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Standard Practice for Installation of Vulcanized Rubber Linings[1]

This standard is issued under the fixed designation D7602; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the techniques used to install rubber lining sheet stock in metal tanks, pipes, and other components. Installation requirements, procedures, inspection instructions, and storage conditions for the lined tanks or equipment are outlined.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. This standard may involve hazardous materials, operations, and equipment.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D429 Test Methods for Rubber Property—Adhesion to Rigid Substrates

D2240 Test Method for Rubber Property—Durometer Hardness

D4285 Test Method for Indicating Oil or Water in Compressed Air

D4417 Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel

D4538 Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities

D5162 Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates

E1216 Practice for Sampling for Particulate Contamination by Tape Lift

2.2 *International Organization for Standardization:*[3]

ISO 8502-3 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)

2.3 *NACE Standards:*[4]

SP0178 Standard Recommended Practice—Fabrication Details, Surface Finish Requirements and Proper Design Considerations for Tanks and Vessels to be Lined for Immersion Service

SP0188 Discontinuity (Holiday) Testing of New Protective Coatings

2.4 *SSPC Standards:*[5]

SSPC-Technology Guide 15 Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates

SSPC-SP 1 Solvent Cleaning

SSPC-SP 2 Hand Tool Cleaning

SSPC-SP 3 Power Tool Cleaning

SSPC-SP 5/NACE No. 1 White Metal Blast Cleaning

SSPC-VIS 1 Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

3. Terminology

3.1 *Definitions*—Definitions for use with this standard are shown in Terminology D4538 or other applicable standards.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *autoclave, n*—a pressure vessel used for the curing or vulcanization of rubber parts by means of steam under pressure.

3.2.2 *blister, n*—an isolated convex deformation arising from the detachment of one or more layers of lining material.

3.2.3 *bond failure, n*—a separation of two adjoining surfaces.

[1] This practice is under the jurisdiction of ASTM Committee D33 on Protective Coating and Lining Work for Power Generation Facilities and is the direct responsibility of Subcommittee D33.09 on Protective Lining for Air Quality Control Systems.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from NACE International (NACE), 1440 South Creek Dr., Houston, TX 77084-4906, http://www.nace.org.

[5] Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656, http://www.sspc.org.

3.2.4 *calender, n*—a machine equipped with two or more heavy, internally heated or cooled rolls, that is used for continuous sheeting or plying-up of rubber compounds.

3.2.5 *calender blister, n*—trapped air between calender plies of a multi-ply rubber buildup.

3.2.6 *chemical cure, n*—a rubber lining system which can cure at low temperatures by topically applying a liquid curing agent.

3.2.7 *cutting table, n*—a table used for laying out, cutting and cementing rubber sheets prior to application to the component to be lined; often, the table is heated when used.

3.2.8 *closed skive, n*—a reverse-angle cut along the edge of a rubber panel that enables the installer to stitch down the cut edge so that the bottom layer of rubber or tie gum is protected from exposure to the commodity contained within the tank or pipe.

3.2.9 *defect, n*—a condition that prevents the lining from serving its function.

3.2.10 *down skive, n*—see **closed skive**.

3.2.11 *durometer, n*—an instrument used for measuring the hardness of rubber and plastics; the "A" durometer scale is used for flexible materials and the "D" for rigid materials.

3.2.12 *durometer hardness, n*—a value that indicates the indentation or resistance to indentation of the indicator point of a durometer; higher values indicate harder materials.

3.2.13 *face stock, n*—the commodity-contacting stock in a multi-component lining.

3.2.14 *freshening, v*—solvent washing of a rubber surface to provide tack.

3.2.15 *hard rubber, n*—a material made by the vulcanization of rubber with high levels of sulfur, where the higher hardness is due to the sulfur content.

3.2.16 *liner cloth, n*—a separator, usually of cloth, plastic film, or paper, used to prevent adjacent layers of material from sticking together.

3.2.17 *muslin, n*—a broad term describing a wide variety of plain-weave cotton or polyester/cotton fabrics ranging from lightweight sheers to heavier sheeting; quite frequently used as a liner in rolling up cemented rubber lining panels.

3.2.18 *open skive, n*—a cut made on an angle to the surface producing a tapered or feathered edge with the bottom layer of rubber or tie gum exposed to the commodity contained within the tank or pipe.

3.2.19 *overlay, n*—a layer of uncured stock applied to uncured sheet stock to achieve at least the minimum thickness specified.

3.2.19.1 *Discussion*—If properly performed, a non-rubber adhesive will not be required. After vulcanization, the area so treated is homogeneous and should be considered identical to a lap joint or seam, not a patch or repair.

3.2.20 *patch or repair, n or v*—the remedy to a defect that is done after vulcanization necessitating application of uncured sheet stock to fully cured or vulcanized stock.

3.2.21 *primer, n*—a coating applied to the surface of a material, prior to the application of an adhesive; sometimes considered as a part of the adhesive system.

3.2.22 *semi-hard rubber, n*—a term used for hard rubber which when fully cured is flexible and can be bent without shattering.

3.2.23 *skive, n*—a cut made on an angle to the surface producing a tapered or feathered edge.

3.2.24 *soft rubber, n*—a term used for rubber with a hardness after cure of 70 durometer "A" scale, or less.

3.2.25 *stitch, v*—the act of joining two pieces of uncured rubber compound together by means of a stitching roller, which is a handheld tool comprised of a wheel with a narrow edge that is often serrated.

3.2.26 *surface imperfection, n*—a condition on the surface of sheet stock that, although presenting an appearance other than smooth, is not detrimental to the serviceability of the lining.

3.2.27 *tack cement, n*—a formulated rubber/cement mixture which can be rolled or brushed on surfaces which will hold the rubber panel in place until cure takes place; normally considered a part of the adhesive system.

3.2.28 *tie gum, n*—an intermediate layer of rubber employed to promote bonding of two surfaces; usually a soft rubber compound.

3.2.29 *wrinkle, n*—it is a *(1)* surface imperfection if is has no effect on the serviceability of the lining because the full thickness and integrity of the material under the surface imperfection is unaffected or *(2)* defect if it violates the thickness tolerance specified or the integrity of the sheet and shall be appropriately addressed with an overlay if it is identified before cure or removal and repair if it is identified after cure.

4. Significance and Use

4.1 The storage of corrosive or abrasive solutions or suspensions requires that the metal surface of storage tanks, large pipes, or holding vessels be lined with a material that resists such action. Vulcanized rubber that is securely adhered to the tank or other metal surface imparts such resistance. An integral part of the installation of such linings is the vulcanization operation that produces proper mechanical strength, chemical resistance, and sufficient rubber-to-metal adhesion.

4.2 Service conditions will dictate what type of rubber is used. Also, the service conditions will determine the proper thickness of the rubber and the particular compound or compounds used in a lining. For example: temperatures over 140°F (60°C) typically require a thickness of ¼ in. (6.35 mm). Some service conditions that have a solution composed of several chemicals may require different layers of rubber compounds. Within these layers, the hardness or durometer of the rubber may be changed as well to provide the longest service life of the rubber lining. Consult with the rubber lining manufacturer when selecting the rubber lining system and preparing application specifications and procedures.

5. Chemical Resistance of Rubber Sheet Linings

5.1 Rubber linings have excellent resistance to various chemicals (acids and bases) as well as provide superior abrasion resistance. Each manufacturer has rubber linings that are compounded for specific service conditions. For example, a typically soft natural rubber could be specified for a low-temperature solution; however, as the temperatures increase, the hardness of the rubber must increase to provide the same resistance to permeation. Also, various types of rubber have specific resistance to different chemicals. Linings can also be made with several combinations or layers of different rubber compounds to provide multiple levels of chemical and temperature resistance. Even various colors can be provided when necessary.

5.2 The types of rubber sheet linings can be listed in four categories:

5.2.1 *Soft Rubber (Natural Rubber (NR) or Isoprene Rubber (IR))*—One homogeneous layer.

5.2.2 *Two-Layer Construction*—Semi-hard, hard, or flexible hard rubber face with a soft cushion layer of rubber (tie gum).

5.2.3 *Three-Layer Construction*—Soft face, semi-hard rubber, and soft cushion (tie gum).

NOTE 1—Each layer usually consists of 0.02- to 0.03-in. (0.5- to 0.8-mm) plies calendered together to produce the specified thickness.

5.2.4 *Synthetic Rubbers*—Including but not limited to neoprene (polychloroprene) (CR), butyl (isobutylene-isoprene) (IIR), chlorobutyl (chloro-isobutylene-isoprene) (CIIR), bromobutyl (bromo-isobutylene-isoprene) (BIIR), ethylene propylene diene (EPDM), hypalon (chlorosulfonated-polyethylene) (CSPE), and so forth.

5.3 Rubber sheet linings resist many chemicals and are considered suitable for the following, subject to temperature and concentration limitations:

5.3.1 Most inorganic acids including, but not limited to, hydrochloric, phosphoric, sulfuric, hydrofluoric, and hydrofluosilicic;

5.3.2 Many organic acids including, but not limited to, acetic, tannic, and gallic;

5.3.3 Inorganic salt solutions including, but not limited to, ferric chloride, zinc chloride, tin chloride, sodium cyanide, and ferrous sulfate;

5.3.4 Inorganic bases including, but not limited to, sodium hydroxide, calcium hydroxide, and potassium hydroxide;

5.3.5 Plating solutions including, but not limited to, nickel, brass, tin, zinc, silver, and cadmium; and

5.3.6 Bleach solutions including, but not limited to, sodium hypochlorite, calcium hypochlorite, and chlorine.

5.4 The type of rubber sheet lining to be used for a specified chemical service should be recommended by the rubber lining manufacturer based on their laboratory tests and individual past experience. Past experience is very important and, in many cases, cannot be confirmed by short-term laboratory tests.

5.5 A complete specification of service conditions is very important in the selection of a rubber sheet lining. The following information should be included:

5.5.1 Size, shape, and dimensions of tank or equipment to be lined (drawings if possible);

5.5.2 Dimensions, wall thickness, and type of flanges or couplings for the pipe systems;

5.5.3 Chemical concentrations of all ingredients, including defoamers, additives, or impurities in the solution to be handled;

NOTE 2—It is important that all ingredients be listed, no matter how small their concentration, as certain materials may not remain totally in solution. They may concentrate on the bottom, the top (liquid vapor interface), or volatilize in the vapor phase above the liquid level.

5.5.4 Maximum, minimum, and operating temperatures and time cycle for temperature fluctuations;

5.5.5 Percent abrasive solids, type of solid, particle size, and velocity;

5.5.6 Indoor or outdoor installation;

5.5.7 Operating pressure or vacuum; and

5.5.8 Special requirements or conditions not covered in the factors in 5.5.1 – 5.5.7.

NOTE 3—To assure that the best possible lining system is specified, provide the rubber lining manufacturer with all the information requested in 5.5.1 – 5.5.8.

5.6 When concentrations are low, from 0 to 5 %, it is often preferable to use hard or semi-hard rubber linings, especially at higher temperatures 150 to 185°F (65 to 85°C), because of their superior water resistance when compared with soft rubber.

5.7 Soft rubber linings are normally considered suitable up to 130°F (55°C) and semi-hard, hard, or synthetic rubber linings up to 185°F (85°C). At elevated temperatures, the chemical effect on the lining is accelerated and the effects of oxidation and diffusion are more rapid, so that the overall life of the lining will be shorter than it would be at room temperature.

5.8 There have been many economical applications of linings for chemical service in the range of temperatures from 185 to 300°F (85 to 150°C). No potential application should be rejected because of service temperature but should be referred to the protective linings manufacturer.

NOTE 4—Generally, rubber has limited resistance to elevated temperatures. To take full advantage of rubber's good chemical resistance, tanks and vessels can be designed to use a refractory material, such as brick, to protect the rubber from the operating environment. The type and thickness of the refractory is selected so that sufficient ΔT is achieved across the refractory to ensure the rubber won't exceed its temperature ratings. The rubber lining, protected in this manner, serves as a chemical and fluid permeation resisting anti-corrosion membrane.

5.9 Alternating from one chemical service to another is not generally recommended. In such cases, objectionable surface effects often develop that can take the form of crusting, flaking, and pitting, which can cause contamination of the chemical solution. Alternate chemical service can also shorten the service life of the lining.

5.10 Certain linings will swell and deteriorate in various degrees by certain liquid fatty acids, drying oils, cyclic aliphatic liquids, aromatic solvents, carbon tetrachloride, ethylene dichloride, and carbon disulfide. This effect can be

significant even with small quantities present as the result of cumulative absorption into the lining.

5.11 For the majority of installations, 3⁄16- or ¼-in. (4.76- or 6.35-mm) nominal thickness linings are considered standard. However, there are many installations in which a ⅛- to ½-in. (3.18- to 12.70-mm) nominal thickness has been used. When either the temperature or concentration of the chemical solution approaches a maximum operating condition, the ¼-in. (6.35-mm) nominal thickness or heavier is recommended. The heavier lining thickness is also used with soft rubber to handle a severe abrasion problem.

NOTE 5—Although often omitted from service condition specifications, rubber linings may cause discoloration or contamination of chemically pure solutions.

6. Requirements for Installation of Rubber Sheet Linings

6.1 *General*—Rubber sheet linings can be applied in a shop or in the field.

6.2 *Services and Facilities*—The following services and facilities are required to install a rubber sheet lining. Their availability and cost should be agreed upon between the applicator and the purchaser.

6.2.1 *Environmental Conditions*—Environmental conditions during storage and application shall be established and maintained per manufacturer's instructions. The environmental conditions recommended by the manufacturer during storage will likely be significantly different than those recommended for application. Also, the manufacturer should be consulted for the recommended storage configuration of sheet or rolls; stack height, etc. Time shall be allowed for the materials to reach the recommended application temperature when removed from storage.

6.2.2 *Scaffolding and Ladders*—For large tanks, scaffolding and ladders shall be provided and removed after the lining operation and the initial spark tests are completed.

6.2.3 *Workroom and Cutting Table Storage of Materials for Immediate Use*—The workroom and materials storage should be located as close to the equipment being lined as possible. Both areas should be reasonably clean, and the temperature should be maintained between 60 and 90°F (15 and 32°C) 72 h before, and throughout, the application procedure. A cutting table (heated per lining manufacturer's recommendations) with a smooth top shall be provided.

6.2.4 *Air Lines and Electrical Connections*—Compressed air lines and electrical connections shall be provided for as specified by the applicator.

6.2.5 Rubber shall be stored per the rubber manufacturer's requirements.

6.2.6 *Ventilation and Safety Precautions:*

6.2.6.1 Solvent vapors from adhesives may be explosive under certain conditions; therefore, no flame, welding, or smoking shall be permitted during the lining application. Precautions shall be taken to ensure that all electrical switches or materials that could cause sparks are a safe distance from solvent vapors. Precautions shall be taken to ensure all electrical equipment, including lighting, are explosion proof.

6.2.6.2 Tanks, cutting tables, and air-moving blowers shall have ground wires to eliminate the possibility of static sparks during cementing and solvent-washing operations.

6.2.6.3 Applicators and inspectors shall be provided with industry standard protective and breathing equipment during the cementing and solvent-washing operation as protection against toxic solvent vapors when required.

6.2.6.4 Adequate provisions for removal of solvent vapors by a suction blower and recirculation of fresh air shall be provided. Atmospheric monitoring shall be used to ensure vapors are maintained below the lower explosive limit (LEL).

6.2.6.5 When possible, two 24-in. (610-mm) diameter manholes, free of obstructions, should be provided for access to closed tanks. Other openings required for safety or to facilitate lining operations will be indicated by the applicator.

6.2.6.6 All safety requirements shall conform to applicable regulations.

6.3 *Metal Fabrication:*

6.3.1 All welding (hot work) on the tank, pipe, or other equipment to be lined shall be complete before the application of adhesives or rubber lining materials.

6.3.2 Metal fabrication and welding shall be in accordance with specified codes. Welds shall be continuous and have a round and smooth surface in accordance with NACE SP0178, Condition "C," as a minimum. Welds shall be free of porosity, undercuts, and sharp edges. All corners shall be ground to a minimum of ⅛-in. (3.18-mm) radius.

6.3.3 All attachments inside the tank shall be fitted flush and fully welded and ground as described in 6.3.2.

6.4 *Surface Preparation:*

6.4.1 *Preliminary Preparation:*

6.4.1.1 Remove all loose corrosion products, weld spatter, mill scale, burrs, and sharp edges from the surface to be coated using the appropriate hand or power tools in accordance with SSPC-SP 2 and SSPC-SP 3.

6.4.1.2 Remove all visible dirt, oil, grease, adhesives, tapes, markers, or other surface contaminants in accordance with SSPC-SP 1. If necessary, use approved solvents to assure that all contaminants are removed.

6.4.1.3 Cast iron equipment that is to be rubber lined shall undergo steam cleaning or other heat treatment before blasting to remove any volatiles or oils that may prevent the rubber from bonding.

6.4.1.4 Surfaces to be lined may be evaluated for the presence of soluble salts or other surface contamination that could inhibit the performance of the lining system. Guidance for soluble salts is contained in SSPC-Technology Guide 15.

6.4.2 *Blasting:*

6.4.2.1 Before the blasting, and at the beginning of each shift, ensure supplied air stream is oil and water free by performing a blotter test in accordance with Test Method D4285.

6.4.2.2 A production blast will be performed on all metal surfaces to be lined to remove corrosion products and staining. All metal surfaces shall present a uniform white metal appearance represented in SSPC-VIS 1 corresponding to SSPC-SP 5/NACE No. 1. This step may require multiple iterations.

6.4.2.3 Once the surface has been determined to be suitably clean, a profile blast shall be performed using a sufficiently coarse abrasive to achieve a sharp, angular surface profile. All surfaces to be coated shall exhibit a 2- to 4-mil (50- to 100-µm)