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Field-Applied, Heat-Shrinkable-Sleeve Coating System for Pipelines: Application, Performance, and Quality Control

ABSTRACT

Revised in 2020, this NACE International standard practice provides current technology and industry practices for the use of field-applied heat-shrinkable-sleeve coating systems. The standard is intended for use by corrosion control personnel, design engineers, project managers, purchasers, and construction engineers and managers. It is applicable to underground steel pipelines in the oil and gas gathering, distribution, and transmission industries.

The standard practice presents guidelines for establishing minimum requirements to ensure proper application and performance of field-applied, heat-shrinkable sleeves to the external surfaces of coated pipe. Included are methods for (1) qualifying and controlling the quality of a heat-shrinkable sleeve, (2) guidelines for proper application, and (3) inspection and repair techniques to ensure its long-term performance. The standard is applicable to coating systems used to prevent corrosion in conjunction with cathodic protection, and heat-shrinkable wraparound- or tubular-type sleeve coating systems, underground steel pipelines.

KEYWORDS

Alyeska shear test, cathodic protection, dry film thickness, external corrosion, field-applied, heat-shrinkable-sleeve coating systems (HSS-CS), hot-melt adhesive layer, Lap shear, mastic-based adhesive layer, oil and gas distribution, polyolefin, SP0169, STG 03, submerged steel pipelines, surface preparation, TG 248, tubular-type heat-shrinkable-sleeve, weld-after-backfill, wraparound-type heat-shrinkable-sleeve

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Foreword

This NACE standard practice provides the most current technology and industry practices for the use of two types of field-applied, heat-shrinkable-sleeve coating systems (HSS-CS); one, where the polyolefin backing is coated with a mastic-based adhesive layer, and the other has the polyolefin backing coated with a hot-melt-based adhesive layer. This standard is intended for use by corrosion control personnel, design engineers, project managers, suppliers, purchasers, and construction engineers and managers. It is applicable to underground or submerged steel pipelines in the oil, gas, and water gathering, distribution, and transmission industries.

This standard practice was originally prepared in 2003 and revised in 2020 by Task Group (TG) 248, "Coatings, Heat-Shrink Sleeves for External Repair, Rehabilitations, and Weld Joints on Pipelines." TG 248 is administered by Specific Technology Group (STG) 03, "Coatings and Linings, Protective—Immersion and Buried Service." It is also sponsored by STG 04, "Coatings and Linings, Protective—Surface Preparation," and STG 35, "Pipelines, Tanks, and Well Casings." This standard is issued by NACE under the auspices of STG 03.

In NACE standards, the terms ***shall, must, should,*** and ***may*** are used in accordance with the definitions of these terms in the NACE Publications Style Manual. The terms ***shall*** and ***must*** are used to state a requirement, and are considered mandatory. The term ***should*** is used to state something good and is recommended, but is not considered mandatory. The term ***may*** is used to state something considered optional.

Field-Applied, Heat-Shrinkable-Sleeve Coating System for Pipelines: Application, Performance, and Quality Control

Section 1: General

1.1 This standard presents guidelines for establishing minimum requirements for the application and performance of a field-applied, heat-shrinkable sleeve coating system to the external surfaces of coated pipe at the joints. Practices are included for qualifying and controlling the quality, surface preparation, application, inspection, and repair of a heat-shrinkable-sleeve coating system.

1.2 This standard is applicable to heat-shrinkable-sleeve coating systems used to prevent external corrosion in conjunction with cathodic protection on underground or submerged steel pipelines in the oil, gas, or water gathering, distribution, and transmission industries.

1.3 This standard is applicable to wraparound- or tubular-type heat-shrinkable-sleeve coating systems.

1.4 The purchaser shall assess construction and soil conditions that could lead to mechanical damage (e.g., abrasion, impact, soil stress) to the coating. The supplier should be consulted for recommendations of systems suitable for the construction and service conditions. The shrink sleeve manufacturer should recommend appropriate products and procedures for ensuring the required performance. Recommendations may include either specific products or precautionary measures, e.g., special backfills, rockshield, or other damage prevention techniques.

Section 2: Definitions

Applicator: The organization responsible to the purchaser for the coating system application.

Batch: The quantity of coating material produced during a continuous production run of not more than 24 hours.

Coating Materials: Premanufactured heat-shrinkable sleeves and associated accessory products (e.g., primer, filler material, and coating repair materials).

Coating Repair Materials: Premanufactured patches, filler material, and other materials compatible with and made from similar materials as the coating material.

Coating System: The complete number and types of coats applied to a substrate in a predetermined order. (When used in a broader sense, surface preparation, pretreatments, dry film thickness, and manner of application are included.)

Cutback Area: The area of pipe left uncoated at the coating mill/plant to facilitate welding of adjacent pipe joints.

Filler Material: Compatible material used under a heat-shrinkable sleeve to fill voids or bridge transitions.

Holiday: A discontinuity in a protective coating that exposes unprotected surface to the environment.

Hot-Melt Adhesives: Adhesives that can typically perform up to 120 °C (250 °F).

Mainline Coating: The plant-applied pipeline coating to which the heat-shrinkable-sleeve coating system must adhere and be compatible.

Mastic-Based Adhesives: Adhesives that typically have an upper operating temperature of approximately 80 °C (180 °F).

Maximum Service Temperature: The maximum operation temperature at which the coating system might be used.

Primer: A coating material intended to be applied as the first coat on an uncoated surface. The coating is specifically formulated to adhere to and protect the surface as well as to produce a suitable surface for subsequent coats.[1] Cold-applied liquid that provides a specifically designed environment to enhance the bond of a particular coating system. The primer serves to thoroughly wet the metal surface, penetrate the metal surface variations, and provide an effective bonding medium between the metal surface and the shrink-sleeve coating.

Purchaser: The owner company or the authorized agency that has the authority for the pipe to which the field-applied heat-shrinkable-sleeve coating system is to be applied.

Repair Area: Area of original coating system that has been damaged and is being repaired using the coating materials.

Rockshield: A durable, protective material that is bonded or nonbonded to the coating and is either perforated or electrically conductive under operating conditions.

Shelf Life: The maximum length of time packaged materials (e.g., coating materials) can be stored, at specified conditions, and remain in usable condition.

Supplier: The manufacturer and/or distributor of the coating materials. Supplier or manufacturer (or his delegated and qualified representative) can provide consultations and/or recommendations to the purchaser regarding the recommended product for the target application.

Weld-After-Backfill: The sequence of assembling a lap-welded joint, welding the outside joint (if required), applying the exterior joint coating(s), backfilling the pipe joint, and then welding the inside joint at a later time (where internal welding is safe and practical).

Section 3: Coating System

3.1 The purchaser shall specify all components of the heat-shrinkable-sleeve coating system, in accordance with the supplier's recommendations. The HSS-CS manufacturer/supplier may recommend an HSS-CS that is best suited for the target application and service/operating conditions, as defined by the purchaser.

3.2 Unless otherwise specified, the heat-shrinkable-sleeve coating system shall include the following components:

(a) Primer (if specified by the supplier);
(b) Premanufactured heat-shrinkable sleeve (wraparound- or tubular-type). The heat-shrinkable sleeve shall consist of a heat-recoverable polyolefin backing coated with a mastic-based or hot-melt adhesive layer; and
(c) Coating repair materials (if required).

3.3 The supplier must provide detailed application literature for the specified heat-shrinkable-sleeve coating system. The supplier must clearly state in the literature the required surface preparation for the heat-shrinkable-sleeve coating system application, because surface preparation is critical to performance of the coating system.

Section 4: Coating Materials

4.1 Coating Material

4.1.1 Coating materials may be furnished by different suppliers.

4.1.2 Coating material batches shall be identified by a batch coding system devised by the supplier. The batch code shall include a reference to the date of manufacture.

4.1.3 The supplier shall furnish the following information in writing to the purchaser and/or applicator:

(a) Directions for handling and storing the coating materials;
(b) Material Test Certificate stating minimum performance of the basic physical properties of the coating materials; and
(c) Safety data sheets (SDSs) for all coating materials.

4.2 Handling of Coating Materials

4.2.1 Coating materials shall be shipped and stored in accordance with recommendations from the supplier in a manner that avoids contamination or adverse effects on the coating materials.

4.2.2 Shelf Life

4.2.2.1 Any batch of coating material that has exceeded the recommended shelf life when delivered by the supplier may be rejected by the purchaser.

4.2.2.2 At the discretion of the purchaser, any batch of coating material that has exceeded the recommended shelf life may be tested to verify that it meets or exceeds the requirements as set forth herein.

4.2.2.3 Any rejected coating material shall be immediately removed from the job site.

Section 5: Coating Performance

5.1 Desirable characteristics of an external coating system for pipelines are outlined in NACE SP0169.[2]

5.2 The heat-shrinkable-sleeve coating system and coating repair materials shall meet the performance characteristics specified in Table 1.

5.3 The heat-shrinkable-sleeve coating system must be compatible with the mainline coating as demonstrated by the coating-specific performance testing identified in Table 1.

Table 1
Heat-Shrinkable-Sleeve Coating System Performance Characteristics

Property	Test Method	Units	Mastic-Based Adhesive Sleeve Requirement	Hot-Melt Adhesive Sleeve Requirement
Thickness	ASTM[(1)] D1000[3]	mm	≥ specified minimum value	≥ specified minimum value
Holiday detection	NACE SP0274[4]	J/mm	No holiday	No holiday
Tensile strength at failure	ASTM D6385[(A)]	kPa (psi)	>17,900 (2,600)	>17,900 (2,600)
Ultimate elongation	ASTM D638[5]	%	>500	>500
Volume resistivity	ASTM D257[6]	Ω·cm	10^{14} min.	10^{14} min.
Dielectric voltage breakdown	ASTM D149[7]	kV/mm (kV/in)	25 min. (634 min.)	25 min. (634 min.)
Peel adhesion to steel[(B)]	ASTM D1000[(B)]	N/cm (pli)[(C)]	25 (15)	25 (15)
Lap shear strength[(D)] at ambient temp: at operating temp:	ASTM D1002[8]	kPa (psi)	>150 (20)	>700 (100) >50 (7)
Cathodic disbondment at 23 °C (73 °F)	ASTM G8[9]	mm rad (in rad)	<15 (<0.6)	<15 (<0.6)
Cathodic disbondment at operating temperature	ASTM G42[10]	mm rad (in rad)	<25 (<1.0)	<25 (<1.0)
Hot water immersion 120 days at operating temperature[(E)]	ASTM D870[11]	visual	No delamination, blisters, or water under sleeve	No delamination, blisters, or water under sleeve
Water absorption	ASTM D570[12]	%	0.25 max.	0.25 max.
Hardness[(F)]	ASTM D2240[13] Shore D	mm	>45	>55
Heat aging of backing, 21 days at operating temperature	ASTM D638[(A)]	%	>75% of original elongation value	>75% of original elongation value
Alyeska shear test TP 206[(G)] at operating temperature	Modified ASTM D3080[14]	mm (in)	None	Max 2.54 mm (0.10 in)

[(A)] Properties tested in accordance with ASTM D638 shall be evaluated on the heat-shrinkable sleeve backing material only (i.e., with adhesive removed). Speed of testing 2 in/min.
[(B)] ASTM D1000 shall be modified for applicability to heat-shrinkable sleeves applied on a pipe mandrel or field-applied on a pipe, at a 90° peel angle and at a test speed of 100 mm/min. (4 in/min.).
[(C)] Pounds per linear inch (pli).
[(D)] Lap shear requirements identified are representative of many pipeline applications. However, factors such as pipe diameter, steel wall thickness, soil type, and burial conditions may result in higher shear stress forces being imparted on the coating materials. Test shall be performed at a test speed of 25 mm/min. (1 in/min.).
[(E)] Hot water immersion test shall be performed to assess the performance of coating material applied to the bare steel substrate and the intended mainline coating. This evaluation can be done by mounting a cup on top of the applied samples, filling the cup with DI water and monitoring the system over time. Max. test temperature shall be 95 °C.
[(F)] Should be tested on the backing only.
[(G)] Alyeska shear test shall be performed at Operating temperature.

[(1)] ASTM International (ASTM), 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.

5.4 Performance requirements have been identified for heat-shrinkable-sleeve coating systems with mastic-based and hot-melt adhesives.

5.4.1 Mastic-based adhesives typically have an upper operating temperature of approximately 80 °C (180 °F).

5.4.2 Hot-melt adhesives can typically perform up to 120 °C (250 °F).

5.4.3 For properties identified as “at operating temperature,” the supplier shall provide results at the rated pipeline operating temperature, or stated maximum test temperature for the product or system.

5.5 At the purchaser’s option, the supplier shall demonstrate fitness for service through prequalification testing, which consists of a field application and subsequent peel adhesion testing of the heat-shrinkable-sleeve coating system to the steel cutback and mainline coating, which shall be done under certain defined conditions. Additional tests may be specified by the purchaser.

5.6 This standard does not cover the additional materials and procedures that may be required for difficult installation conditions, such as those encountered in construction of submerged lines, casing pipe, river crossings, elevated temperature, or lines that are located in exceptionally rocky areas, or where soil conditions are known to be severe. Under these conditions, additional layers of material, outerwraps, rockshield, appropriate backfill, or other methods may be necessary. The manufacturer should be consulted for specific recommendations when these conditions exist.

Section 6: Surface Preparation

6.1 The purchaser shall specify the mainline coating cutback distance.

6.2 The applicator shall inspect the pipe surface to be coated for visible dents, scabs, slivers, and other damage. These defects shall be noted and corrected.

6.3 The edge of the mainline coating shall be beveled to 30° or less, either at the coating plant or in the field before installation of the heat-shrinkable-sleeve coating system.

6.4 The pipe shall be preheated to at least 5 °C (9 °F) above the dew point to remove the presence of moisture before surface cleaning.

6.5 Before dry abrasive blast cleaning or wire-brush cleaning, the surface of the pipe, weld, or repair area shall be inspected and, if required, cleaned in accordance with SSPC[(2)]-SP 1[15] to remove any oil, grease, or other contaminants.

6.6 Metal surfaces shall be dry abrasive blast cleaned or wire-brush cleaned to achieve the surface preparation specified by the supplier, and as agreed to by the purchaser. Unless otherwise specified, the surface preparation shall be as follows:

6.6.1 For surfaces requiring dry abrasive blast cleaning, the surface should be grit blasted in accordance with NACE No. 2/SSPC-SP 10.[16] The cleaned surface should be free of loose mill scale, rust, and old coatings.

6.6.2 For surfaces that are required to be wire-brush cleaned, the surface should be power tool cleaned in accordance with SSPC-SP 3.[17] The cleaned surface should be free of loose mill scale, rust, and old coatings.

6.7 The surface profile of dry abrasive blast cleaned pipe shall be angular and a minimum of 50 µm (2 mil) from peak to valley or as specified by the supplier. The surface profile should be measured in accordance with NACE SP0287.[18]

6.8 Wire-brush cleaning shall leave a coarse surface profile such that the surface is not polished.

6.9 The adjacent mainline coating(s), over which the heat-shrinkable-sleeve coating system is to be applied, shall be sweep blasted, or manually abraded, before application of the heat-shrinkable-sleeve coating system. Existing mainline coatings that are not being coated shall be protected from damage by impact, gouging, mechanical cleaning, or any other contact.

6.10 Residual products from the surface preparation process shall be removed from the exterior surface of the pipe.

[(2)]SSPC: The Society for Protective Coatings, 800 Trumbull Drive, Pittsburgh, PA 15205.

Section 7: Coating Application

7.1 The heat-shrinkable-sleeve coating system shall be applied before any corrosion products form on the prepared steel pipe surface, but within 4 hours after surface preparation. If the heat-shrinkable-sleeve coating system is not applied within the specified period, the surface preparation shall be repeated.

7.2 The primer (if specified by the supplier) shall be applied in accordance with the supplier's detailed application literature.

7.3 Before application of the primer (if used) or heat-shrinkable sleeve, the steel cutback and adjacent mainline coating shall be preheated as recommended by the supplier.

7.3.1 After preheating is complete, the temperature of the pipe substrate shall be checked with calibrated surface thermometers to ensure preheat is in the acceptable temperature ranges in accordance with the supplier's recommendation. If the preheat is not in the acceptable ranges, either more preheat shall be added; or, if overheated, the area shall be allowed to cool to an acceptable range.

7.3.2 All required safety procedures shall be followed before any sparks, ignition sources, or torches are allowed into the ditch or coating area. Those responsible for handling heating equipment, performing preheating of the pipe, applying shrink sleeve components, and heating the shrink sleeves shall have proper training to safely operate the heating equipment and perform the application process.

7.3.3 Only manufacturer-recommended gas torches, induction coils, or infrared heaters shall be used to heat the pipe.

7.3.4 Caution must be used in the preheating process so that no damage occurs to the existing coating system. Preheating should not cause the existing coating system to disbond, crack, sag, burn, or cause other degradation to the mainline coating adjacent to the field joint. If possible, testing should be performed to ensure no such damage will occur. If necessary, the existing coating can be protected with heat resistant wraps or blankets.

7.4 When a primer is specified, it shall be applied uniformly and be free of sags, drips, bare spots, and other defects.

7.5 When a primer is specified, it shall be applied in accordance with the supplier's recommendations. The primer thickness should be measured using a calibrated electronic DFT measuring instrument, or as calculated from thickness measurements using a wet-film gauge as it is being applied.

7.6 When a primer is specified, it shall be cured in accordance with the supplier's recommendations before application of the heat-shrinkable sleeves or other coating materials (e.g., filler material).

7.7 After the primer is cured, the temperature of the pipe substrate shall be checked with calibrated surface thermometers to ensure preheat is in the acceptable temperature ranges recommended by the supplier. If the preheat is not in the acceptable ranges, more preheat shall be added.

7.8 The heat-shrinkable-sleeve shall be applied as specified by the individual supplier's detailed application literature.

7.8.1 The heat-shrinkable-sleeve shall cover the mainline coating by at least 50.8 mm (2.0 in) on each side of the girth weld area.

7.8.2 For the tubular-type installation, the sleeve must be installed on the pipe before the pipe is welded together, then slid over the area once the area is preheated and primed (if required).

7.8.3 The wraparound-type installation may be applied by wrapping the material around the area after preheating and primer application (if required). The wraparound-type shall have the enclosure strip sealed using the appropriate sealing process.

7.8.4 Do not over heat the sleeve in one area since this may cause the sleeve to crack.

7.8.5 Under heating the sleeve may not allow the sleeve to properly adhere to the pipe surface.

7.8.6 Apply in a manner that minimizes air entrapment.

7.8.7 If air pockets exist, these can be removed while the sleeve is hot by using a small hand roller to force the air to the edge of the sleeve, or by other methods in accordance with the manufacturer's recommendations.

7.9 An alternate application method is weld-after-back fill, which is an acceptable practice for lap-welded joints, provided the requirements of all applicable NACE standards are followed.

7.9.1 Consult with the manufacturers and all other responsible parties regarding recommended products, installation, and backfill procedures required for the weld-after-backfield sequence.

7.9.2 At the request of the purchaser, the coating manufacturer shall provide testing or historical information to verify that the exterior joint coating will retain minimum performance requirements in accordance with the applicable standard throughout the heat-affected area.

Section 8: Inspection and Repair

8.1 Inspection

8.1.1 Surface Preparation: The surface preparation of the pipe shall be monitored in accordance with SSPC-VIS 1[19] or ISO[(3)] 8501-1[20] for compliance with Paragraph 6.6.

8.1.2 Holiday Inspection: The entire heat-shrinkable-sleeve coating system on each field application area may, at the purchaser's option, be inspected with a holiday detector in accordance with NACE SP0274 and set at a voltage in accordance with the supplier's specifications.

8.1.3 Peel Adhesion Testing: Adhesion of the applied heat-shrinkable-sleeve coating system may, at the purchaser's option, be verified by performing a field peel adhesion test in accordance with the modified ASTM D1000 using an electronic hand peel gauge and controlling conditions as closely as possible. The modification to ASTM D1000 is described in footnote [(B)] of Table 1.

8.2 Repair: Areas of the heat-shrinkable-sleeve coating system that require repair because of holidays or destructive testing shall be identified, marked, and repaired in accordance with the procedures specified in the supplier's application literature.

Section 9: Backfilling

9.1 Backfilling shall only be done after the heat-shrinkable-sleeve coating system has cooled to ambient temperature and after any required inspection or repairs are completed.

9.2 If required, rockshield, or other protective outer wraps, should be applied before backfilling the ditch.

9.3 The backfill shall not contain any material that may damage the coating system.

[(3)]International Organization for Standardization (ISO), Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

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NACE values your input. To provide feedback on this standard, please contact: standards@nace.org.

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