conformed to pipe and adjacent coating		Satisfactory
3	Free from air entrapments & air voids		Satisfactory
4	Sleeve surface free of burns & punctures		Satisfactory
5	Weld bead profile evident from the sleeve		Satisfactory
6	Visual indicator – Dimples vanished from the backing		Satisfactory

- **HOLIDAY TESTING**

1.	Holiday check at 25Kv	NACE RP-02 -74	Satisfactory

- **COATING THICKNESS IN / MM**

Required Thickness on steel Surface 2.5mm& Required Thickness on weld Seam 2.0mm

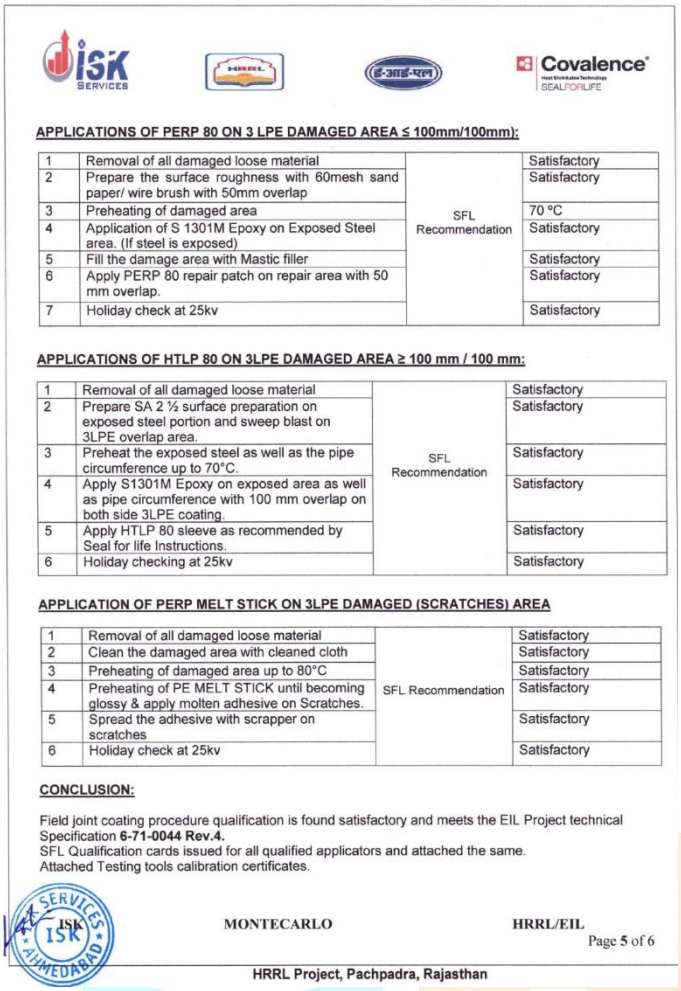
Joint No.	Thickness on Steel Surface	Thickness on Weld Seam
8.625", SJ-07	2.56, 2.64, 2.69, 2.71, 2.59, 2.64, 2.67, 2.66	2.29, 2.21, 2.28, 2.31

- **PEEL TEST**

Joint No.	Temp. °C	Peel to Steel Kg / 25mm	Peel to 3LPE Kg / 25mm	PASS/FAIL
SJ-07	32.0°C	>15 Kg/25mm	>17 Kg/25mm	PASS

APPLICATIONS OF PERP 80 ON PEEL TEST AREA:

1	Cut the peel test strip (25mm X200mm)	SFL Recommendation	Satisfactory
2	Prepare the surface roughness with 60mesh sand paper with 50mm overlap		Satisfactory
3	Preheat peel area up to 70°C		Satisfactory
4	Fill the peel test area with S 1137 Mastic filler.		Satisfactory
5	Apply PERP 80 repair patch on peel area with 50mm overlap		Satisfactory
6	Adhesive has to come out from the PERP 80 patch from all directions		Satisfactory
7	Holiday check at 25kv		Satisfactory



APPLICATIONS OF PERP 80 ON 3 LPE DAMAGED AREA ≤ 100mm/100mm):

1	Removal of all damaged loose material	SFL Recommendation	Satisfactory
2	Prepare the surface roughness with 60mesh sand paper/ wire brush with 50mm overlap		Satisfactory
3	Preheating of damaged area		70 °C
4	Application of S 1301M Epoxy on Exposed Steel area. (If steel is exposed)		Satisfactory
5	Fill the damage area with Mastic filler		Satisfactory
6	Apply PERP 80 repair patch on repair area with 50 mm overlap.		Satisfactory
7	Holiday check at 25kv		Satisfactory

APPLICATIONS OF HTLP 80 ON 3LPE DAMAGED AREA ≥ 100 mm / 100 mm:

1	Removal of all damaged loose material	SFL Recommendation	Satisfactory
2	Prepare SA 2 ½ surface preparation on exposed steel portion and sweep blast on 3LPE overlap area.		Satisfactory
3	Preheat the exposed steel as well as the pipe circumference up to 70°C.		Satisfactory
4	Apply S1301M Epoxy on exposed area as well as pipe circumference with 100 mm overlap on both side 3LPE coating.		Satisfactory
5	Apply HTLP 80 sleeve as recommended by Seal for life Instructions.		Satisfactory
6	Holiday checking at 25kv		Satisfactory

APPLICATION OF PERP MELT STICK ON 3LPE DAMAGED (SCRATCHES) AREA

1	Removal of all damaged loose material	SFL Recommendation	Satisfactory
2	Clean the damaged area with cleaned cloth		Satisfactory
3	Preheating of damaged area up to 80°C		Satisfactory
4	Preheating of PE MELT STICK until becoming glossy & apply molten adhesive on Scratches.		Satisfactory
5	Spread the adhesive with scrapper on scratches		Satisfactory
6	Holiday check at 25kv		Satisfactory

CONCLUSION:

Field joint coating procedure qualification is found satisfactory and meets the EIL Project technical Specification **6-71-0044 Rev.4.**
SFL Qualification cards issued for all qualified applicators and attached the same.
Attached Testing tools calibration certificates.

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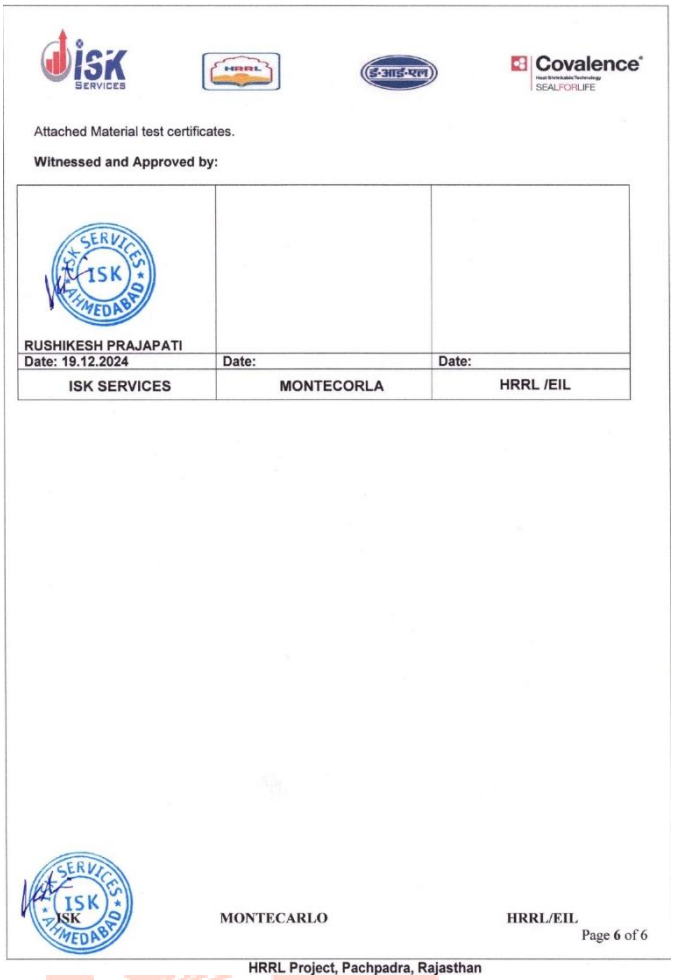

Attached Material test certificates.

Witnessed and Approved by:

RUSHIKESH PRAJAPATI		
Date: 19.12.2024	Date:	Date:
ISK SERVICES	MONTECORLA	HRRL /EIL

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4.3 DISCUSSION

The practical results demonstrate that heat shrinkable sleeves offer a reliable and effective method for protecting underground mild steel pipelines from corrosion. The strong adhesive bond, combined with the shrink-fit mechanism, provides both a mechanical barrier and moisture-resistant seal, which are critical in preventing corrosive agents in soil from reaching the pipe surface.

The successful application also highlights the importance of proper surface preparation and heating technique. Any deviation from the standard procedure—such as inadequate cleaning, uneven heating, or moisture presence—could compromise the protective performance of the sleeve.

Additionally, the sleeve showed good mechanical resistance during burial simulation, with no evidence of tearing or disbandment. This suggests that heat shrink sleeves are suitable for field conditions where the pipe may experience soil pressure, movement, or vibrations.

The short-term corrosion resistance performance was promising, and it is recommended that further long-term studies or accelerated aging tests be conducted to assess durability over time under different soil types, temperatures, and moisture levels.

V. CONCLUSION

The results of the practical work clearly demonstrate that heat shrinkable sleeves (HSS) provide an effective and reliable method for protecting underground mild steel pipelines against corrosion. The proper application of the sleeves resulted in strong adhesion, uniform sealing, and excellent surface coverage, all of which are critical factors in preventing moisture ingress and corrosion initiation.

The comparison with uncoated control samples highlighted the superior performance of the HSS in resisting early-stage corrosion under soil exposure. Additionally, the mechanical integrity and durability of the sleeves during simulated burial conditions confirm their suitability for long-term underground use.

Overall, the practical findings support the conclusion that HSS is a cost-effective, easy-to-apply, and efficient corrosion protection solution for industrial underground pipelines, provided that surface preparation and installation procedures are properly followed.

The practical evaluation of heat shrinkable sleeves (HSS) for underground mild steel pipe corrosion protection provided valuable insights into the material's effectiveness, reliability, and application feasibility in real-world conditions. From the initial surface preparation to the final inspection after burial simulation, each stage of the process was closely monitored to assess the performance of the HSS as a protective barrier against corrosion.

The application process revealed that with proper surface cleaning and uniform heating, the HSS adhered strongly to the pipe surface, creating a tight and continuous seal. This seal was crucial in preventing direct contact between the pipe metal and the surrounding soil and moisture, which are the primary contributors to corrosion in underground environments. The thermoplastic adhesive effectively bonded with the pipe, and the heat-shrunk polyolefin layer provided mechanical strength and environmental resistance.

Visual and physical inspections after cooling and burial simulation confirmed that the sleeve remained intact, without any signs of wrinkling, air entrapment, or edge lifting. This indicates a successful application that could withstand ground movement, pressure, and environmental stresses over time. Furthermore, when compared to unprotected control pipe sections, the HSS-covered pipes showed no visible corrosion, while the bare pipes exhibited early-stage rusting. This confirmed the superior protection offered by the sleeve system, even in short-term soil exposure conditions.

The results also emphasized the importance of proper application techniques. The success of the HSS depends heavily on surface preparation (free from rust, dust, and oil), correct alignment, and even heating during the shrinking process. Any oversight during these steps could compromise the sealing and adhesion, reducing the sleeve's long-term performance.

From a practical standpoint, the HSS method proves to be not only effective but also field friendly. Its ease of application, minimal equipment requirements, and quick installation process make it suitable for industrial projects where time and labour efficiency are essential. Moreover, it can be used as both a primary corrosion protection method and as a supplementary layer over other coating systems or field joints.

In conclusion, the practical work supports the effectiveness of heat shrinkable sleeves as a dependable corrosion protection system for underground mild steel pipelines. The findings validate the sleeve's ability to prevent corrosion under normal soil conditions, offering a viable alternative to traditional coating systems. For comprehensive assurance, however, it is recommended that long-term field trials and further studies be conducted to evaluate performance under varying soil chemistries, temperatures, and mechanical stress conditions. Nevertheless, this study reinforces the relevance of HSS in modern corrosion protection strategies for underground steel infrastructure.

REFERENCES

[1] Fontana, M.G. (1986). Corrosion Engineering. McGraw-Hill.
[2] Revie, R.W., & Uhlig, H.H. (2008). Corrosion and Corrosion Control. Wiley-Interscience.
[3] Peabody, A.W. (2001). Control of Pipeline Corrosion. NACE International.
[4] Andrews, R. et al. (1995). "Performance Evaluation of Heat Shrinkable Sleeves for Pipeline Protection." Journal of Protective Coatings & Linings.
[5] Kumar, S., & Singh, A. (2012). "Comparative Study on Corrosion Protection Techniques for Underground Steel Pipelines." International Journal of Corrosion Science and Engineering.
[6] Shell Pipeline Services (2010). Long-Term Assessment of Heat Shrink Sleeve Performance in Buried Pipelines.
[7] Gupta, M., & Thomas, J. (2014). "Field Installation Challenges and Quality Control for Heat Shrinkable Sleeve Systems." Pipeline Coating Journal.

APPENDIX I

Reference codes & standards

Where reference is made to the following standards and codes, the latest edition shall be applicable.

1. Surface Preparation

ISO 8501-1 (BS 7079-A1) (SIS 05 5900)
Preparation of Steel Substrate before Application of Paints and Related Products-Visual Assessment of Surface Cleanliness. Pt 1: Specification for Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Substrates after Overall Removal of previous Coatings. Sup 1: Representative Photographic Examples of the Change of Appearance Imparted to Steel When Blast- Cleaned with Different Abrasives.

ISO 8502 (2-4) {BS7079 (B2-B4)}
Preparation of Steel Substrate before Application of Paints and Related Products - Tests Methods for Assessment of Surface Cleanliness.

ISO 11124 (1-4) {BS7079 (E1-E4)}
Preparation of Steel Substrate before Application of Paints and Related Products - Metallic Blast-Cleaning Abrasives.

SSPC-SP1 Steel Structure Painting Manual - Ch.2, Surface Preparation Specifications - Solvent Cleaning.
SSPC-SP2 Steel Structure Painting Manual - Ch.2, Surface Preparation Specifications – Hand Tool Cleaning.
SSPC-SP3 Steel Structure Painting Manual - Ch.2, Surface Preparation Specifications – Power Tool Cleaning.
SSPC-SP7 (NACE No. 4) Steel Structure Painting Manual - Ch.2, Surface Preparation Specifications – Joint Surface preparation Standard, Brush-off blast Cleaning NACE No. 4.
SSPC SP10 (NACE No. 2) Joint Surface Preparation Standard - Near White Blast Cleaning (Steel Structures Painting Council - Surface Preparation Specifications).
SSPC SP11 Steel Structure Painting Manual - Ch.2, Surface Preparation specifications – Power Tool Cleaning to Bare Metal.
SSPC VIS1 Steel Structure Painting Manual - Ch.2, Surface Preparation Specifications – Visual Standard for Abrasive Blast Cleaned Steel (Standard Reference Photographs).

2. Field Joint Coating

AWWA C-216 Heat Shrinkable Cross-linked Polyolefin Coatings for the Exterior of Special Sections, Connections and Fittings for Steel water Pipelines.
NACE RP0190 External Protective Coating for Joints, Fittings and Valves on Metallic Underground or Submerged Pipelines and Piping Systems.
NACE RP0169 Standard Recommended Practice for Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

3. Inspection and Testing

ASTM G14 Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test).
ASTM D4417 Field Measurement of Surface Profile of Blast Cleaned Pipe.
ASTM D 638 Standard Test Method for Tensile Properties of Plastics.
ASTM D 2671 Standard Test Method for Heat –Shrinkable Tubing for Electrical Use.
ASTM D 1000 Standard Test Method for Pressure Sensitive Adhesive-Coated Tapes Used for Electrical & Electronic Application.
ASTM D 2240 Standard Test Method for Rubber Property – Durometer Hardness.
ASTM D257 Standard Test Method for DC Resistance or Conductance of Insulating Materials.
ASTM D570 Standard Test Method for Water Absorption of Plastics.
ASTM D870 Standard Practice for Testing Water Resistance of Coatings Using Water Immersion.
ASTM D1002 Standard Test Method for Apparent Shear Strength of Single-lap- joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)
ASTM E 28 Standard Test Method for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus.
ASTM G 8 Standard Test Method for Cathodic Disbonding of Pipeline Coatings.

ASTM G42 Standard Test Method for Cathodic Disbonding of Pipeline Coatings Subjected to Elevated Temperatures.
DIN 30670 Polyethylene Coatings for Steel Pipes and Fittings.
DIN 30672 Corrosion Protection Wrapping Tape and Heat Shrinkable Material for Pipes Designed for Service Temperatures up to 50º C.
ISO 9000-2-4 Quality Management Systems and Quality Assurance Standards.
NACE RP 0274 High Voltage Electrical Inspection of Pipeline Coating Prior to Installation.
NACE RP 0287 Field Measurements of Surface Profile of Abrasive Blast Cleaned Steel Surface Using Replica Tape.
SSPC – PA2 Measurements of Dry Coating Thickness with Magnetic Gauges (Steel Structure painting Manual – Ch. 5, Paint Application Specifications).