

Selecting Elastomeric Linings For Storage Tanks

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Conventional carbon steel and other alloy materials used for pressure vessels and processing and storage tanks, frequently require linings that protect the metal against attack from corrosive solutions. When barriers to protect these vessels are being considered, natural and synthetic rubber linings are frequently chosen. Elastomeric material formulations can be tailored for practically every process and storage situation and survive in service for 20 yr or longer. This article **describes the material properties of** elastomeric lining materials and the criteria that should be used in specifying them.

Lining Materials - The vast array of lining materials can be organized in two basic categories:

permanent and temporary. The characteristic that sets one category apart from the other is the curing level of the material before application.

Temporary linings are made from pre-vulcanized (completely cured) loose materials that are considered only temporary solutions to corrosive problems. They cannot be considered a permanent solution because the slightest pinhole leak in the lining permits fluids to migrate between the lining and the tank wall.

Permanent linings are properly applied uncured with adhesives and then vulcanized by heat so that they are tightly bonded and are in intimate, total contact with the tank's metal surface. Before vulcanization

INFORMATION NECESSARY FOR TANK LINING SELECTION

Selection of the correct lining for a specific application requires that all available details concerning the tank and other equipment to be lined, and the process to be contained, be itemized. Some of the essential data follow:

- Chemicals: the type of chemicals contained in the tank and their concentration; the amount of impurities and contaminants, if any, potential chemical reactions
- Abrasion: abrasive particle type, weight, and size; velocity of particle movement; proportion of solids; nature of abrasive action (sliding or impinging)
- Temperature: maximum, minimum, and operating temperatures; severity and spread of temperature change; temperature cycle time
- Pressure: maximum, minimum, and operating pressure or vacuum; pressure cycle time
- Equipment: complete description of tank to be lined including physical design, dimensions, and information on whether it is stationary or portable
- Operating conditions: any other pertinent external and internal operating conditions
- Product condition: levels of discoloration, contamination, odor, or taste allowed for lading; Food and Drug Administration requirements, if any
- Experience: Past experience under similar conditions such as lining compound used and length of previous service life.

Armed with this information, plant engineers should be prepared to evaluate the various types of linings that satisfy application requirements. Each of the parameters listed should be analyzed separately so that the final lining selection takes into account all of the specific needs of the application.

Plant engineers should not make the mistake of selecting a lining material because it has performed well in applications similar to tank lining. For example, butyl rubber that is used to provide abrasion resistance for coal-handling conveyor belts may not provide the same abrasion resistance in a coal slurry tank.

And a lining material should not be selected on the basis of just one outstanding physical property. For example, ethylene propylene rubber may be known to withstand 300 F temperatures, but it does not necessarily follow that a tank lining of this material can withstand such a high temperature over a prolonged period. The specific tank lining material must be compounded to be compatible with application and curing procedures that could alter the properties of the cured material.

the lining is soft, pliable, and easily applied to the areas requiring protection. During vulcanization the rubber is cured to its final state, either soft or hard depending on the compound, to achieve its full physical and chemical resistance properties.

The physical makeup of lining materials is also a factor in achieving barrier protection. Each lining is made from numerous plies so that an imperfection or void in one ply does not affect the continuity of the final sheet. In the manufacture of a 3/16 in. thick sheet, for example, uncured rubber lining material is calendered in thin 1/64 in. thick plies. Twelve of these plies are layered to form the 3/16 in. thick sheet. Thermosetting adhesives, which cure in the same cycle as the linings, are used to attach these linings to tank walls. After curing, they resist physical change, such as softening, in the same fashion as the linings. These adhesives have an upper temperature limit; they may fail if the temperature reaches 300 F or more.

Selection Criteria-The factors that influence the plant engineer's choice of lining material include the material properties of the lining as well as its end use (see accompanying table). A logical starting point in selecting a lining, therefore, is to obtain manufacturers' literature containing chemical resistance tables for various types of lining materials. These tables also list the maximum temperature ranges for linings used with specific chemicals. Some general guidelines on the compatibility of linings and their particular application follow:

- **Temperature and Chemical Environment** - The necessary properties of natural rubber can be evaluated according to the following rule: the harder the lining material, the higher the operating temperature it can withstand and, to a lesser degree, the higher the chemical concentrations it can tolerate.

Natural and synthetic rubber materials as a group are not resistant to hydrocarbons such as oil products or solvents. Exceptions do exist, however. Chlorinated polyethylene (CPE), neoprene, and chlorosulfonated polyethylene (CSPE) synthetic rubber linings,

for instance, resist moderate amounts of oil. Hard rubber linings are resistant to small amounts of oil. Although nitrile synthetic rubber (Buna N) provides good resistance to aliphatic hydrocarbons such as kerosene, it is expensive and difficult to work with as a lining material. Ethylene-propylene-diene-terpolymer (EPDM) and butyl rubber have good resistance to polar and oxygenated solvents such as methyl and ethyl ketone and acetone.

All selections of tank linings should be supported by laboratory testing results or evidence of successful experience under identical conditions, information that is generally available from manufacturers. Plant engineers should ask the manufacturer for additional information when the proper choice is not obvious. For example, a lining that is recommended for several individual chemicals may not be suitable for a blend of those chemicals.

- **Abrasive Action** - When im-

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pingement on the lining is expected, a resilient type of rubber provides the most satisfactory service because it absorbs impact and permits the particles to bounce off without damaging the lining. A soft natural rubber with a Shore A durometer reading of 30 to 40 is generally specified in such applications. When sliding or cutting also is expected in service, a tougher, harder, tear-resistant lining material with a Shore A durometer reading of 50 to 60 should be specified. Hard rubbers, those with a Shore A reading of 90 and above, have poor abrasion resistance and should be avoided.

- **Temperature Variations** - Not all linings exhibit the same degree of resistance to thermal shock, as shown in the table. Soft natural rubber and most synthetic linings have outstanding resistance to thermal shock, and hard rubber has less

resistance. Hard rubber linings can be made to withstand fairly rapid temperature changes, but a thorough study of the conditions, proper material selection, and special lining constructions must be employed if hard rubber is to perform successfully.

- **Pressure or Vacuum conditions** - Normal pressure ranges are seldom a problem. When full vacuum or pulsating pressure conditions exist, hard rubber liners are used because they reduce diaphragm action. This may occur, for example, if a pinhole in the steel container allows atmospheric pressure to act on the underside of the lining,
- **Weather Conditions** Large outdoor storage tanks are subject to expansion and contraction caused by extreme weather fluctuations. Soft natural and synthetic rubber linings should be considered for such applications. Expansion and contraction of the tank does not usually present a problem indoors; fairly steady temperature conditions can be assumed to exist even if the building is not heated.

Special Linings for Extreme Conditions - Complex or severe service conditions, for example, those that require both chemical and abrasion resistance, may be successfully treated with a three-ply lining. This type of lining incorporates an inner layer of semihard rubber for chemical and heat resistance with two softer outer layers that contribute flexibility and abrasion resistance. Three-ply linings are designed to withstand temperatures between 180 and 230 F. When a combination of severe temperature and abrasive action is encountered, the three-ply lining is formulated with an inner layer of hard rubber and two outer layers of high-temperature resistant soft rubber.

Inspection of Lining Installation - Reputable lining applicators inspect and test the rubber lining extensively before permitting it to be placed in service. The newly lined tank or container is closely examined for leaks and defects such as poor adhesion. Pinhole leaks may be detected using a spark tester, although this method introduces a potential hazard. If the spark testing equipment is not carefully used,

PROPERTIES OF ELASTOMERIC LININGS					
Lining type	Shore A durometer reading	Upper Temperature limit, F	Thermal shock resistance	Resistance to hydrocarbons	Typical uses
Soft natural rubber	30 to 60	160	Excellent	Poor	Acid storage; transportation equipment; abrasive services; white rubber for food grade; sulfur dioxide scrubbers
Semihard natural rubber	80 to 85	180	Good	Fair	Chemical processing and plating
Hard natural rubber	90 to 100	200	Poor	Fair	Chemical processing; high temperature nickel-copper plating; steel pickling; vacuum service
Flexible hard natural rubber	90 to 100	212	Fair	Fair	Same uses as hard natural rubber; better crack and heat resistance
Graphite loaded hard rubber	95 to 100	212	Fair	Fair	Special lining for wet chlorine gas in chlorine cells and associated equipment
Three-ply (soft, hard, soft)	40 to 50	230	Excellent	Fair	Combined abrasion and corrosion services; becoming popular for steel pickling lines; phosphoric acid
Neoprene	40 to 70	230	Excellent	Very good	Chemical or abrasive services with oil present; best for strong bases; good weather resistance; fire retardant
Nitrile	60 to 90	200	Excellent	Excellent	Aliphatic hydrocarbons, kerosene, animal, vegetable, and mineral oils
Butyl	50 to 75	225	Excellent	Fair	Oxidizing acids; 70 percent hydrofluoric acid; super phosphoric acid; best water resistance; good for alternative service
Chlorobutyl	40 to 60	200	Excellent	Fair	Much the same as butyl but easier to apply and faster curing; sulfur dioxide scrubbers
EPDM	40 to 60	180	Excellent	Poor	Hypochlorite bleach; ozone and weather resistant
CSPE	50 to 70	210	Excellent	Good	Strong acids such as chromic acid; high concentrations of nitric and sulfuric acids
CPE	50 to 75	230	Excellent	Good	Strong acids; alternative service

it may burn through the lining when held in one place for too long. It is usually wise for the plant engineer to witness this test.

During the inspection procedure, nozzle flange edges are closely examined for loose adhesion. For permanent protection, full lining adhesion is essential for tanks that operate under vacuum or flowing conditions. Loose liners would collapse or obstruct flow under those circumstances.

Seam construction is also inspected before the lined tank is put in use. All seam edges must be beveled. A simple way to detect air pockets behind seams is to press down at the edge of the lap seam where the under-lining sheet ends. Poor seam construction can be easily observed then: if air is trapped under the rubber, the bubble can be felt as a soft spot. Attempting, and succeeding, to lift the seam edges also reveals looseness in the lining.

The inspection procedure includes a check for over and under cure of the lining material. Shore A

durometer readings are taken at several points; a low reading indicates that the lining has not cured completely, and a high reading may indicate that the rubber is over cured.

Repair of Leaks in Tank Linings-If any leaks are detected after cure, they are repaired with uncured rubber that is vulcanized to the cured lining. Repair procedures are designed so that the repaired area is protected at least as well as the remaining lining.

The specific method of repair depends on the type of the original lining, the extent of repair needed, and the facilities available. If plant engineers repair the lining themselves, they must follow the recommendations of the lining contractors. The following procedure is typical:

- The defective and adjacent lining are thoroughly neutralized, cleaned, and dried. In some cases, it may be necessary to treat the whole lining. All loose and defective rubber is cut away, the exposed edges

of the lining are beveled, and the shell of the equipment is buffed clean.

- The exposed area is cleaned with a suitable solvent and any excess solvent is allowed to evaporate. The adhesive solutions are then applied according to the lining contractor's instructions and allowed to dry.

- A patch of new sheet, which has been cut to shape and made tacky by the application of the adhesive or other solution, is then applied to the prepared area and rolled down firmly with an edge-wheel to exclude any air. In areas where tension is likely to develop, for example at struts, the patch is tightly wrapped and then vulcanized.

- The repaired area should be checked for hardness and continuity.