RubberSource

# General Application Procedures for Rubber Linings on storage vessels

# INDEX

## 1 GENERAL

1.1. This specification covers the procedures necessary to assure that all materials, equipment and operations are in conformance with RubberSource and industry standards.

1.2. Hold points may include (but are not limited to):

- 1.2.1 Pre-surface preparation
- 1.2.2 Ambient conditions/compressed air cleanness
- 1.2.3 Immediately following surface preparation
- 1.2.4 Adhesion test panels
- 1.2.5 Prior to each cement layer application
- 1.2.6 Following each material layer
- 1.2.7 Spark testing
- 1.2.8 Cure testing
- 1.2.9 Repairs

1.3. SSPC refers to specifications and published information of the "Steel Structures Painting Council", 4400 Fifth Avenue, Pittsburgh, PA 15113, USA.

1.4. NACE refers to publications of the "National Association of Corrosion Engineers", P.O. Box 218340, Houston, TX 77218, USA.

1.5. ASTM refers to standards of the "American Society for Testing of Materials", 1916 Race Street, Philadelphia, PA 19103, USA.

1.6. RMA refers to technical bulletins of the "Rubber Manufacturers Association", 1400 K Street N.W., Washington, D.C. 20005 USA.

## 2 SURFACE PREPARATION

2.1. Surfaces shall be inspected prior to the start of surface preparation to assure that they are dry, and that visible deposits of oil and grease have been removed by "Solvent Cleaning" (SSPC-SP1). In addition, the inspector shall identify surface imperfections (such as weld spatter, porosity, pits, laminations, slivers or crevices) for repair as appropriate. (Ref. RMA Bulletins 1, 2, 3. / NACE SP0298-2007 6.3).

2.2. Ambient conditions shall be checked before and during operations which will expose bare steel (e.g. abrasive blasting, power tools) to determine the air and surface temperatures, relative humidity and dew point temperature. These operations shall not be permitted when the surface temperature is less than 5 degrees F. above the dew point, the relative humidity is over 80% and the temperature is not in the range of 50°F (10°C) to 90°F (32°C).

### ABRASIVE BLAST CLEANING

2.3. The compressed air supply for abrasive blasting shall be inspected before and during operations for the presence of oil and/or water by means of the white blotter test. The test shall be performed downstream of separators. The blotter shall be free of visible contaminants of oil or water after being held in the air stream at a distance of 18" (457mm) to 24" (610mm) inches from the source for at least two minutes. (Ref. SSPC Painting Manual Vol.1 Good Painting Practice, Chapter Six, Section VI.A. "Air Compressor and Air Cleanness".) Air pressure at the nozzle shall be determined using a hypodermic needle pressure gauge according to the procedure outlined in SSPC-Vol. I Good Painting Practice.

2.4. Chapter VI.E "Blast Cleaning Nozzles and Nozzle Pressure." A hypodermic needle gauge indicates the pressure at the nozzle, the end of the system.

2.5. Abrasive shall be inspected to assure that it is clean, dry and the type size capable of producing the desired surface profile. Reference data for determination of the adequacy of abrasive type and size can be found in NACE Publication 6G164 and SSPC-SP COM "Surface Preparation Commentary" Sections 5 and 6 which state the type, grade, and surface condition of the steel to be cleaned, type of blast cleaning system employed the finished surface to be produced.

2.6. On stainless steel components, special care must be taken to assure that a profile of 2.0 mils (0.05mm) minimum is achieve.

2.7. Strict adherence to air temperature, 50°F (10°C) to 90°F (32°C), relative humidity and shell temperature 5°F (2.8°C) above the dew point will be required. At the beginning and middle of every shift, the inspector will record in the area of the tank they will be working, the steel temperature, the air temperature, and calculate the dew point and relative humidity.

2.8. The entire surface of the tank to be lined is to be white metal blasted clean (SSPC-SP-5) to a profile of 2.0 mils (0.051 mm) minimum. This will be tested and recorded by the contractor using a Testex Press 0 film blast profile gauge (Testex, Inc.) or other suitable method. Applicator shall supply testing materials as specified and make them available for additional inspection.

2.9. All areas blasted are to be primed with one coat of primer as soon as possible after blasting. Allow to dry one- hour minimum and preferably 24 hours. If the primer is left sitting for 7 days and greater it will require an additional coat before the application of the intermediate. Apply primer and intermediate adhesive to surfaces with temperatures less than 38°C.

2.10. All sandblasted areas are to be vacuumed and wiped to "white glove" clean to remove all contaminating materials prior to applying primers.

2.11. A test panel must be made prior to the start of production blasting to establish the proper grade of blast media to be used to achieve the required blast profile. The test and panel must be reviewed and approved. Test panel shall be supplied by the lining applicator.

2.12. Upon commencement of sandblasting and continuing for the remainder of the project; no gasoline, kerosene or diesel operated engines will be permitted in or near the tank without venting such equipment to the exterior atmosphere.

## 3 *Adhesive System Application*

3.1. Strict adherence to environmental conditions as in is required for all stages of adhesive application. Avoid drips and runs in primers, intermediates, and tack as they can be detrimental to the adhesion.

| Relative Humidity | Maximum Wait |
|---|---|
| Over 80% | No Application |
| 70-80% | 1 Hour |
| 60-69% | 4 Hours |
| 50-59% | 8 Hours |
| Below 49% | 24 Hours |

3.2. Vacuum primer as in if dust has accumulated on its' surface. Apply one coat of intermediate over the primer that was applied to hold the blast. Allow to dry one hour.

3.3. Apply one coat Tack over the intermediate at least on the same day as the intermediate has been applied. Allow to dry at least one half-hour.

3.4. Just prior to the application of the rubber repeat above step (3.3) using Tack on substrate then apply Tack on rubber lining. Allow to dry until tacky on both the substrate and the rubber – approximate 1 hour. Note, before applying adhesive to the lining, the rubber may require to be freshened" by giving it a wipe with solvent.

- One coat of Primer, Chemlok 205/289 on metal only
- One coat of adhesive, Chemlok 6224/290 on metal only
- Two coats of tack cement, Chemlok 286 on metal & surrounding 4" (100mm) of parent lining

## 4 APPLICATION OF RUBBER LINING

4.1. Strict adherence to environmental conditions as in is required for all stages of lining application.

4.2. All layout marks on rubber must be made using chalk or spotted chalk lines. Use of a metal scribe or other device that cuts or scratches the rubber is not permitted.

4.3. Rubber is to be cut using skiving machines with blade set for a 30 degree skive cut. Reservoir of water must be kept full during cutting. Rough, wavy, irregular surface of skive cuts will be rejected. All mill edges and mills end shall be cut off by liner. A skiving knife is also acceptable to use.

4.4. Prior to application, rubber is to be protected from dust, grease and oil while lying on the cutting tables by covering with polyethylene sheets. All cutting tables must be smooth and flat and not leave joint impressions on the rubber.

4.5. Depending on the rubber lining the rubber may be required to sit on hot tables (minimum of 10 minutes / 100°F guideline) before application to facilitate workability. General guideline is when the rubber is warm to the back of the hand.

4.6. All panel seams are to be 30 degrees closed reversed skives with a two (2) inch minimum (50mm) overlap. All lining personnel must be certified trained to applicate linings and have knowledge with skive joint requirements. All seams, and any rubber to rubber adhesion should be done just simply wiping both surfaces with solvent, wait for the solvent to evaporate and become tacky. Then proceed to stitch.

4.7. Panels of rubber lining shall overlap each other a minimum of two (2) inches (50mm). Use an open-skive on the underneath edge as a closed-skive on the overlapping edge. Panel size should not be greater than 10 linear feet.

4.8. The sheet lining shall be rolled and stitched as required to exclude all air between the lining and substrate. Trapped air may be vented with a needle, but the vent opening must be covered with a suitable overlay. To do this properly, the needle must be inserted at a 30° angle, and wiped with toluene after withdrawing the needle. Review repair procedures.

4.9. The sheet lining shall extend over the entire outside of flanges. Special conditions such as internal steam curing may be an exception.

4.10. The ambient temperature during lining application shall be maintained between 50°F (10°C) and 120°F (51°C) and the relative humidity shall not exceed 80%, 50 % is the optimum humidity level for adhesion. The temperature of the surface being cemented shall be at least 5°F (2.8°C) above the dew point or wet bulb temperature.

4.11. All deficiencies and defects found must be removed and relined prior to cure.

4.12. During the installation of the floor lining, all contractors' personnel must wear nail-less soft rubber sole shoes, rubber shoe covers, or work in stocking feet.

4.13. All joints and seams will be staggered. No four-corner joints will be permitted. The rubber lining panels on the floor, wall, etc. shall be applied in a manner that will assure complete and uniform adhesion with the steel. There shall be no air trapped behind the lining. There shall be no stretching of the rubber during application. All rubber is to be supported so as not to be stretched during application. The lining shall be free of blisters, porosity, and tears. After installation and before cure, the lining is to be spark tested at 15,000 volts (15kv) and visually inspected for trapped air, loose edges, and damage to the rubber linings.

## 5 *CURING*

5.1. The three basic methods:

5.1.1 Autoclave
5.1.2 Internal Pressure (Internal Steam)
5.1.3 Exhaust or Atmospheric Steam

The specific method used will depend on the nature and size of the vessel to be lined. Note that recommendations are suggested guidelines only. Actual cure times will depend on factors such as rubber thickness, vessel size and metal wall thickness, heat loss, ambient conditions and elevation. All cures should have proper temperature recording charts, and these should be properly identified with job number and date. If there are any questions regarding conformance of cure to published time and temperature recommendations, please contact your Rubbersource representative.

### 5.2. Autoclave Cure

5.2.1 This refers to vulcanization where the rubber-lined vessel/part is placed inside a pressure vessel and subjected to controlled steam under pressure.

5.2.2 An autoclave cure provides the best and most uniform cure and should be used whenever possible.

5.2.3 Metal parts should be placed in the autoclave so that the best possible drainage of condensate from the rubber will be obtained.

5.2.4 To obtain the most accurate and uniform cure, it is desirable to have the autoclave fully equipped with thermocouples and instrument controls on air pressure and steam. Sufficient boiler capacity should be available to raise the temperature from ambient to cure in a relatively short period of time.

5.2.5 After finishing the cure process, it is recommended the rubber-lined vessel be cooled down by using water and/or air. Proper cool down of autoclaves will prevent post curing and preclude the possibility of cracking hard rubbers. The following cool-down procedures are suggested as recommended methods. Cool down soft natural and synthetic rubbers one hour with air and water. Cool down hard rubber with air and water until autoclave temperature reaches 200°F (93°C). Continue a gradual cooling down of the autoclave with air and then with air and water. This cool down procedure can be modified, but a step-wise procedure will prevent cracking of the hard rubber.

5.2.6 During the cool down procedure, it is important to maintain an air and water pressure equal to or greater than the steam pressure. All autoclaves should be equipped with temperature and pressure recorders. The recording charts should be properly identified and dated. Precautions must be taken against stratification of steam and air particularly in large vulcanizer. During start-up the bottom exit valve must be cracked open to allow a complete sweep of steam and cold air through the autoclave to avoid a cold bottom and subsequent undercured rubber, follow the Autoclave manufacturer's operation manual. Follow the recommendations on the Technical Data Sheet for cure times and temperatures.

## 5.3. Internal Pressure Steam Cure

5.3.1 Internal steam pressure cures are used on vessels that are designed for pressure or vacuum service and are too large to be placed in an autoclave. The vessel should be positioned during cure so that complete condensate drainage is obtained. To accomplish this, tanks with a sump should be cured with a well pipe connected to a trap. Tanks without a sump can be cured. A drain valve shall be open enough so that the continuous flow of steam can be observed. All nozzles should be bled with a 1/4" (6mm) petcock.

5.3.2 Drain valve should be left open long enough to be sure that all air is evacuated before building up pressure. Sufficient boiler capacity should be available to raise the temperature from ambient to curing in a relatively short period of time. Long uninsulated pipe runs from the steam source should be avoided. Low pressure steam plus un-insulated lines promote excessive condensate.

5.3.3 Outside temperature has a significant influence on the time required to cure a vessel. In cold winter temperatures, if it is practical, the vessel should be insulated to effectively carry out the cure. Steel thickness is also a factor. Heavy thick steel needs additional time to compensate for the heat sink and warm-up period.

5.3.4 This is where external temperature gauges are quite valuable in monitoring the time/temperature so one can judge and insure themselves that a complete cure is being obtained. Prior to introducing steam into the vessel, all outlets should be blanked off with a blind flange equipped with a petcock so as to insure the release of steam thereby guaranteeing the nozzle and flange are properly cured. Always insert Mylar or a like material between blind flange and rubber on the flange to insure removal of the blind flange after cure without damaging the rubber on the flange.

5.3.5 The blind flanges should not be bolted down too tight initially as they can be tightened as the cure progresses. To bolt the flange too tight initially forces the rubber to squeeze out as the temperature increases thereby leaving a very thin ply of rubber on the flange · The blind flanges may be tightened as the cure progresses. However, the rubber on the flange will have started to harden. So the blind flanges can be tightened down with less rubber squeezing out. The pressure should be brought up in the tank as quickly as possible.

5.3.6 When the desired pressure has been reached, the petcocks can be slowly opened until there is a visible amount of steam flowing through the petcock. It will allow curing the nozzles and flanges properly. When the tank is being readied for cure, the air and steam line should be inserted separately so as to allow air to be inserted in the tank while the steam is still on. After curing completely, cool down internal steam cures by introducing air until temperature reaches 150°F (60°C). All cures should have proper temperature and pressure recording charts with identified job number and date.

## 5.4. Exhaust or Atmospheric Steam Cure

5.4.1 If it is practical, the vessel shall be adequately protected and insulated to prevent loss of the heat required to fully vulcanize the rubber. Exhaust or atmospheric steam is normally used for field vessels that have open tops and/or bottoms, vessels that do not withstand pressure or vessels that are too large to fit in an autoclave.

5.4.2 In the case of open top tanks, the opening must be covered with fabric or combinations of fabric and plastic. The covering must be made tight so the steam will be contained. Steam should be introduced into tank by means of a steam line through an outlet from the bottom of the tank. It is absolutely essential that provisions be made to be able to remove all condensate from the vessel during cure.

5.4.3 The bottom outlet on a closed top tank may be left open for drainage, but other outlets should be covered. Tanks that have an enclosed top with bottom outlet should start timing the cure when the temperature of the bottom outlet is about 140°F (60°C) and the temperature of the rubber surface has reached the desired cure temperature (as measured in the coldest spot in the vessel).

5.4.4 Thermometers through outlets and internally located thermocouples at various points in the tank should be used to monitor the temperature. When temperature varies at different spots in the vessel, the coldest spot should govern how much the overall cure should be increased.

5.4.5 No cool down period is required for this type of cure.

5.4.6 Frequently the cure times are extended for the lining to receive the optimum cure. The following are all considerations in determining the correct cure cycle. · Warm up vessel at a rate of 30 – 50°F/hour (16 – 28°C/hour). The time it takes to warm up the unit does not count toward the cure time.

5.4.7 Curing is a function of time and temperature. Lower temperatures will lengthen the cure time.

5.4.8 Tank insulation, temperature of the surrounding air, elevation and wind velocity over the tank can shorten or lengthen the cure. Thickness and surface area (structure) of the metal will act as a heat sink and increase the length of the cure.

5.4.9 Cold spots can develop as a result of trapped air, condensate accumulation or ineffective steam circulation. Thermocouples must be strategically placed to monitor the coldest spots in the tank. Temperature readings must also be taken on the metal opposite the rubber lining to ensure the metal temperature is about minimum 150°F (66°C) to cure the rubber/cement interface.

5.4.10 The amount of steam must be properly estimated for curing.

5.4.11 To ensure proper cure of flange faces, steam must escape around openings. If the steam is stagnant, cold spots form. The steam supply must not only be adequate but must be directed in such a way to ensure it is flowing over all rubber lining surfaces, especially the bottom.

5.4.12 Drains should be provided at the bottom of the vessel and elsewhere to ensure condensate will run off and not collect in any pockets. An open top tank or one sitting on a concrete pad can result in situations where the tank walls are cured but the floor is not. ·

5.4.13 The entire cure and cool down must be monitored, especially if it is possible to pull a vacuum and collapse the vessel. Vacuum breakers may be necessary depending on the construction of the vessel.

## 5.5. Rule of Thumb for Percent Increase in Time for 10 degrees in Temperature

The general rule of thumb that can be used to estimate how cure time should be adjusted when the vulcanization temperature is lower than the specified temperature. The general guideline is to increase the cure time by approximately 50% for every 10 degrees Fahrenheit (°F) decrease in temperature from the specified temperature. Here's how you can apply this rule:

1. Determine the temperature difference:

- Specified temperature (T_specified) = 212°F
- Actual maximum temperature reached (T_actual) = 180°F
- Temperature difference = T_specified - T_actual = 212°F - 180°F = 32°F

2. Calculate the adjustment in cure time:

   - For every 10°F decrease, increase the cure time by 50%.
   - So, for a 32°F decrease, you would increase the cure time by (32°F / 10°F) * 50% = 160%.

3. Apply the adjustment to the original cure time (t1):

   - Original cure time (t1) = 24 hours
   - Adjustment factor = 1 + (32°F / 10°F) * 0.5 = 1 + 1.6 = 2.6
   - Adjusted cure time (t2) = t1 * Adjustment factor
   - t2 = 24 hours * 2.6 = 62.4 hours

## 6 INSPECTION AFTER CURE

6.1. After cure, all surfaces are to be thoroughly inspected to the same criteria as the pre-cure inspection. Blisters (trapped air), loose laps, etc., are to be marked in chalk and numbered for future repairs.

6.2. All surfaces are to be spark tested (RMA Bulletin 13).

6.2.1 This spark test and all others shall be the same using Electro-Technic model BD-10AV or BD-50EV model testers operated at 15,000 volts (15kv).

6.2.2 All personnel spark testing shall carry a second spark tester because spark testers are subject to failure from overheating.

6.2.3 All testers are to be operated 15 minutes, and then turned off for 15 minutes. Testers must be allowed to cool down to avoid burnout.

6.3. All scaffolding or other equipment will have pneumatic tires and will be rolled on ¾" (18mm) plywood, with rounded corners, at all times.

6.4. A durometer (Shore "A" as per ASTM Standards) hardness survey shall be made of the cured lining. A sufficient number of readings shall be taken at all elevations to assure all areas of the lining are properly cured. The lining shall be allowed to cool to ambient temperature before durometer readings are taken.

6.5. Monitor adhesion testing (per ASTM D429) on blind flange assembly that contractor has previously lined, installed and cured. The rubber shall be adhered to the steel so that tests will show strength of adhesion not less than 25 pounds (11.3 kilos) as determined by the standard test in accordance with ASTM D429.

6.6. All pinholes indicated by breakthroughs when spark testing shall be repaired. The repair materials, application methods, and curing procedures shall be based upon the type, size and frequency of the defect. Patching with materials other than those recommended by RubberSource is not permitted.

## 7 REPAIRS TO LINING

7.1. Bubbles or Blisters:

7.1.1 All lining material containing bubbles or blisters (air trapped between rubber & steel substrate) shall be removed to an area of good adhesion.

7.1.2 Bevel edges of remaining rubber to approximately 45-degree angle to the metal and buff existing rubber back at least 4" (10.16cm) from the edge of area to be repaired.

7.1.3 Repairs are to be made with the same rubber as the parent lining material.

7.2. All exposed steel surfaces shall be prepared by blasting or grinding to a clean bright metal finish.

7.3. Upon completion of surface preparation, adhesives shall be prepared and applied as follows:

- Primer on metal only
- Intermediate on metal only
- Tack on metal & surrounding 4" (100mm) of
- Parent lining (follow section 3)

7.4. Upon completion of adhesives system application, rubber will be applied as follows:

7.4.1 To repair cracks and small areas, fill in the area flush with existing lining using uncured filler stock. Cover this with larger patch extending out 4" (10.16cm) on the existing lining, using the specified material. Activate the backside with solvent as well as the top of the inlay piece.

7.4.2 For large areas (above 12" (30.48cm) diameter or equivalent) to be covered, it will be satisfactory to use a single thickness of the repair stock over the metal area. Bringing stock up over an extended bevel in the existing lining and back 4" (10.16cm) on the original rubber. Activate the backside side with solvent before applying.

7.4.3 Should air be inadvertently trapped during these procedures, puncture blisters with a hypodermic needle and stitch down the stock. The air will bleed out through the needle. Important: insert needle on a 30° angle, remove needle, wipe the area with toluene and stitch the needle hole closed. Apply a 2" (5.08cm) square patch of uncured rubber centered over point of needle insertion.

7.4.4 Completed repair shall be re-spark tested at 15,000 volts (15kv) in accordance with established procedures.

7.4.5 Area of repair shall then be re-cured in accordance with manufacturers' material specification sheet.

7.4.6 Repaired areas will be re-checked in accordance with the spark tests.

7.4.7 Loose seam edges and skives must be corrected.

7.4.8 Loose seam edges and skives shall be repaired be grinding feather edging loose area, if it is possible to maintain a minimum seam overlap of 2" (5.08cm) upon completion of the repair.

7.4.9 If 2" (5.08cm) minimum overlap cannot be maintained, an area of 4" (10.16cm) back from defect on all sides shall be buffed to a rough grainy surface.

7.4.10 Adhesives system shall be applied in accordance with application of adhesives in this procedure.

7.4.11 Upon completing application of adhesive, an overlay will be applied to the cemented area, skives down and stitched in place.

7.4.12 Testing prior to curing will be in accordance with spark test procedures outlined in this procedure.

7.4.13 Curing will be in accordance with curing procedures outlined in this procedure.

7.4.14 Testing after curing will be in accordance with testing procedures as outlined in this procedure

7.4.15 Third Party Rubber Inspector is to sign off to verify all procedures have been followed and documented.

***Note: The above procedures is based as a guideline, please refer to the NACE Standard Practice / Sheet Rubber Linings for Abrasion and Corrosion Services (SP0298-2007) for in-depth procedures and methods.