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 1⁄4-in. (4.76- or 6.35-mm) nominal thickness linings are considered standard. However, there are many installations in which a 1⁄8- to 1⁄2-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 1⁄4-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 1⁄8-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) profile, unless otherwise directed by the rubber lining manufacturer, when measured in accordance with Test Methods D4417.

6.4.2.4 The production and profile blast may be performed concurrently.

6.4.2.5 Following the profile blast, remove all dirt and debris generated by vacuuming or broom cleaning. To verify removal of all particulate, surfaces to be lined can be tested using Practice E1216 or ISO 8502-3.

NOTE 6—Design details may require the application of a chemically cured (for example, two part epoxy) putty or mastic to fill and smooth surface voids or to provide a coved transition at inside corners (chine) prior to priming. When a putty or mastic is used it must be verified that they are compatible with the adhesive system and that the material will not be degraded by vulcanizing temperatures.

6.5 *Temperatures of the Substrate:*

6.5.1 Temperature of substrate should remain between 60 and 90°F (15 and 32°C) for ease of installation. This will ensure proper solvent evaporation from the primers and tack cement without curing and make the rubber pliable enough to work into corners and edges.

6.5.2 Surface temperature shall remain 5°F (3°C) or greater above the dew point to prevent condensation on the surfaces being lined.

6.6 *Vulcanization:*

6.6.1 Curing of rubber linings can be accomplished by a variety of methods. This standard addresses vulcanized rubber. Vulcanization is an irreversible process during which the rubber achieves its design properties through changes in its chemical structure. These changes are attained via heat or chemically or a combination of both. Steam is the most common heat source for vulcanization, with vulcanization by steam under pressure being optimal because contact between the rubber stock and the substrate is enhanced. When vulcanizing with steam under pressure the lined components can serve as their own autoclaves provided precautions are taken to ensure that the steam pressure cannot exceed the design pressure of the component. The amount of steam required will depend on whether the lining will be pressure cured or open steam cured with ambient temperatures and weather conditions playing significant roles. A number of variables will come into play and the rubber lining manufacturer should be consulted for detailed procedures. Other methods of vulcanization, such as hot water, hot air, or chemical cure, are acceptable when performed in accordance with the rubber lining manufacturer's recommendations and the approval of the end owner. Non-vulcanized rubber, sometimes referred to as "pre-cured" or "room temperature cured," may also be encountered; follow the rubber lining manufacturer's recommendations for storage and cure times.

6.6.2 Adequate piping and headers to circulate the steam during vulcanization and a drainage system to remove condensate shall be provided.

6.6.2.1 The steam shall be directed and distributed evenly to ensure maximum exposure of all lined surfaces, particularly in the downward direction so the bottom will cure as well as the top of the vessel. However, the rubber shall be protected from direct impingement of steam.

6.6.2.2 Drainage to prevent accumulation of steam condensate is critical for uniform and complete cure; puddles of condensate will act as an insulator. Smaller components or pipe can be tilted in a manner to facilitate drainage and condensate removal.

6.6.3 When vulcanizing rubber outside an autoclave, additional measures will be required to ensure temperatures are maintained within ranges recommended by the rubber manufacturer. The vessel shall be adequately protected and insulated to prevent loss of the heat required to fully vulcanize the rubber; loss of heat from the system will prevent complete cure of the rubber. Conversely, overheating the vessel during cure may cause the adhesive to cure more rapidly than the rubber. This can result in a lack of adequate adhesion to the substrate. To prevent the premature curing of the adhesive, cooling of the vessel walls may be necessary. In all cases follow the rubber manufacturer's recommendations.

7. Procedure

7.1 *Application of Rubber Sheet Lining:*

7.1.1 Verify that environmental conditions meet those required by the rubber lining manufacturer.

7.1.2 Prepare all metal surfaces to be lined in accordance with Section 6.

7.1.3 Apply one coat of primer immediately after blasting to prevent rusting. Apply additional coats of primer, if necessary, as specified by the rubber manufacturer.

7.1.4 Apply required number of coats of intermediate or tie adhesives, or both, to the substrate and lining as specified by the rubber manufacturer. Allow sufficient drying time between adhesive coats so the coat being applied does not lift up the preceding coat.

7.1.5 Apply tack cement to the side of the rubber to be adhered to the vessel wall per the manufacture's recommendation. Some rubber linings do not require this step.

7.1.6 Apply the type and thickness of lining specified using a minimum number of sheets and splices consistent with good lining practice. Overlap or butt and cap the edges of the sheets approximately 2 in. (50 mm), unless restricted by dimensional tolerances. The rubber lining sheets may be washed with recommended solvent (freshening) and allowed to dry before application. During the application, roll the sheets and carefully stitch all the seams and corners to eliminate all trapped air between the lining and adhesive-coated surfaces so there is full contact with all coated areas. A muslin liner cloth may be used to prevent the rubber from sticking until it is positioned properly, at which point the muslin liner cloth is removed.

NOTE 7—Sheet rubber linings should not be applied in excess of 3-layers. This can be an issue where joints and seams intersect or overlap due to the configuration of the component being lined. In these areas, extra layers should be cut back and edges appropriately treated prior to vulcanization.

7.1.7 Skive the edges of all the sheets. The recommended angle of the cut for the skive is from 30 to 45° as shown in Figs. 1-3. Use a closed-skive construction, commonly known as a down skive, wherever possible. This is required when the lining is a combination of hard-face stock and soft cushion.

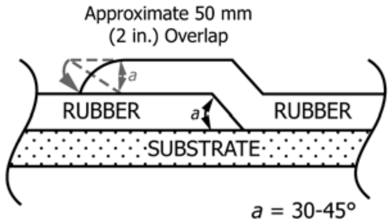

FIG. 1 Closed Skive

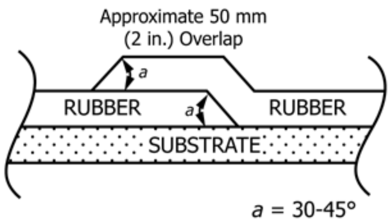

FIG. 2 Open Skive

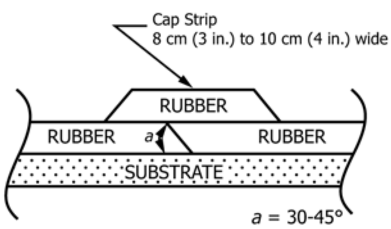

FIG. 3 Butt and Capp

Open-skived splices may be used when specified by the rubber lining manufacturer (for example, rubber stock that does not have tie gum).

7.1.8 When the lining application is complete, stamp, stencil, or otherwise mark the exterior of lined equipment or components: "Rubber Lined—Do Not Cut or Weld" in readily observable locations. If the lined equipment or components exterior is to be painted, remark after painting.

7.2 *Rubber Sheet Lining Inspection and Repairs before and after Vulcanization:*

7.2.1 Before vulcanization, inspect all lined surfaces for blisters (trapped air), pulls, or lifted edges at seams and surface defects. Also, verify that any required or specified tolerances have been met.

7.2.2 Spark test all areas, before and after vulcanization, for "pinholes" using a high-voltage spark tester. Refer to Practice D5162 or NACE Standard Practice SP0188 for general practices. Contact the rubber lining manufacturer for specific recommendations. A calibration standard will be required to determine the appropriate test voltage.

7.2.2.1 *Calibration Standard*—A rubber-covered steel plate, minimum 12 in. (300 mm) square, with a known pinhole shall be prepared. The pinhole is made by puncturing the material with a 22-gage hypodermic needle or comparable piercing tool. The coupon shall be covered with the same material and thickness of stock, and cured the same as the material to be tested.

7.2.2.2 *Calibration Procedures*—The probe to be used for the test shall be passed over the surface of the calibration standard in a constant stroke of approximately 1 ft/s (0.3 m/s) until the pinhole is found. The voltage shall be adjusted to the lowest setting that will yield an indication. The spark tester shall be recalibrated periodically using the calibration standard to ensure that the settings on the tester have not changed. The spark tester shall be calibrated using the same power source, cable lengths from power source to tester if applicable, and probe to be used for testing the work piece.

7.2.2.3 *Test Procedure*—After calibration, the probe is then used to test the work piece by passing the probe over the lining in an uninterrupted constant stroke of approximately 1 ft/s (0.3 m/s) looking for pinholes. The pattern used shall be designed such that no surface is missed and the strokes shall overlap. Pinholes that are found shall be marked for repair using oil and grease free chalk. The probe shall not be allowed to remain stationary at any time as this may cause pinholes in the lining.

7.2.3 The vulcanization of the lining is a time and temperature function and is needed to produce the required chemical and physical properties as well as sufficient adhesion to the metal being lined. The time and temperature of vulcanization are to be in accordance with rubber lining manufacturers' specifications. Temperature and pressure monitoring/recording instruments can be used to verify these parameters are maintained as required. As discussed in 6.6.1, vulcanization with steam under pressure is recommended; however, many linings have been developed that will cure in steam at atmospheric pressure and can be used in most services with good life expectancy. Chemical cure (those linings that are cured by application of a liquid surface curing agent) and room temperature cure linings and repairs are also acceptable if within the rubber lining manufacturer's recommendations.

7.2.4 After vulcanization, inspect all lined surfaces again for blisters, open seams, lifted edges, and surface defects.

7.2.5 After vulcanization, linings shall be checked with a durometer to determine the hardness or state of cure. Keep in mind that the rubber lining manufacturer's specifications will provide the optimum hardness or durometer reading for each specific lining. This specified hardness value is an instantaneous reading of the instrument, without applying any undue pressure, on a flat surface that is lined with ¼-in. (6.35-mm) rubber at 70°F (21°C). As these conditions are optimal, they may not be practical in the field. Therefore, the sound judgment of an experienced inspector is necessary to determine if the rubber is cured even though the durometer may give a reading different than that specified.

7.2.6 Spark test all areas again for pinholes, as described in 7.2.2 and repair all pinholes and other lining defects in accordance with the rubber lining manufacturer's specifications. Be aware that the procedure to address pinholes identified before vulcanizing will be different than the repair required for pinholes identified after vulcanizing.

NOTE 8—The importance of a thorough visual inspection before and after vulcanizing is critical to a successful, holiday free rubber lining application. The spark test will not find seam leaks, trapped air blisters, or open seams. These can only be found through visual inspection by an experienced and qualified inspector.

7.2.7 Adhesion testing may be performed on test coupons in accordance with Test Method D429, Method E. When this testing is performed the test coupons are to be prepared and cured under the same conditions as the applied lining.

7.3 *Standard for Surface Appearance of Rubber Sheet Lining Materials:*

7.3.1 This section addresses surface imperfections and defects or rubber sheet lining materials, and the repair of these imperfections and defects.

7.3.2 In spite of all possible precautions, defects may be found on some units of rubber-lined equipment after the prescribed cure is completed. The most common defects will be blisters between rubber and metal, roller skips, blowholes in which the rubber lining is actually ruptured, small cracks in a hard rubber lining, or physical damage that may result in a scuffed or broken lining.

7.3.3 If such a defect occurs, the defective rubber shall be removed (peeled from the metal to a point where firm adhesion to the metal is found). The surrounding rubber, about 4 in. (10 cm) around the repair area, shall then be buffed to provide a smooth sloping transition from the good rubber to the substrate. The patch is made by filling in the hole with rubber and then applying another larger piece of rubber covering the entire area including the 4-in. (10-cm) surrounding properly buffed area of sound original rubber. The repair shall be made with the same or equivalent lining material.

7.3.4 When a flaw in the lining does not have to be cut out, such as a thin area or surface damage to the lining, a patch is sufficient if agreed upon between the applicator and owner. The patch can be as small as a 2-in. (5-cm) circle or square or large enough to cover several flaws to provide a professional appearance to the repair.

7.3.5 It is improper to specify indiscriminately the number of true repairs (made after vulcanization) that will be considered acceptable without consideration being given to the total area involved. A specific number of repairs considered acceptable in a simple, small vessel would be entirely too restrictive if applied to a much larger and particularly more complex vessel as a means of determining whether or not the applied lining is commercially acceptable.

7.4 *Applying Rubber Sheet Linings in Pipe:*

7.4.1 *Metal Specification*—Pipe shall be fabricated and welded in accordance with specified codes. Welds shall have a round and smooth surface suitable for applying rubber lining. Complex configurations should be avoided. Any special requirements specified by the engineer or end user shall be agreed upon by all parties before pipe fabrication.

7.4.2 *Metal Preparation*—All surfaces to be lined shall be prepared in accordance with 6.4.

7.4.3 *Cementing:*

7.4.3.1 Apply one coat of primer as soon as possible after blasting to prevent oxidation. Apply additional coats of primer, intermediate, or tie adhesives as specified by the adhesive system or rubber lining manufacturer.

7.4.3.2 Follow the coating manufacturer's recommendations for curing, recoat time and recoat limits to prevent damage or disbanding of the preceding coat(s).

7.4.4 *Lining Application:*

NOTE 9—Pipe large enough to allow personnel to enter should be rubber lined in the same manner as tanks or duct work.

7.4.4.1 *Flat Sheet*—Whenever calendered or extruded flat sheet lining is supplied, a tube should be formed by using longitudinal skived butt splice(s) as illustrated in Fig. 4. The spliced tube's outside circumference should be slightly smaller than the inside circumference of the pipe to be lined.

7.4.4.2 *Extruded Tube*—Whenever unvulcanized extruded seamless elastomer tubes are supplied, the tubes should have a slightly smaller outside circumference than the inside circumference of the pipe to be lined.

7.4.4.3 *Bleeder Strings*—Apply twisted multifilament string or yarn lengthwise in two to four locations to allow for proper gas venting between lining and pipe.

NOTE 10—Use of bleeder strings is optional with applicator, unless otherwise directed by the rubber manufacturer.

7.4.4.4 Enclose the tube in a muslin liner and attach a tow rope. Pull tube into pipe with a slow constant pull.

NOTE 11—The muslin liner facilitates the positioning of the tube in the pipe and prevents premature bonding.

7.4.5 *Tube Inflation:*

7.4.5.1 *Small-and Medium-Diameter Pipe*—Remove muslin liner and expand elastomer tube against the pipe wall by using pressurized air. A mechanical extension and flange arrangement may be used for the pipe ends so that a minimum of 10-psig (69-kPa) internal pressure can be maintained in the expanded tube for at least 5 min.

7.4.5.2 *Large-Diameter Pipe*—Pipe too large to feasibly line by inflating a tube and large enough to allow personnel to enter should be rubber lined in the same manner as tanks or duct work. "Bleeder strings" may be used, at applicator's option or as directed by the rubber manufacturer, to facilitate the escape of gases during cure.

7.4.6 *Treatment of Flanges:*

7.4.6.1 For small-diameter pipe, apply a covering to full face of flange. Trim inside diameter of the bolt circle at a 45° angle. Remove extension of pipe lining and fold the edges over the flange face mating up to the flange rubber with a closed skive (refer to Fig. 5). Rubber shall be removed from bolt holes after cure by means of a knife, reamer, or other suitable tool.

NOTE 12—After cure, buffing may be required on the flange face to assure a clean, tight seal.

7.4.6.2 For large-diameter pipe with little or no flow, a manway for example, remove the extension of the pipe lining and trim flush to the pipe end. Then apply the flange stock and

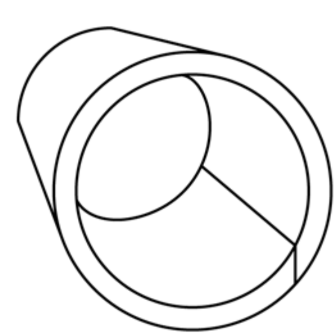

FIG. 4 Longitudinal Skived Butt Splice

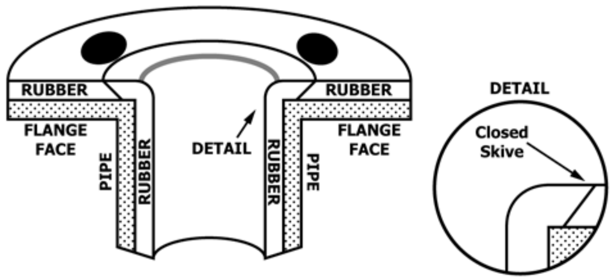

FIG. 5 Small Diameter

lap it on to the pipe lining with a closed skive (refer to Fig. 6). Rubber shall be removed from bolt holes after cure by means of a knife, reamer, or other suitable tool.

NOTE 13—For large-diameter pipe joints with flow, the pipe lining shall be brought onto the flange face in the same manner as for the small-diameter flange face treatment described in 7.4.6.1.

NOTE 14—Special attention may be needed on manway flange faces due to the lining material on the flange face and the manway cover fusing together, subsequently damaging the lining when the hatch is opened. The use of a harder rubber on the flange face(s), sacrificial gaskets or gasket release agents (provided the gasket release agent is compatible with the stored chemical or solution) should be discussed with the rubber lining manufacturer.

7.4.7 *Curing*—Vulcanize rubber-lined pipe as described in 6.6, or as recommended by rubber lining manufacturer.

7.4.8 *Inspection and Testing*—Lining inspection and spark test in accordance with 7.2. Special equipment is usually required so the spark tester can reach all areas inside long lengths of pipe.

7.4.9 *Identification and Protection:*

7.4.9.1 When the lining application is complete, stamp, stencil, or otherwise mark the exterior of lined equipment or components: "Rubber Lined—Do Not Cut or Weld" in readily observable locations. If the pipe exterior is to be painted, remark after painting.

7.4.9.2 Protect lining on flange faces during shipment or storage by covering with plywood or other suitable material.

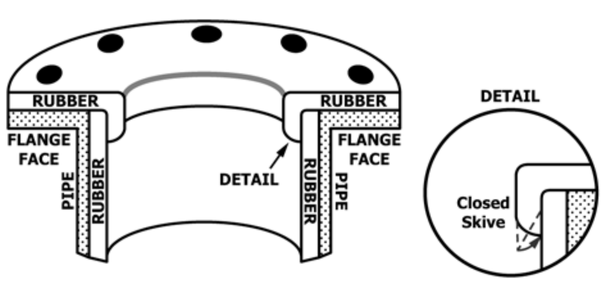

FIG. 6 Large Diameter

8. Storage of Rubber Lined Tanks and Pipe

8.1 Between delivery and use, store lined vessels away from direct sunlight, heat, or outdoor seasonal weathering. Flexible-type linings may be stored outdoors provided the vessels are covered with protective materials and not subjected to extreme temperatures; outside the range of 32°F (0°C) to 120°F (49°C). Avoid sudden changes in temperature. The exterior of tanks stored or used outdoors may be painted a light color to reflect heat.

8.2 Semi-hard and hard rubber-lined equipment shall not be exposed to freezing or below freezing temperatures. These materials become brittle at these temperatures; thermal and mechanical stresses can cause them to crack.

8.3 Rubber-lined equipment may also be protected for extended periods of time by storing the tank partially filled with a solution as recommended by the rubber-lining manufacturer. Some may recommend a 5 % sulfuric acid, 5 % sodium carbonate solution, and a weak salt solution as an ideal storage media to keep the lining flexible, minimize expansion and contraction, and keep the air (ozone) from prematurely deteriorating the lining surface. Do not permit the solution to freeze.

8.4 Shelter large rubber-lined equipment that cannot be filled with a solution under a suitable structure to protect it from the direct rays and heat of the sun. Provide sufficient air space between the tank and covering to allow for air circulation.

8.5 For small tanks that can be stored inside, cover any open tops and outlets with plywood or other suitable material and store them away from steam coils or other high-temperature sources.

8.6 Inspect any stored vessel before putting it into service to ensure that there has been no damage to the lining during shipment or storage and that dirt, debris, or other foreign materials have not collected.

8.7 Do not perform welding or any other activity that generates intense heat in the vicinity of a lined tank.

8.8 When tanks are stored outside, take care to ensure good weatherability of the exterior paint. Primer paints are not designed to withstand prolonged atmospheric weather conditions.

9. Keywords

9.1 rubber; rubber lining; tank lining; vulcanized rubber

Bibliography

(1) IP-4 Protective Linings Publications Set, Rubber Manufacturers Association (RMA), 1400 K St., NW, Suite 900, Washington, DC 20005, www.rma.org.

(2) NACE SP0298-2007, Sheet Rubber Linings for Abrasion and Corrosion Service, NACE International, 1440 South Creek Dr., Houston, TX 77084-4906, www.nace.org.