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International (call collect) 202-483-7616

or

CANUTEC (in Canada) 1-613-996-6666

or

SETIQ (in the Mexican Republic) 01-800-00-214-00

(Calls originating in Mexico City or the Metropolitan Area) +5-559-1588

(Calls originating elsewhere) +52-555-559-1588

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LyondellBasell TDI (Transportation / Distribution Incident) reporting Hotline

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1.1 Product Identification

Chemical Name: Ethenylbenzene
Chemical Family: Aromatic Hydrocarbon
Common Names: Styrene monomer, Vinylbenzene, Vinylbenzol, Phenylethylene, Phenylethene, Cinnamol, Cinnamene, Styrol, Styrole, Styrolene
CAS#: 100-42-5
Formula: C₈H₈

Figure 1.1 Conventional Technologies

1.1.1 Chemistry

The conventional method of producing styrene monomer involves the alkylation of benzene with ethylene to produce ethyl benzene, which is followed by dehydrogenation to product styrene monomer.

Lyondell Chemical Company uses an alternative process, a proprietary technology, to manufacture styrene monomer. Ethyl benzene is oxidized to form ethyl benzene hydroperoxide, which reacts with propylene to form propylene oxide and methyl benzyl alcohol. Methyl benzyl alcohol is then dehydrated to form styrene monomer.

Figure 1.2 Lyondell Chemical Company Technologies
## 1.2 Physical Properties

### Table 1.1 Styrene Monomer Physical Properties

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<thead>
<tr>
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<td>Physical State</td>
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<tr>
<td>Color</td>
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<td>Boiling Pt.</td>
<td>145.2°C (293.4°F)</td>
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<td>Molecular Wt.</td>
<td>104.152</td>
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<td>Freezing Pt.</td>
<td>-30.6°C (-23.1°F)</td>
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<tr>
<td>Density @ 25°C</td>
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<tr>
<td>Density of Sat’d Liquid</td>
<td>See Figure 1.3 and Table 1.2</td>
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<tr>
<td>Vapor Density</td>
<td>See Figure 1.4</td>
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<tr>
<td>Vapor Pressure</td>
<td>See Table 1.3</td>
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<tr>
<td>Viscosity of Sat’d Liquid</td>
<td>See Figure 1.5</td>
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<tr>
<td>Viscosity of Vapor</td>
<td>See Figure 1.6</td>
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<tr>
<td>Index/Refraction @ 20°C</td>
<td>1.54682</td>
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<tr>
<td>Index/Refraction @ 25°C</td>
<td>1.54395</td>
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<tr>
<td>Coeff. of Cubical Expansion @ 20°C</td>
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<td>Crit. Temperature</td>
<td>363°C (685°F)</td>
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<tr>
<td>Crit. Pressure</td>
<td>3.84 MPa</td>
</tr>
<tr>
<td>Crit. Volume</td>
<td>3.38 cc/g</td>
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<td>Crit. Compress.</td>
<td>0.256</td>
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<td>Heat/Combustion, Liquid @ 25°C</td>
<td>-1019 Kcal/mol</td>
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<td>Heat/Formation, Vapor @ 25°C</td>
<td>35.23 Kcal/mol</td>
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<td>Heat/Formation, Liquid @ 25°C</td>
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<td>Heat/Fusion @ -30.6°C</td>
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<td>Heat/Vaporization</td>
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<td>Enthalpy of Sat’d Liquid</td>
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<td>Surface Tension</td>
<td>See Figure 1.12</td>
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<tr>
<td>Thermal Conductivity of Sat’d Liquid</td>
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<td>Lower Flam. Limit</td>
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<td>Sat. Conc. in Air @ 25°C</td>
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### Table 1.2 Styrene Monomer Densities as a Function of Temperature

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Figure 1.3 Styrene Monomer Density of Saturated Liquid as a Function of Temperature
Figure 1.4  Styrene Monomer Density of Vapor @ 1 Atmosphere as a Function of Temperature

Table 1.3  Styrene Monomer Vapor Pressure as a Function of Temperature

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<th>Temperature °F</th>
<th>Vapor Pressure</th>
<th>Vapor Pressure</th>
<th>Temperature °C</th>
<th>Temperature °F</th>
<th>Vapor Pressure</th>
<th>Vapor Pressure</th>
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<td>0.08</td>
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Figure 1.5  Styrene Monomer Viscosity of Saturated Liquid as a Function of Temperature

Figure 1.6  Styrene Monomer Viscosity of Vapor @ 1 Atmosphere as a Function of Temperature
Figure 1.7  Styrene Monomer Heat of Vaporization as a Function of Temperature

Figure 1.8  Styrene Monomer Heat Capacity of Saturated Liquid as a Function of Temperature
Figure 1.9  Styrene Monomer Enthalpy of Saturated Liquid as a Function of Temperature

Figure 1.10  Styrene Monomer Heat Capacity of Vapor (Ideal Gas) as a Function of Temperature
Figure 1.11 Styrene Monomer Enthalpy of Saturated Vapor as a Function of Temperature

![Graph showing Enthalpy of Saturated Vapor as a Function of Temperature](image)

Reference: Saturated Liquid Styrene Monomer at 0°C

Temperature (°C)

Figure 1.12 Styrene Monomer Surface Tension as a Function of Temperature

![Graph showing Surface Tension as a Function of Temperature](image)

Surface Tension (dynes/cm)
Figure 1.13 Styrene Monomer Thermal Conductivity of Saturated Liquid as a Function of Temperature

Figure 1.14 Styrene Monomer Thermal Conductivity of Vapor @ 1 Atmosphere as a Function of Temperature
1.3 Typical Values
Lyondell styrene monomer meets the requirements of ASTM D 2827-13:
- Purity, wt. % min .......................................................... 99.8
- Ethyl benzene, ppm max ............................................. 500
- Benzene, ppm max .......................................................... 1
- Aldehydes (as Benz aldehyde), ppm max ....................... 100
- Peroxides (as H₂O₂), ppm max .................................. 50
- Polymer, ppm max .......................................................... 10
- 4-tert-Butylcatechol, ppm range ................................. 10-15
- Color, Pt-Co (ASTM D-5386), max ............................. 15

1.4 Instability Hazards
Styrene monomer can self-react and polymerize unless properly inhibited. Polymerization will release heat and results in temperature and pressure increases. The most commonly used inhibitor is 4-tert-Butylcatechol (TBC). The standard addition range is 10-15 ppm. Maintaining the TBC levels above 10 ppm, the storage temperature below 21°C (70°F) and the dissolved oxygen content of the liquid at 15 to 20 ppm will help inhibit polymerization (See Section 4.1.4).

1.5 Reactivity Hazards
Styrene monomer reacts with oxidizers, peroxides, strong acids and alkali metal-graphite compounds. Avoid copper and copper containing alloys. Styrene monomer will dissolve many natural and synthetic rubbers. Storage vessels must be free of rust and scale which can promote polymerization. Styrene monomer emits acrid vapors on thermal decomposition. Incomplete combustion can produce carbon monoxide.

1.6 Self-Polymerization
Styrene monomer is inhibited with TBC to reduce and control self-polymerization. Styrene monomer undergoes polymerization slowly at ambient temperatures, but polymerization will become rapid at elevated temperatures. Styrene monomer may experience rapid polymerization if TBC inhibitor and dissolved oxygen are depleted at elevated temperatures or if product is contaminated with incompatible materials. Styrene monomer polymerization is exothermic evolving 290 BTU/lb (16.7 Kcal/mol). If excess heat is not adequately dissipated, the product temperature will rise with a subsequent rise in the rate of polymerization. At temperatures above 65°C (149°F), runaway polymerization is possible.

When a runaway polymerization occurs, temperatures can quickly exceed the boiling point of styrene monomer. Vapors may erupt violently from tank vents or, if vents become plugged with polymer, excessive pressure can be generated that may rupture the containment vessel.

Styrene monomer should be monitored regularly for TBC content. During excessive transit times, monitoring should also be conducted. At the first sign of uncontrolled polymerization, TBC should be added and product temperature should be reduced.

TBC inhibitor should be added as an 85 percent solution in methanol. Add TBC to an initial concentration of 50-100 ppm TBC in styrene monomer. Circulate tank contents to mix the TBC in styrene monomer. If circulation is not possible, agitate by bubbling air into tank bottom. (Caution: The air/styrene monomer vapor mixture may be within the flammability envelope). If runaway polymerization continues, add TBC up to a 0.5 wt. % concentration. Dilution with toluene, xylene or ethyl benzene will slow the polymerization.

Lowering product temperature will also slow polymerization. Tanks can be cooled by refrigeration, circulation and water spray.

When tank temperatures are stable and polymerization has stopped, product should be removed from tank before it becomes solid. If product’s viscosity prohibits removal, dilute with toluene, xylene or ethyl benzene before emptying the tank.

1.7 Precautions When Handling TBC
TBC and solutions of TBC are corrosive and can cause severe burns to the skin and eyes. TBC may cause allergic reactions in certain individuals. Consult the manufacturer’s Safety Data Sheet for additional information.

When handling TBC, personnel should prevent exposure to the skin by wearing chemical protective gloves, apron and boots. Prevent eye contact by wearing chemical splash goggles or face shield.
2. ENGINEERING

This section is included for use as a guideline. It is not intended to be a design handbook and does not relieve the user from exercising competent engineering judgment or using qualified professional personnel to meet the specific requirements. The information contained is only applicable to the specific chemical compound identified in Section 1 General Information, 1.1 Product Identification. Mixtures or compounds using styrene monomer will require additional engineering studies to determine the applicability of the enclosed information.

2.1 Bulk Storage

The construction of low-pressure styrene monomer storage should be according to API-620 and 650 (see Appendix 2 for citations). Higher-pressure storage vessels should comply with ASME Code Section VIII, Division 1 or equivalent. All internal surfaces should be kept clean and rust-free and should be internally lined with an inorganic zinc product or a baked phenolic product to prevent polymerization problems. Liquid styrene monomer should enter through the bottom of the tank. Incoming liquid should be prevented from free-falling through the tank vapor space (see Section 4). Tanks should have a minimum of internal beams, pipes and projections that can provide places for condensed styrene monomer vapors to accumulate and polymerize.

Refrigeration by external chillers may be required to maintain the monomer temperature below 21°C (70°F). All above-ground storage tanks should be insulated and designed with a means of styrene monomer agitation. For a complete discussion on storage conditions, see Section 4.

2.2 Piping

Piping and piping components should comply with the latest edition of ASME/ANSI B31.3 or the appropriate equivalent. Carbon steel is an acceptable material of construction although, to prevent increased polymerization and color problems, stainless steel is preferred. One and one half inch pipe or smaller can use threaded, threaded and back welded or socket welded connections. Butt-welded fittings and flanged connections are preferred.

Piping should be laid out to facilitate complete draining or permit nitrogen purging back to the styrene monomer storage tank or other common collection points. If lines are to be used infrequently, complete draining is crucial. These lines should be buried or shaded to minimize the potential for polymerization due to temperature increases. For extended storage, all lines should be designed to allow recirculation and chilling.

2.3 Electrical Area Classification

All electrical equipment should be suitable for flammable organic liquids, be constructed and installed to recognized, appropriate engineering codes of practice and conform to the appropriate area classification.

2.4 Pump Specifications

Centrifugal pumps: any carbon steel or stainless steel type designed with closed impellers and mechanical seals. Secondary seals should be styrene compatible.

Rotary pumps: any type made for hydrocarbon service with mechanical seals. Check pump regularly for gear wear.

Positive displacement pumps: any type made for hydrocarbon service with mechanical seals. Check pump regularly for wear.

Drum pumps: should be regularly checked for leakage and cleaned thoroughly after each use.

When pumps are installed, care should be taken to avoid the possibility of allowing a pump to run against closed valves. “Deadheading” the pump will cause heat buildup and lead to polymerization of the monomer; therefore, a minimum flow line should be used. The line should have a cooler to keep the styrene monomer below its polymerization temperature. The pump design should also allow for complete drainage and recirculation.

2.5 Instrumentation

Independent high-level alarms and/or shutdowns should be provided for storage tanks. Storage tanks should be equipped with temperature and level indicators. All instrumentation should be designed, manufactured and installed to appropriate engineering codes and conform to the appropriate area classification.

2.6 Relief Requirements

The requirements of API RP-2000 should be followed for low-pressure vertical storage tanks. Pressure-relieving systems for pressure vessels are defined in API RP-520, Parts 1 and 2. Flame arresters, when required, should follow the requirements of API R-2028 and 2210.

Pressure-relief valves in styrene monomer service should be regularly inspected for polymer formation. A nitrogen purge under the seat of the relief valve can be used to minimize polymer buildup. Avoid composite rupture disks with incompatible seals.
Engineering

2.7 Leak Detection Devices
Secondary containment areas in confined spaces should be monitored with instrumentation able to detect the lower flammability limit of styrene monomer in air.

Instruments that have been successfully used to measure styrene monomer are combustible gas indicators, infrared spectrophotometers, flame ionization detectors and photoionization detectors.

2.8 Material Requirements
Styrene monomer, like other aromatics, is not compatible with most elastomers and rubber materials. It is not compatible with copper and copper alloys. Care should be taken when selecting materials that will contact styrene monomer. Consult with individual manufacturers about the specific needs of your facility.

2.8.1 Hoses
All hoses should be flexible stainless steel, have suitable pressure/temperature ratings and should be grounded to discharge static electricity. All hoses should be tested on a regular basis.

2.9 Vapor Containment System
Vapor containment systems for pressure vessels are defined in API RP-520, Parts 1 and 2.

2.10 Chemical Compatibility
Styrene monomer is highly reactive, especially with oxidizers, peroxides, strong acids, metal halides and metal alkyls. Copper and copper alloys should be avoided because their use can discolor styrene monomer.
3.1 Fire and Explosion Hazard

Styrene monomer is classified by OSHA 29 CFR 1910.106 (see Appendix 2 for citations) as a Class IC flammable liquid. The National Fire Protection Association (NFPA) Code 30 also defines styrene monomer as a Class IC flammable liquid. For application of the National Electric Code (NFPA 70), styrene monomer is a Class I, Group D.

Styrene monomer has a flash point of 31.9°C (90°F). Styrene monomer vapors are explosive in air at concentrations between 0.9 and 6.8 percent by volume if an ignition source is present (see Figure 3.1).

Styrene monomer vapor is heavier than air and may travel a considerable distance to a source of ignition and then flashback. All precautions necessary for the safe handling and storage of a volatile flammable liquid or vapor should be strictly observed with styrene monomer.

Uncontrolled polymerization should not occur if TBC inhibitor levels, temperatures and dissolved oxygen are controlled. However, if polymerization does occur, it causes heat and pressure to increase. The resultant increase in heat and pressure can cause storage containers to rupture and, if ignited, explode. Polymer formation can lead to plugging of the relief vents or equipment with an increase in fire and explosion risk.

Storage areas should be designed to prevent exposure of styrene monomer to fire (see Section 4). Inhibitor levels should be checked daily if styrene monomer is stored at temperatures above 25°C (77°F). Section 4 contains further information on TBC monitoring.

If styrene monomer is involved in a fire, unauthorized individuals should be prevented from entering the area, and the area downwind of the fire should be evacuated. All fires should be fought from a safe distance upwind of the fire.

Styrene monomer fires produce carbon dioxide and may produce carbon monoxide upon incomplete combustion. As it decomposes, styrene monomer will emit acrid vapors and may produce a powerful lacrimator (tear producing agent) upon reaction with chlorine or bromine.

Heat may build pressure and rupture closed containers. A water fog should be used to cool the containers. Water may be ineffective as an extinguishing agent due to styrene monomer’s low solubility. The flow of styrene monomer should be stopped before trying to extinguish a fire. Liquid should be kept from entering water sources and sewers by building dikes as necessary to contain the flow. Proper authorities should be notified if styrene monomer enters sewers or public water systems.

3.2 Fire Prevention

Styrene monomer can form explosive mixtures. Sources of ignition including heat, sparks, flames and sources of static electricity should be avoided. Each facility handling styrene monomer should adopt a comprehensive program for fire prevention. The following management systems contribute to an effective fire prevention program:

- “no smoking” policy where styrene monomer is used
- the use of non-sparking tools while working with or near equipment containing styrene monomer
- grounding metallic containers/vessels in which styrene monomer is stored
- bonding and grounding metallic containers
- stringent welding, cutting and burning permit systems
- implementation of inside and outside storage methods that comply with regulatory requirements and good industry practice

3.2.1 Static Electricity

As with other flammable liquids, the transfer of styrene monomer can create static electricity charges, which can act as an ignition source for the flammable vapors. The charge can develop when the liquid flows or is poured through air. To reduce or eliminate this, bonding and grounding is required by federal regulations (OSHA, 29 CFR 1910.106), building and fire codes (NFPA 30, 70 and 77 and API RP-2003) and industry practice.

Bonding provides a low-resistance path to current flow between surfaces that are physically separated or become separated. According to NFPA 77, a maximum of one mega ohm is acceptable but generally much lower values are possible.

Grounding connects the containment vessels and pipes to a grounding electrode (ground) in the earth by means of conductors welded or attached to both the equipment and the grounding electrode. A 10-ohm maximum is the recommended value for the resistance of the cable and ground. Refer to NFPA 77 for relevant consensus guidance for bonding and grounding measures.
3.3 Fire Suppression

Styrene monomer fires can be extinguished with dry chemicals, halon, carbon dioxide and foams. For large fires, water spray or fog may be effective. However, fixed-foam protection using an application rate of 0.1 gallons per minute per square surface is recommended. Several types of foam are effective. Manufacturers should be contacted for specific recommendations.

Water may be ineffective in fighting styrene monomer fires. Water can sometimes be used to extinguish styrene monomer fires when several coordinated hose streams are used to sweep the flames from the surface of the burning liquid. This approach should be used only by experienced firefighters working under favorable conditions. Water spray can also be used to disperse vapors, protect firefighters, absorb heat and protect exposed structures and adjacent storage areas.

Portable fire extinguishers should be placed near styrene monomer storage and handling areas. Workers should be trained in the use of portable fire extinguishers (29 CFR 1910.157). Class B dry chemical or foam extinguishers should be used to fight styrene monomer fires. Information on how to select, use, distribute, inspect, maintain and recharge portable fire extinguishers can be found in NFPA 10.

3.4 Fire Fighting

Facilities that rely on local fire authorities should provide them with information on styrene monomer operations and storage, including an illustration of storage locations and quantities of styrene monomer present. Drills should be conducted periodically with the local fire authority, and facility information should be updated regularly.

Facilities using internal fire brigades should follow the OSHA Fire Brigade Standard 29 CFR 1910.156. This standard includes information on fire brigade organization, personnel qualification, firefighting equipment and training requirements. Firefighters should use full protective clothing and equipment, including approved self-contained breathing apparatus.

If a fire is controllable or styrene monomer containers are not exposed to direct flame, an evacuation zone with a minimum radius of 1,500 feet may be needed. If the fire becomes uncontrollable or styrene monomer containers are exposed to direct flame, an evacuation zone with a minimum radius of 3,000 feet may be required.

After a fire has been extinguished, any residual styrene monomer should be cleaned up to prevent another fire or environmental contamination. Individuals involved in a cleanup should be thoroughly trained in proper techniques according to the OSHA Hazardous Waste Operations and Emergency Response (HazWoper) Standard 29 CFR1910.120.

Figure 3.1 Flammability Region* for Styrene Monomer

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Minimum Oxygen for Combustion (MOC) – <8.0 percent
*This is the region where flammable vapors exist over styrene monomer liquid at atmospheric pressure.
Considerations in the design and construction of styrene monomer storage and handling facilities are flammability, potential to polymerize, environmental contamination and worker exposure. The specific requirements for storing and handling styrene monomer depend on several factors, including volumes stored or handled, container type, mode of transportation, processes used at the facility and the proximity to other hazardous materials. The proper design and construction of storage and handling facilities requires consultation with competent professional engineers.

Additional requirements may be imposed by the OSHA Process Safety Management of Highly Hazardous Chemicals 29 CFR 1910.119 (see Appendix 2 for citations). The standard applies to processes involving flammable liquids in quantities of 10,000 pounds or more. Styrene monomer is highly reactive and, therefore, different from other common aromatic compounds in that it will polymerize. Styrene monomer polymerizes slowly at room temperature and more rapidly at elevated temperatures. Polymer formation may be accelerated by any of the following:

- depleted inhibitor concentration
- high temperatures
- acids
- peroxides
- oxidizers
- other catalysts such as dirt and scale
- insufficient dissolved oxygen levels

The rate of polymerization can become uncontrollable. This can lead to hardening and plugging of equipment or, in the worst cases, a fire or explosion. To prevent polymer formation in styrene monomer, TBC inhibitor is typically added at a concentration of 10-15 ppm. In addition to using TBC, temperature control and proper selection of a storage environment should ensure shelf life with the necessary quality specifications.

4.1 Storage Tanks

When designing bulk storage facilities for styrene monomer, certain factors should be considered. In addition to normal precautions taken for flammable liquids against fire and explosion hazards, care must be taken to avoid conditions that could cause polymerization and oxidation. Tanks and distribution systems should be designed to eliminate excessive temperatures and contamination from polymer residue left in infrequently used lines and pumps. Additional design features should include inhibitor addition, tank content sampling and recirculation, tank breathing and control of vapor emissions.

4.1.1 Tank Construction

Atmospheric styrene monomer storage tanks should be designed and constructed according to NFPA 30 as it applies to Class IC liquids and API 650 as a minimum. API 620 is also acceptable. This API standard is intended to ensure that tanks possess sufficient structural strength and pressure-relief systems to prevent catastrophic loss of contents either in normal service or under fire conditions. A typical storage tank for styrene monomer can be seen in Figure 4.1. Proper storage conditions are essential to ensure good styrene monomer quality with minimal polymer formation. The storage tank should be clean, constructed of steel with a self-supporting dome roof for vertical storage tanks. Styrene monomer vapors are not inhibited and can form polymer. The ceiling of the storage tank should be smooth and free of internal superstructure to eliminate sites for polymer formation. Keep an absolute minimum of internal beams, pipes, projections and crevices that can provide places for condensed styrene monomer vapors to accumulate and polymerize. In addition, it is recommended that all internal structural connections be welded.

Tank cleanliness is important, as dirt and scale may act as catalysts for polymer formation. Copper and copper-bearing alloys such as brass and bronze should be avoided because copper will react with the TBC and impart a bluish-green color to the styrene monomer.
4.1.1 Tank Construction

Openings in the roof and sidewalls above normal liquid levels should be of large diameter, and the number should be kept to a minimum. Large-diameter openings facilitate easy cleaning and dual-purpose use, where feasible.

Tank openings (vents, arrester plates and man-ways) should be inspected every six months for polymer buildup. If polymer buildup occurs, it is a good indication that more serious polymer formation in the form of stalactites on the tank roof may be occurring. The polymer buildup should be removed. Tank linings have proven quite successful in controlling polymerization problems in styrene monomer storage. Liners will cover any scale and oxidation and prevent future scale. A tight, nonporous, non-wettable smooth surface allows the uninhibited styrene monomer vapor condensate to return quickly to the inhibited liquid monomer before polymerization can take place. Baked phenolic, carbon-zinc, modified epoxy and catalyzed epoxy linings have all been used for this type of service. However, these lining are all nonconductive and, at a minimum, the lower portion of the storage tank should be lined with a conductive coating that provides electrical grounding. Inorganic zinc silicate linings have been used for years in styrene monomer service, giving both the conductivity and smooth surface desired. Other comparable linings are available, and the manufacturers of the coating should be consulted for performance and application information. Rubber-based coatings should not be used.

The storage tank can be filled from the bottom or top. When using a top-fill line, the line should be extended inside the tank to the bottom so to prevent static electric discharge. The fill outlet should be below minimal operating level.

Circulation is recommended for all styrene monomer storage tanks to facilitate thorough mixing when new monomer or inhibitor is added, to help control temperature and to maintain the required dissolved oxygen in the system. Circulation of tank contents may be achieved by using a swing pipe design or an eductor. For the swing pipe design, the outlet line operates through a floating swing pipe adjusted so the monomer is always withdrawn a few inches below the surface. Warm monomer is withdrawn from the top, circulated and discharged at the bottom of the tank. The other mixing option is to install an eductor inside the tank on the discharge end of the recirculation line. Mixing improves temperature uniformity of the monomer and ensures that samples are representative of the tank’s content. The inlet line and outlet line should be at opposite ends of the tank.

Valves located below liquid level must be designed to prevent breakage from freezing, heat shock or mechanical stress. Lubricated plug cocks and non-lubricated ball valves lined with Viton are satisfactory. Stainless steel ball valves have been used for styrene monomer service. All valves require routine maintenance to prevent plugging.

Consideration in site selection and tank spacing include proximity to other flammable material storage facilities, nearby sources of ignition, accessibility for firefighting and the impact of a vapor cloud explosion on nearby areas. Bulk storage tanks should have fire monitors to provide cooling in the event of an external fire.

Storage tanks should be situated within containment systems that are capable of providing detection and control of an accidental release of styrene monomer from any tank surface and from piping to and from the tank. Containment-system design and operation should conform to all federal requirements. Tanks must also be designed to provide complete drainage. Separate drain lines, a small built-in sump with a bottom drain and floors sloped to the drains are important for complete drainage.

4.1.2 Tank Breather Vents

Tank breather systems should be designed to minimize the emission of vapors. Unloading piping should include an equalization or vapor return line to exchange displaced vapors between the storage tank and the unloading vehicle. Tank-venting and emergency relief should comply with API Standards. When designing large storage tanks, it should be noted that it is impractical to install sufficient relief capacity in the event of a runaway polymerization. Therefore, it is critical to maintain the correct inhibitor and oxygen concentrations, control tank temperature and provide tank circulation.
**Figure 4.1 Typical Atmospheric Storage Tank Configuration**

- **CONTAINMENT DIKE**
- **LEVEL TRANSMITTER**
- **LEVEL INDICATOR**
- **LEVEL SWITCH HIGH/LOW**
- **LEVEL ALARM HIGH/LOW**
- **TEMPERATURE INDICATOR**
- **NFPA IDENTIFICATION CODE**
- **MANWAY**
- **SUCTION LINE AND FLOAT**
- **SWING JOINT**
- **MIXING EJECTOR/S**
- **TEMPERATURE TRANSMITTER**
- **TEMPERATURE SWITCH HIGH**
- **PRESSURE INDICATOR W/SEAL**
- **TEMPERATURE ALARM HIGH**
- **FOAM CHAMBER/FOAM MAKER**
- **STRAINER**
- **GROUND WIRE**
- **PUMP**
- **INHIBITOR ADDITION POINT**
- **PRESSURE INDICATOR W/SEAL**
- **RECYCLE**

*This figure illustrates a typical configuration and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet the applicable requirements.*
4.1.3 Control of Vapor Emissions

Bulk storage tanks should be vented to a vapor collection and containment system that effectively eliminates discharges of styrene monomer vapors to the atmosphere. The exchange of vapors between the bulk delivery vehicle and the storage tank through an equalization line may be used. Different types of vapor recovery systems are available. These include carbon adsorption beds, condensers, incinerators, flares and thermal oxidizers. Emission reductions may be achieved by reducing tank temperatures. The venting or collection system should be designed to prevent the passage of a flame or explosion from one container to another.

4.1.4 Inhibitor Control

Lyondell Chemical Company adds 4-tert-Butylcatechol to all styrene monomer. It acts as an inhibitor to prevent polymer formation. The standard addition rate is 10-15 ppm. This level of inhibitor permits the use of styrene monomer in most applications while still providing good shelf life. Higher levels of TBC may be added to meet customer specifications. Another important factor for product stability is the effect of TBC depletion over time in styrene monomer. Table 4.1 shows maximum recommended storage times as a function of tank contents temperature. This table should be considered only a guideline, as other factors will also influence stability.

Table 4.1 Styrene Monomer Storage Testing

<table>
<thead>
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<th>Temperature</th>
<th>Frequency of TBC &amp; Polymer Monitoring</th>
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<tr>
<td>&gt;25°C (&gt; 77°F)</td>
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<tr>
<td>15 - 25°C (59 -77°F)</td>
<td>2 - 3 times a week</td>
</tr>
<tr>
<td>&lt; 15 °C (&lt; 59°F)</td>
<td>1 time weekly</td>
</tr>
</tbody>
</table>

The levels of 4-tert-Butylcatechol should be monitored on a routine basis (see Table 4.1 and Appendix 3). Polymer and color analyses should be conducted at the same frequency as the TBC analysis. The preferred method for 4-tert-Butylcatechol analysis is the ASTM Method D-4590. A Visual Quick Test Method is provided in Appendix 3 for use when rapid test results are justified.

If TBC levels fall below 10 ppm, inhibitor should be added to bring the level up to 10-15 ppm. The 4-tert-Butylcatechol concentrations should never fall below 4 ppm. Depending on tank conditions, incipient polymerization may occur at this level. This is evidenced by a slight increase in styrene monomer viscosity and/or temperature. Polymer formation is shown by diluting one part of styrene monomer with 10 parts methanol and observing a cloudy solution. Polymer levels can be determined using ASTM Method D-2121, Method A.
The 4-tert-Butylcatechol levels will be depleted if tank temperatures are too high (see Figure 4.2). Tank temperatures should generally be maintained below 21°C (70°F). Lower temperatures are recommended if styrene monomer will be stored for extended periods. Tank temperatures can be reduced in warmer climates by tank insulation, reflective painting and circulation. Refrigeration should be provided when no other means exist to maintain tank temperatures below 21°C. Tanks should be equipped with recirculation lines and pumps to aid in cooling, in addition to providing mixing and dissolved oxygen requirements. Recirculation of process and offloading lines should be considered where there is a potential for extended holdup of material. Temperature indicators should be provided at various levels in the tank. If infrequent temperature checks are made, a temperature alarm system may also be provided.

The 4-tert-Butylcatechol inhibitor requires dissolved oxygen to work effectively. The minimum required dissolved oxygen level in styrene monomer is approximately 8 ppm. This can be maintained easily by recirculation of the styrene monomer in an air blanketed storage tank at least three to four times per week. If oxygen is totally removed from a storage tank by using a nitrogen blanket, dissolved oxygen will be removed and TBC becomes ineffective, leading to polymerization. Nitrogen blanketing is only recommended for short-term storage. If an inert gas is used as a blanket for extended storage, the oxygen content in the vapor phase should be controlled between 3 and 6 volume percent. This oxygen content will provide sufficient dissolved oxygen for TBC as well as prevent flammability. An oxygen analyzer may be useful to maintain proper oxygen content under this storage condition. When TBC addition is needed, it can be made most easily by adding a TBC solution of 85 percent TBC and 15 percent methanol supplied directly by the manufacturer. It may be added through the suction line of the recirculation pump. Each 20,000 liter increment of styrene monomer should have 210 gm of TBC solution added to an approximate 10 ppm TBC concentration. The TBC will only be effective when the tank is circulated and thoroughly mixed.

4.2 Unloading Installations

The installation for unloading rail tank cars and tank trucks of styrene monomer should be designed, maintained and operated to meet current standards for fire protection, worker safety and environmental safety.

Loading racks should be in accordance with all federal and regulatory requirements. Piping systems for tank trucks and tank cars should be connected to a common earth ground and bonded to the discharge system. Continuity to ground should be checked prior to unloading.

Instrumentation at the loading station should warn the operator of the potential for overfilling and shut off flow whenever overfill is imminent. Neither device is to be used as a regular operating tool for determining tank level.

Styrene monomer collection systems should be large enough to contain the worst credible accidental release of styrene monomer, plus an additional volume for flush water and rain water. The unloading area should be curbed to divert spillage into the drainage system and prevent run-off into the surrounding areas. Adjacent unloading areas should be segregated by curbing. At a minimum, the surface of the unloading area under and around the bulk-transport vessel should be constructed with an impermeable membrane or ballast installed over an impermeable barrier suitable for the retention of styrene monomer. The drainage surfaces should be pitched with a grade toward the collection basin or sump.

The sump or catch-basin should have fire seals and should be equipped with instruments that will reliably detect liquid levels and the presence of styrene monomer vapor. Rain water and spills trapped inside the containment area are to be disposed of through the sump or catch-basin. Discharge valves from the collection area should be closed under normal conditions. Accumulated liquids should be disposed of only by a trained operator after determining the liquid’s composition.

Lighting adequate for night time unloading operations should be provided, unless all unloading will be done during daylight.

A suitable method of discharging container contents should be provided. Acceptable methods include gravity flow, pumping from the top through a dip pipe or pressurization with nitrogen. If nitrogen pressurization is used, the facility should be designed to avoid over-pressurization of the vessel. Furthermore, a means of collection and environmentally acceptable treatment of the vapor (e.g., flaring or scrubbing) should be provided. Vapor containment systems should be designed to remove or recover vapor. Additionally, nitrogen containing 3 to 6 vol% oxygen should be used (see Section 4.1.4). The location of tank car loading and unloading should be distant from general activity, ignition sources and traffic. The ground should be sloped toward a containment area to permit recovery or disposal of any spills.

An automatic deluge sprinkler system should protect the loading facility and rail tank car. A fire-water monitor nozzle should be located within 40 feet of the tank car and should have an unobstructed path to the target. Dry- powder or carbon dioxide fire extinguishers should also be present.
4.4 Workplace Location

Processing operations using styrene monomer should be located and operated according to federal and regulatory requirements.

Facilities storing or using styrene monomer should use either a gravity or continuous mechanical-exhaust ventilation system. If styrene monomer is dispensed within the room, mechanical ventilation is required. Dispensing of styrene monomer in the warehouse is not recommended unless the dispensing area is suitable separated from the other combustible storage area.
Styrene monomer should be transferred and handled according to written operating procedures developed for the specific facility. This section includes guidelines used by Lyondell Chemical Company in its handling of styrene monomer.

Operating procedures should address the hazards associated with this material (see Safety Data Sheet), the selection of personal protective clothing and equipment (see Safety Data Sheet) and fire prevention methods (see Section 3). Only workers trained in proper operating procedures should handle styrene monomer.

Dedicated unloading lines are recommended for styrene monomer service. All unloading lines should be purged with an inert gas before and after use to prevent air from entering the storage system or to prevent spilling of liquid styrene monomer.

5.2 Tank Cars DOT111A

Lyondell Chemical Company ships styrene monomer in DOT 111A tank cars (see Figure 5.1). Refer to 49 CFR 174 Subparts C and G (see Appendix 2 for citations) for DOT unloading regulations. The following procedures are comparable to those used by Lyondell Chemical Company for unloading tanks cars and can be used as a basis for site-specific procedures. A suggested unloading checklist is provided in Figure 5.2.

5.2.1 Unloading Procedures

The unloading procedures for rail/tank cars are as follows:

1. Gather all necessary equipment. For tank car unloading, also include:
   - Wheel chocks
   - DOT-approved “STOP” signs
   - Derailer

2. Position the tank car correctly with respect to the unloading station, then set its brake and chock one wheel on both sides.

3. Place DOT-approved, blue rectangular “STOP” signs at both ends of the car between rails. Place an additional sign at the rail siding switch.

4. Place a derailer on the rail siding between the car and the siding switch. Lock derailer, if possible.

5. Ensure that the receiving tank’s ullage (available space) is sufficient to receive the full load with room to spare after the transfer is complete.

6. Identify all pipelines so proper valve alignment can be made.

7. Connect ground cable to car and check for continuity.

8. Remove and read the Lyondell Chemical Company label attached to the car’s outlet valve. Make sure that it identifies the car’s contents as styrene monomer. Also, remove the one-eighth inch wire cable seal and verify the seal number with the paperwork.

9. Determine that the unloading station’s spill collection sump drain is closed and that the sump is substantially free of accumulated liquid.

10. A sample can be taken, if needed, by using the three-fourths inch sample valve at the top of the car.

11. Some tank cars may contain equipment for optional nitrogen padding during off-loading. Tank car should be unloaded with air only if the product temperature is below the lower flammable limit (see Figure 3.1). If product temperature is above lower flammable limit, unload under nitrogen. Connect the nitrogen or dry air line to the one inch threaded airline valve at the top of the car and open the valve. The recommended psig is 20-30 for unloading if not using a pump. If using a pump, you must feed nitrogen or air in at a rate that will displace the liquid as the car is being unloaded to prevent the tank from implosion.

For more information on polymerization hazards, see Section 1.6.
Transfer Operations

12. Attach flexible unloading hose to the car's bottom outlet valve after ensuring that all parts including gaskets and O-rings are in good condition.
13. Set valves in fixed piping to begin transfer.
14. Open car's external (lower) bottom valve.
15. Open car's internal bottom valve. Check carefully for leakage. If any is noted, take remedial action.
16. Start transfer pump.
17. Immediately make a visual check for leaks, especially at places where seals and O-rings are present; shut down immediately and take remedial action if leaks are observed.
18. Check that receiving tank's level is rising at the expected rate for the transfer system.
19. Monitor the transfer. When the tank car is empty, close pump discharge valve and immediately shut off pump.
20. Close valves connecting transfer line and pump to receiving tank.

21. Close tank's internal and external bottom outlet valves.
22. Disconnect unloading hose, taking precautions to catch residual styrene monomer for proper disposal.
23. Close and secure manway latch.

5.2.2 Release of Empty Car

The following steps complete the process of unloading tank cars:
1. Disconnect the ground cable.
2. Remove the wheel chocks, derailer, blue flag and caution signs. Leave the car brakes engaged for railroad crew to release.
3. Make sure placards are affixed for return trip.
4. If there were any mechanical problems with the tank car, advise LyondellBasell Transportation Distribution Incidents (TDI) at 1-800-245-4532.

Figure 5.1 Typical Tank Car 111A-100W Configuration*

1. WHEEL CHOCKS (BOTH SIDES OF WHEEL) 9. DRY DISCONNECT & FLEX. HOSE ASSEMBLY (FOR TOP UNLOADING) 16. APPROVED GROUND
2. LABEL (FLAMMABLE LIQUID) 10. ISOLATING VALVE 17. STRAINER
3. HAZARD INDICATION PLACARD 11. PRESSURE GAUGE 18. PUMP
4. DRY DISCONNECT & FLEX. HOSE ASSEMBLY (FOR BOTTOM UNLOADING) 12. NITROGEN HIGH POINT PURGE 19. PRESSURE GAUGE W/DIAPHRAGM SEAL
5. SAFETY VALVE 13. CHECK VALVE 20. HANDRAIL
6. MANWAY 14. PRESSURE SAFETY VALVE 21. HAND BRAKE WHEEL
7. VAPOR RETURN/AIR/NITROGEN CONNECTION 15. PRESSURE CONTROL VALVE 22. DERAILER
8. FLEX. HOSE ASSEMBLY

*This figure illustrates a typical configuration and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet the applicable requirements.
Figure 5.2  Styrene Monomer Unloading Checklist – DOT 111A

<table>
<thead>
<tr>
<th>Prior to Unloading Tank Car</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheels chocked and hand brakes engaged</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Blue flag and derailer in place</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Metal caution signs located in front of and behind tank car</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Storage tank capacity and tank car liquid level determined before filling</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Proper piping alignment made and checked</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Product hose and fittings visually inspected prior to use</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Eyebath and safety shower flushed and ready</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ground cable to car connected and checked for continuity</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>N₂ hose hooked up to vapor valve</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Transfer started and system visually checked for leaks</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Qualified operator in attendance during transfer</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>After Unloading Tank Car</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>When tank car is empty, shut down the pump</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Unloading line valve closed to the storage tank</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Tank car liquid unloading valve closed</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>N₂ valve closed</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Transfer line disconnected and residual liquid collected</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Manway cover secured</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ground cable disconnected</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Are placards affixed and in good condition?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Blue flag and derailer device removed</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Wheel chocks removed</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Car brake left engaged for railway crew</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Advise Lyondell Chemical Company of any mechanical problems at 1-800-245-4532.
5.3 Tank Cars DOT 105J

Lyondell Chemical Company also ships styrene monomer in DOT 105J tank cars (see Figure 5.3). These tank cars are top unloaded by pressure or pumping. Refer to 49 CFR 174 for DOT unloading regulations.

The following procedures are comparable to those used by Lyondell Chemical Company for unloading tanks cars and can be used as a basis for site-specific procedures. A suggested unloading checklist is provided in Figure 5.4.

5.3.1 Unloading Procedures

The unloading procedures for tank cars are as follows:

1. Gather all necessary equipment. For tank car unloading, also include:
   - wheel chocks
   - DOT-approved “STOP” sign
   - derailer

2. Position the tank car correctly with respect to the unloading station, then set its brake and chock one wheel on both sides.

3. Place DOT-approved, blue rectangular “STOP” signs at both ends of the car between rails. Place an additional sign at the rail-siding switch.

4. Place a derailer on the rail siding between the car and the siding switch.

5. Connect ground cable to car and check for continuity.

6. Remove the one-eighth inch wire cable seal and verify the seal number with the paperwork.

7. Remove the housing cover pin and lift pressure dome cover. This will expose all valves and fittings which are required for unloading and sampling (see Figure 5.5).

8. Inspect for leakage around valves and fittings in the pressure dome area by pouring soapy water on the connections only and checking for bubbles. If leaks are detected, tighten fittings and recheck.

---

*Figure 5.3 Typical Car J105-J Configuration*

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*This figure illustrates a typical configuration and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet the applicable requirements.*
Figure 5.4  Styrene Monomer Unloading Checklist – DOT 105J

<table>
<thead>
<tr>
<th>Prior to Unloading Tank Car</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheels chocked and hand brakes engaged</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Blue flag and derailer in place</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Metal caution signs located in front of and behind tank car</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Eyebath and safety shower flushed and ready</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ground cable to car connected and checked for continuity</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Pressure dome inspected for leakage around valves and fittings</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Bill of lading checked and sample verified</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Certificate of analysis and placards checked</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Storage tank capacity and tank car liquid level determined before filling</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Load and vent-back lines connected, purged and tested for leaks</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Proper piping alignment made and checked</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Open transfer lines and monitor liquid level</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Qualified operator in attendance during transfer</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>After Unloading Tank Car</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>When tank car is empty, shut down the pump</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Transfer line blown clear of styrene monomer</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Unloading line valve closed to the storage tank and the storage tank vent</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Tank car vapor valve and liquid unloading valve closed</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Transfer line vented of pressure</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Transfer, nitrogen and storage tank vent lines disconnected</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Test for leakage and secure dome cover</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ground cable disconnected</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Are placards affixed and in good condition?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Blue flag, metal caution signs and derailer device removed</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Wheel chocks removed</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Car brake left engaged for railroad crew</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Advise Lyondell Chemical Company of any mechanical problems at 1-800-245-4532.
Transfer Operations

Figure 5.5  Typical Tank Car Dome Configurations*

*This figure illustrates a typical configuration and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet the applicable requirements.
9. If a sample from the tank car is required to confirm its contents, the following procedure may be used: Sample tank car through the sample line, which is located in the pressure dome area. Fill the sample bottle leaving approximately 20 percent vapor space to allow for expansion. If closed sampling system is not employed, proper personal protective equipment should be used.

10. Determine the receiving tank ullage (available space) and the liquid level in the tank car before transfer.

11. Attach nitrogen or vapor return line to the vapor valve.

12. Attach flexible hose to the liquid unloading (eduction) valve.

13. Open vapor valve. If product will be unloaded under nitrogen pressure, open vapor valve and use a regulator to adjust the nitrogen pressure to equalize that of the tank car. This will force liquid styrene monomer into unloading hose. Nitrogen should be supplied in nominal pressures to equalize the tank and ensure the pressure supply is compatible with unloading system.

14. Open liquid unloading valve and allow styrene monomer to fill the pump by opening the liquid line block valves. These valves must be opened slowly to avoid activating the excess flow valve. Start pump and begin pumping styrene monomer to the storage tank. A positive pressure should be maintained on the tank car to keep the pump from pulling a vacuum on the car. Monitor this closely.

15. Check that the receiving tank's level is rising at the expected rate for the transfer system.

16. Monitor the transfer. When the tank car is empty, immediately shut off pump.

17. Clear the transfer line. Close the unloading line valve to the storage tank and the storage tank vent. Close the tank car vapor valve and the tank car liquid unloading valve. Vent transfer line of pressure. Disconnect transfer, nitrogen and storage tank vent lines.

18. Test for leakage by pouring soapy water over the valves. If bubbles are present, retighten all valves and retest. If leaks are still detected, contact LyondellBasell Transportation Distribution Incidents at 1-800-245-4532.

---

Figure 5.6 Typical Tank Truck Configurations*

1. REAR END PROTECTION
2. WHEEL CHOCKS (BOTH SIDES OF WHEEL)
3. CHEMTREC EMERGENCY NUMBER (800) 424-9300
4. DOT PLACARD (Figure 11.2) (ALL 4 SIDES)
5. MANHOLE ASSY. & OVERTURN PROTECTION
6. CUSTOMER VENT
7. AIR INLET ASSEMBLY
8. PRESSURE VENT
9. VACUUM BEAKER
10. OUTLET VALVE
11. FLEX. HOSE ASSEMBLY
12. GAUGING DEVICE
13. CERTIFICATION PLATE
14. GROUND WIRE
15. STRAINER
16. PUMP
17. CHECK VALVE
18. PRESSURE GAUGE
19. FLEX. HOSE ASSEMBLY
20. PRESSURE RELIEF VALVE
21. PRESSURE CONTROL VALVE
22. DOT CLASSIFICATION NUMBER

*This figure illustrates a typical configuration and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet the applicable requirements.
5.3.2 Release of Empty Car

The following steps complete the process of unloading tank cars:

1. Ensure that all valves are closed, and caps/plugs are in place and are tightened.
2. Disconnect the ground cable.
3. Remove the wheel chocks, derailer, blue flag and caution signs. Leave the car brakes engaged for railroad crew to release.
4. Make sure placards are affixed and in good condition.
5. If there were any mechanical problems with the tank car, advise Lyondell Chemical Company Customer Service.

5.4 Tank Trucks

Lyondell Chemical Company ships styrene monomer in DOT 407 stainless steel tank trucks with approximate capacity of 5,500 to 6,500 gallons. DOT 307, 312, 407 and 412 tank trucks are also acceptable. They are normally bottom unloaded by gravity or pumped through a valve located at the bottom of the truck (see Figure 5.6). Refer to 49 CFR 177 for information on unloading regulations. The following procedures are comparable to those used by Lyondell Chemical Company for unloading tank trucks and can be used as a basis for developing site-specific procedures for unloading styrene monomer. A suggested unloading checklist is provided in Figure 5.7.

5.4.1 Unloading Procedures

The unloading procedures for tank trucks are as follows:

1. Gather all necessary equipment. For tank truck unloading, also include:
   • road barriers
   • wheel chocks
2. Instruct driver to position tank truck for unloading at designated station, then set brakes, shut off engine and leave cab. The driver should remain in a designated area.
3. Safeguard truck from nearby traffic by putting up road barriers or warning lights.
4. Chock both sides of one tank truck wheel.
5. Attach ground connectors and ensure continuity to ground.
6. Remove and read the label attached to the tank truck's outlet valve to confirm that its contents are styrene monomer.
7. Visually inspect hoses and fittings prior to use.
8. Determine that the receiving storage tank has sufficient capacity to hold the entire contents of the tank truck.
9. Identify all pipelines so that proper valve alignment can be made.
10. Determine that the unloading station's spill-collection sump drain is closed and substantially free of accumulated liquid.
11. Trucks are equipped for nitrogen unloading. Attach N₂ line and open valve. Tank cars should be unloaded with air only if the product temperature is below the lower flammable limit. If product temperature is above lower flammable limit, unload under nitrogen.
12. Connect a flexible unloading hose to bottom discharge valve connector.
13. Set valves in fixed piping to begin the transfer.
14. Open tank truck’s external (lower) outlet valve.
15. Open tank truck's internal bottom valve. Check carefully for leakage. If any is noted, take remedial action.
16. Start transfer pump.
17. Immediately make a visual check for leaks, especially at places where seals and O-rings are present. If leaks are observed, shut down immediately and take remedial action.
18. Check that the receiving tank's level is rising at the expected rate for the transfer system.
19. Monitor the transfer. When the tank truck is empty, close pump-discharge valve and immediately shut off pump.
20. Close valves connecting transfer line and pump to receiving tank.
21. Close the trailer's internal and external bottom outlet valves.
22. Disconnect unloading hose, taking precautions to catch residual styrene monomer for proper disposal. Store hose in a protected location.
23. Close and secure the man way cover.
24. Pad with N₂.

5.4.2 Release of Empty Truck

The following steps complete the process of unloading tank trucks:

1. Ensure that all valves are closed, and caps/plugs are in place and are tightened.
2. Disconnect the ground cable. Remove the wheel chocks and traffic-control devices.
3. Ensure that tank truck placards for the return trip meet DOT regulations. Ensure truck has been resealed.
4. Release the vehicle to the driver.
5. If there were any mechanical problems with the tank truck, advise Lyondell Chemical Company Customer Service.
Figure 5.7 Styrene Monomer Unloading Checklist – DOT 407

<table>
<thead>
<tr>
<th>Prior to Unloading Tank Truck</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trailer safeguarded with road barriers/warning lights</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Wheels chocked and parking brakes engaged</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ground cable to truck connected and checked for continuity</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Storage tank capacity checked</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Proper piping alignment made and checked</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Product hose and fittings visually inspected prior to use</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Eyebath and safety shower flushed and ready</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>( \text{N}_2 ) hooked up to vapor connection</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Transfer started and system visually checked for leaks</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Qualified operator in attendance during transfer</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>After Unloading Tank Truck</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>When tank truck is empty, shut down the pump</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Unloading line valve closed to the storage tank</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Tank truck’s internal and external bottom outlet valves closed</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Transfer line disconnected and residual liquid collected</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Manway cover secured</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ground cable disconnected</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Placards proper for shipment</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Wheel chocks removed</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Advise Lyondell Chemical Company of any mechanical problems at 1-800-245-4532.
Transfer Operations

5.5 ISO Tanks

Lyondell Chemical Company ships styrene monomer in intermodal bulk transport tanks meeting IM 101 (T2 tank container) specifications. These tanks contain up to 4,800 gallons of styrene monomer and are shipped at atmospheric pressure. The unloading valve is located at the rear bottom end of the tank (see Figure 5.8). International Organization for Standardization (ISO) tank work preparation and unloading procedures are essentially the same as those in this section.

Figure 5.8 Typical T2 Tank Configuration

*This figure illustrates a typical configuration and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet the applicable requirements.*
5.6  Marine Transport

A customer considering receipt of styrene monomer by water for the first time should contact Lyondell Chemical Company Customer Service for specific requirements.

Styrene monomer handling in marine transport is similar to that required for other flammable liquid hydrocarbons. However, a number of areas may be different and should be evaluated before handling styrene monomer. These areas are:

1. Materials Compatibility – material requirements for styrene monomer should be reviewed. Specifically, check compatibility of loading hoses and tank and compartment liners or coatings.

2. Water Solubility – Styrene monomer is minimally soluble in and somewhat lighter than water. Contact with water should be avoided to maintain product quality. Also, any water contaminated with styrene monomer should be evaluated for waste classification and proper disposal.

3. Fire Foams – As discussed in Section 3, fire foams should be evaluated to determine if alcohol resistant foams are required.

4. Exposure – Any vented marine transfer operations should be monitored to insure that vapor exposure is below the permissible limits (see Safety Data Sheet). Exposure to high levels of styrene monomer can result in eye, skin and respiratory irritation and anesthetic-like effects (see Safety Data Sheet).

Although styrene monomer has low atmospheric reactivity, vapor recovery during marine loading operations may be utilized, particularly in ozone- containment areas.

In the event that vapor recovery is utilized, Coast Guard regulations require that the Maximum Experimental Safe Gap (MESG) be evaluated to determine proper fire protection equipment. The MESG for styrene monomer is .95 mm.

All barges to be loaded at Lyondell Chemical Company’s Houston facility must be Coast Guard certified. Certification will require the installation of a vapor recovery system.

In the case of a marine spill, styrene monomer should form a slick which will slowly volatilize. Because of styrene monomer’s water solubility, little of the spilled styrene monomer will dissolve into the water. The amount that dissolves will depend on a number of factors including air and water temperatures and turbulence. See Safety Data Sheet for general spill handling guidelines.

Independent inspectors or surveyors take quality and a quantity measurement to endure that styrene monomer is loaded only into uncontaminated tanks. Tanks or compartments should be in dedicated service for styrene monomer. Where tanks or compartments are not in dedicated service, a cleaning certificate along with a list of the last three cargos will be required prior to loading. In addition, all tanks and compartments receive an additional check at the one foot level to insure product quality. Lyondell Chemical Company has detailed guidelines available for inspectors.

Styrene monomer should not be stored adjacent to tanks or compartments that are heated. Shifting of the styrene monomer to other tanks or compartments should be avoided. Styrene monomer quality and reactivity can be adversely affected by low levels of any contaminant present. As with other handling operations, the unloading of barges or ships that contain hazardous materials such as styrene monomer must only be carried out by fully trained personnel equipped with all necessary information, PPE and suitable equipment, following correct operating procedures.

In the event of any problems that may affect product, or any indications of polymerization, contact Lyondell Chemical Company Customer Service immediately.
6. TANK CLEANING AND EQUIPMENT REPAIR

6.1 Work Preparation

Proper preparation for cleaning or maintaining styrene monomer storage vessels and equipment is necessary to prevent fire or harm to workers or the environment. Only fully trained and properly equipped workers should clean or repair styrene monomer tanks and equipment.

A hazardous work permit system should be established before any maintenance or inspection activities involving hot work, line breaking or confined-space entry are performed. A permit should identify all job-related hazards and include a work plan to address them. Facilities should use engineering controls and appropriate personal protective equipment.

Before opening, tanks and equipment that contained styrene monomer should be emptied of all liquid by draining at low points. Tanks and equipment should then be purged with an inert gas, then air, to a vapor management system, or they should be flushed with water.

Eyewash and safety showers should be located near the work area. Appropriate fire extinguishing equipment should be present (see Section 3.3).

6.2 Control of Hazardous Energy

A facility’s procedures for controlling hazardous energy sources should comply with the requirements of 29 CFR 1910.147 (see Appendix 4 for citations). These procedures should be used to protect workers in areas where styrene monomer vessels or equipment are cleaned, maintained or entered. After styrene monomer has been purged, positive measures should be taken to ensure that all potential sources of styrene monomer or hazardous energy are physically tagged and locked out and affected persons notified. Personal protective equipment should be worn by workers who might be exposed to styrene monomer residue.

6.3 Confined Space Entry

The OSHA standard (29 CFR 1910.146) establishes requirements for entry into confined spaces. An OSHA confined space is defined as a work zone large enough and so configured to permit entry and work, has limited openings for entry or exit and is not designed for continuous human occupancy. A confined space may present one or more of the following characteristics: a toxic, oxygen-deficient, flammable and/or explosive atmosphere, an engulfment hazard and sidewalls that could trap a worker. Tanks and other process equipment that require worker entry may be considered confined spaces.

Permit Required Confined Space PRCS program requirements include:

1. Written program
2. Identify and classify spaces
3. Establish hazard control measures
   • Prevent unauthorized entry
   • Establish acceptable conditions
   • Isolation
   • Ventilation
   • Coordinate entry by multiple workers
   • Periodic re-evaluation for change of conditions
4. Develop permit system
   • Preparation
   • Issuance
   • Implementation
   • Cancellation
   • Returning space to service
5. Provide specialized equipment
   • Atmospheric monitoring
   • Ventilation
   • PPE
   • Lighting
   • Communication
   • Emergency
6. Designate key personnel
   • Entrants
   • Attendants
   • Entry supervisor
   • Qualified atmospheric tester
   • Emergency response
7. Perform testing and monitoring
   • Prior to entry and periodically during entry and work
8. Establish rescue and emergency procedures
9. Procedures for contractors – multi-employer work sites
10. Provide information and training
11. Conduct program review
Training is required for three categories of workers involved in confined space work: those entering the confined space, attendants or standby/safety persons and the person authorizing the permit. Workers should not enter confined spaces where the styrene monomer vapor concentrations exceed 10 percent of its lower flammable limit of 1.1 percent by volume without a proper permit. Respiratory protection should be worn whenever the styrene monomer concentration exceeds the TLV (see Safety Data Sheet) or the oxygen concentration is less than 19.5 percent. An employee entering a confined space should be able to readily and continuously communicate with a standby person trained to provide emergency rescue.

6.4 Equipment Cleanout

Cleaning styrene monomer equipment is a hazardous operation and should be conducted by experienced and trained workers in compliance with a written, approved procedure. A job safety analysis (JSA) or hazards analysis should be used to identify hazards and necessary protective measures. The emptying of styrene monomer vessels or storage tanks presents a danger of ignition, toxic vapors and environmental contamination.

Vessels, lines and equipment should be emptied from low-point drains and repeatedly rinsed with water until the styrene monomer concentration is less than 1 percent. Residual styrene monomer can be removed by purging with inert gas such as nitrogen. Acidic cleaning solutions should not be used because their residues can cause polymerization. To protect product quality vessels, lines and equipment should be clean and dry before being placed into service initially or after repair. Polymerized styrene monomer should be removed from interior surfaces. Polymer usually forms around internal tank supports, openings, valves, flanges and vents.

If a vessel is to be entered for cleaning, the guidelines for control of hazardous energy and confined space entry in this section should be followed.

6.5 Maintenance and Inspection

Facilities should conduct preventive maintenance and inspection of containers, hoses, pumps, fittings, fire protection equipment and refrigeration units used for styrene monomer. An adequate supply of spare parts for refrigeration units should be maintained. Maintenance and inspection schedules should be established that are appropriate for the device or equipment. Inspectors should be trained how to identify abnormal situations and conduct a proper inspection. A checklist or guide should be used to conduct inspections and all findings and work carried out should be recorded.

Styrene monomer bulk storage tanks should be emptied and visually inspected regularly, such as every two years. The inspection frequency should be increased if polymer formation occurs. Inspections should include lining, roof, vents, seals, relief valves piping and tank openings.

Preventative maintenance schedules should be developed for critical equipment such as firefighting equipment, combustible gas detectors, tank instruments and gauges, pumps, safety-relief valves, isolating valves, gaskets and emission-control equipment.
7. TRANSPORTATION REGULATORY REQUIREMENTS

The Distribution Safety Program of LyondellBasell Industries has been implemented in accordance with the company’s Operational Excellence Standards.

Not every authorized U.S. Department of Transportation (DOT), International Maritime Organization (IMO), International Civil Aviation Organization (ICAO) or International Air Transport Association (IATA) packaging is addressed in this chapter. LyondellBasell has selected transport routes and modes, in concert with packaging configurations, to develop and implement risk reduction alternatives. This bulletin is written in accordance with the Code of Federal Regulation, Title 49 issued Jan. 29, 2003.

Federal regulations describe authorized procedures to properly package, mark, label, placard and manifest shipments. These procedures depend upon the quantity and type of hazardous material and the method of transport of the substance. If one plans to transport hazardous material internationally by air, then the requirements of the IATA and ICAO must be met. Shipment by water requires compliance with the IMO regulations. LyondellBasell recommends that those offering hazardous materials for transport be trained in the proper application of these regulations.

7.1 Classification

Styrene monomer is listed in the Hazardous Materials Table (49 CFR 172-101). Therefore, it is classified as a hazardous material for transportation purposes. The table gives the following designation for styrene monomer:

- **Proper shipping name** – Styrene monomer, stabilized
- **Hazard Class** – 3
- **Identification Number** – UN2055
- **Packing Group** – III
- **Label Required** – Flammable Liquid
- **Appendix A to HMT – RQ is 454 kg, 1000 lbs. The following description is required on the bill of lading for styrene monomer under DOT regulations (49 CFR 172 Subpart C):**
  - **UN 2055, STYRENE MONOMER, STABILIZED, 3, PG III.**
  - **RQ (454 kg, 1000 lbs.)**

7.2 Marking, Labeling and Placarding

Identification numbers are required on each side and each end if the packaging capacity is 1000 gallons or more; on two opposing sides if the packaging capacity is greater than 119 gallons, but less than 1000 gallons. Markings for non-bulk packaging (119 gallons or less) include the proper shipping name, identification number preceded by UN or NA, the technical name, if applicable, and the consignor’s name and address.

Labels are required on non-bulk packages and must be located on the same surface and near the marking.

Placards are required on each side and each end of bulk packaging.

Requirements concerning marking, labeling, placarding and the preparation of shipping papers vary somewhat depending on the transport mode, packaging configuration and quantity of hazardous material being transported.

Marking, labeling and placarding requirements are explained in detail in 49 CFR 172 Subparts D, E and F, respectively. Labels and placards applicable to flammable liquids are required for styrene monomer (see Figures 11.1 and 11.2). Bulk containers should remain placarded when emptied unless the special requirements of Subpart F are met.

7.3 Packaging

Packaging exceptions are permitted. Limited quantity shipments with inner packaging not exceeding 5.0 liters net capacity each, are authorized (49 CFR 173 Subpart D).

Non-bulk packaging is explained in 49 CFR 173 Subpart E, and bulk packaging is described in Subpart F.

In bulk packaging, liquids must be loaded so that the outage is at least 1 percent of the total capacity of a cargo or portable tank, or compartment thereof, or at least 1 percent of the total capacity of the tank and dome for tank car and multi-unit tank car tanks at the reference temperature of 46°C (115°F) for uninsulated tanks and 41°C (105°F) for insulated tanks. Hazardous materials may not be loaded into the dome of a tank car. If the dome of the tank car does not provide sufficient outage, vacant space must be left in the shell to provide the required outage (49 CFR 173 Subpart B). The outage for an IM portable tank may not be less than 2 percent at a temperature of 50°C (122°F).

The maximum volume of styrene monomer in various bulk packaging may be calculated for the referenced temperature using Table 1.2, Styrene Monomer Density as a Function of Temperature.

7.3.1 Tank Cars

In accordance with 49 CFR 173, DOT 111A tank cars are authorized to carry styrene monomer. Lyondell Chemical Company prefers to ship styrene monomer by rail in tank cars meeting DOT Specification 105J300W. Such cars are of mild steel construction and have capacities of 26,000 gallons. These are pressure cars with no bottom outlets. The DOT 105J300W cars are preferred because their probability of consequential product release is lower than the general purpose car.

Styrene monomer should be transported by rail only if it is consigned to a party having a private track (49 CFR 171.8) or to a party using railroad siding facilities that are equipped for piping styrene monomer from the tank car to permanent storage. Tank cars loaded with styrene monomer should be placarded with Flammable placards that display the ID number 2055 according to 49 CFR Subpart F (see Figure 7.1).
Transportation Regulatory Requirements

Figure 7.1

7.3.2 Tank Trucks
Lyondell Chemical Company ships styrene monomer in DOT 407 stainless-steel tank trucks with capacities ranging from 5,500 to 6,600 gallons. They are equipped for unloading from bottom outlet valves. See 49 CFR 173 Subpart F for special requirements concerning the pressure relief system and bottom outlets.

Refer to 49 CFR 180 Subpart E for information on requirements for testing and inspection of cargo tanks, minimum qualification for inspectors and testers, tests and inspection markings and reporting and records-retention requirements. These regulations should be reviewed in detail to establish inspection protocols for tank trucks used in the transport of styrene monomer.

These trucks should be placarded with Flammable placards that display ID 2055 according to 49 CFR 172 Subpart F (see Figure 7.1).

7.3.3 ISO Tanks
ISO tanks are a specific class of intermodal (IM) tanks designed and constructed to permit their use interchangeably in two or more modes of transport. Lyondell Chemical Company ships styrene monomer in ISO tanks constructed of either steel or stainless steel that meets IM-101 (T2 tank container) specifications (1.5 bar minimum test pressure) and Chapter 13 of the International Maritime Dangerous Goods (IMDG) Code. Such tanks must be at least 80 percent full during transport. When ISO tanks are transported by road, they must be on drop-chassis trailers only.

Reciprocal agreements are found in the respective regulations. Retro reflective placards are required in both directions. Intra Canadian shipments are governed by Transport Dangerous Goods regulations exclusively.

7.3.5 Marine Transportation
The transport of styrene monomer on cargo and passenger vessels is permitted for on-deck and under-deck stowage. For cargo vessels, the United States DOT specification and UN Standard packaging is constructed of materials that will not react dangerously with or be decomposed by the styrene monomer (see Section 1.5).

The requirements for shipment of poisonous and flammable liquids such as styrene monomer over water are defined in 49 CFR 176. Lyondell Chemical Company transports styrene monomer in ISO tanks on container ships or barges.

Vessel/barge owners should comply with 46 CFR 153, Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (BCH Code) and Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. These are Coast Guard and IMO regulations governing vessel/barge operation and construction.

The application and maintenance of a nitrogen blanket for styrene monomer in an ISO tank is detailed in 46 CFR 153.500. An independent inspector is employed for quality and quantity measurements to ensure that the styrene monomer is loaded in uncontaminated tanks.

7.3.6 Air Transportation
Styrene monomer may be transported domestically and internationally by air in specific packaging and quantities which comply with ICAO technical instructions. These
Transportation Regulatory Requirements

regulations have been generally incorporated in DOT regulations (49 CFR 175) cited in this section. A package shall not contain more than 220 liters on a cargo-only aircraft. Inner packaging not over 5.0 liters net capacity each, packed in strong outer packaging, are authorized by exception in limited quantities. The entire package cannot exceed 66 pounds gross weight (CFR Part 173, Subpart D). Applicable regulations should be reviewed thoroughly prior to shipping styrene monomer by air.

7.4 Transportation Emergencies

Lyondell Chemical Company markets its products in a manner which takes into consideration the health and safety of customers, transporters and the general public. However, emergencies can occur in spite of best precautions. Lyondell Chemical Company has made provisions to respond to all emergencies.

All LyondellBasell Safety Data Sheets (SDS) include telephone numbers for Chemical Transportation Emergency Center (CHEMTREC). The CHEMTREC numbers are (800) 424-9300, and collect calls are accepted. The number for LyondellBasell Transportation Distribution Incidents (TDI) is 1-800-245-4532. These numbers are staffed 24 hours a day. If the event of a transportation emergency, CHEMTREC should be called first, with a follow-up call to SCDI. SCDI was established to minimize the effects of any out-of-plant incidents by providing an efficient and responsible means of emergency assistance. It covers incidents such as transportation accidents (e.g., collisions, rollovers or derailments), shipping container damage or leaks, difficulties at customer facilities, leaks or spills in distribution terminals or toll processors’ facilities and exposure under all circumstances. When notification of an SCDI emergency is received at Lyondell Chemical Company Channelview, Texas plant, the call is immediately directed to a group of trained coordinators. The coordinator who receives the emergency call will immediately contact the person originally requesting assistance (according to 49 CFR 172 Subpart G) to confirm receipt of the notification, obtain details and agree upon the course of action.

7.4.1 CANUTEC

If an emergency involving a Lyondell Chemical Company product occurs in Canada, you may call Canadian Transport Emergency Centre (CANUTEC) collect at (613) 996-6666. CANUTEC is the national bilingual advisory service provided by Transport Canada to assist emergency response personnel in handling dangerous goods emergencies. CANUTEC should be called first, with a follow-up call to SCDI.

7.4.2 SETIQ

If an emergency accident/incident occurs in Mexico, you may elect to call SETIQ (in the Mexican Republic) at (800) 002-1400; (Calls originating in Mexico City or in the Metropolitan Area) (5) 559-1588; (Calls originating elsewhere) (52-555) 559-1588.

7.4.3 Reporting Requirements

A transportation incident involving styrene monomer may necessitate the notification of federal authorities. Refer to 49 CFR 171 for detailed response and reporting requirements.

7.4.4 Transport of Styrene Monomer Residue

If a discharge of styrene monomer occurs during transport, an official of the federal, state or local government may require its immediate removal to prevent further consequences, according to DOT regulations (49 CFR). The removal may be made without preparing a manifest. The EPA does not require the freight carrier to have an EPA identification number (see EPA regulations, 40 CFR) under such circumstances. If a hazardous waste transporter removes the residue, EPA regulations require that an EPA identification number be used.
APPENDIX 1: REFERENCES

ANSI - American National Standards Institute
1819 L Street, NW
Washington, DC 20036
   ANSI Z358.1; Emergency Eye Wash and Shower Equipment
   ANSI Z88.2; American National Standard for Respiratory Protection
   ANSI Z87.1; Occupational and Educational Personal Eye and Face Protection Devices

API - American Petroleum Institute
1220 L Street, N.W.
Washington, DC 20005
   API RP-520; Recommended Practice for the Design and Installation of Pressure-Relieving System in Refineries Part I – Design
   API RP-520; Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries Part II – Installation
   API 601; Metallic Gaskets for Raised-Face Pipe Flanges and Flanged Connections (Double-Jacketed Corrugated and Spiral-Wound)
   API 620; Recommended Rules for the Design and Construction of Large Welded, Low-Pressure Storage Tanks
   API 650; Welded Steel Tanks for Oil Storage
   API RP-2000; Venting Atmospheric and Low-Pressure Storage Tanks
   API RP-2003; Protection Against Ignition Arising Out of Static, Lightning, and Stray Currents
   API RP-2028; Flame Arresters in Piping System
   API RP-2210; Flame Arresters for Vents of Tanks Storing Petroleum Product
   API RP-2350; Protection for Petroleum Storage Tanks, First Edition

ASME - American Society of Mechanical Engineers, United Engineering Center
45 East 47th Street
New York, New York 10017
   ASME Code, Section VIII, Division 1; Boiler and Pressure Vessel Code
   ASME/ANSI B31; American National Standard Code For Pressure Piping

DOT - Department of Transportation
400 Seventh Street, S.W.
Washington, DC 20590
   49 CFR 171; General Information, Regulations and Definitions
   49 CFR 173; Shippers – General Requirements for Shipments and Packaging
   49 CFR 174; Carriage by Rail
   49 CFR 176; Carriage by Vessel
   49 CFR 178; Shipping Containers Specifications
   49 CFR 179; Specifications for Tank Car
   49 CFR 180; Qualification and Maintenance of Cargo Tanks
Appendix 1: References

**EPA** - United States Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460
  40 CFR 260; *Hazardous Waste Management System: General*
  40 CFR 261; *Identification and Listing of Hazardous Waste*
  40 CFR 262; *Standards Applicable to Generators of Hazardous Waste*
  40 CFR 263; *Standards Applicable to Transporters of Hazardous Waste*
  40 CFR 264; *Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities*
  40 CFR 265; *Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities*
  40 CFR 266; *Standards for the Management of Specific Hazardous Waste and Specific Types of Hazardous Waste Management Facilities*
  40 CFR 267; *Interim Standards for Owners and Operators of New Hazardous Waste Treatment, Storage and Disposal Facilities*
  40 CFR 268; *Land Disposal Restrictions*
  40 CFR 270; *EPA Administered Permit Programs: The Hazardous Waste Permit Program*
  40 CFR 271; *Requirements for Authorization of State Hazardous Waste Programs*
  40 CFR 272; *Approved State Hazardous Waste Management Programs*
  40 CFR 372; *Toxic Chemical Release Reporting: Community Right-to-Know*

**IMO**
International Maritime Organization
Albert Embankment
London, SE, 1 England

**IMDG**
International Maritime Dangerous Goods Codes

**NFPA**
National Fire Protection Association
Batterymarch Park
Quincy, Massachusetts 02269
  NFPA 10; *Portable Fire Extinguishers*
  NFPA 11; *Foam Extinguishing Systems, Low Expansion and Combined Agent*
  NFPA 30; *Flammable and Combustible Liquids Code*
  NFPA 70; *National Electrical Code*
  NFPA 77; *Static Electricity*
  NFPA 704; *Standard System for the Identification of the Fire Hazards of Materials*

**OSHA**
Occupational Safety and Health Administration
United States Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210
  29 CFR 1910.106; *Flammable and Combustible Liquids*
  29 CFR 1910.119; *Process Safety Management of Highly Hazardous Chemicals*
  29 CFR 1910.120; *Hazardous Waste Operations and Emergency Response (HazWOpER)*
  29 CFR 1910.134; *Respiratory Protection*
  29 CFR 1910.146; *Permit-Required Confined Space*
  29 CFR 1910.147; *Sources of Standards*
Appendix 1: References

**OSHA**  
Occupational Safety and Health Administration  
United States Department of Labor  
200 Constitution Avenue, N.W.  
Washington, DC 20210  
29 CFR 1910.151; *Medical Services and First Aid*  
29 CFR 1910.156; *Fire Brigades*  
29 CFR 1910.157; *Portable Fire Extinguishers*  
29 CFR 1910.252; *Welding, Cutting, and Brazing*  
29 CFR 1910.1000; *Air Contaminants*  
29 CFR 1910.1200; *Hazard Communication*

**UL**  
Underwriter’s Laboratories  
333 Pfingston Road  
Northbrook, IL 60062  
UL 525; Flame Arresters for Use on Vents of Storage Tanks for Petroleum Oil and Gasoline

**US COAST GUARD**  
US Coast Guard, Headquarters  
2100 Second Street, S.W.  
Washington, DC 20093-0001  
46 CFR 153; *Ships Carrying Bulk Liquid, Liquefied Gas, or Compressed Gas Hazardous Material*

**UN**  
United Nations  
First Avenue and 42nd Street  
New York, NY 10017  
Recommendations on the Transport of Dangerous Goods

**STYRENE PRODUCERS ASSOCIATION**  
Sector Group of the European Chemical Industry Council (CEFIC)  
Avenue E Van Nieuwenhuyse 4  
B- 1160 Brussels

**CANUTEC**  
Transportation Canada – Dangerous Goods  
330 Sparks Street  
Office 1415  
Place de Ville, Tower C  
Ottawa, Ontario, Canada  
K1A 0N5

**SECRETARIAT OF COMMUNICATIONS AND TRANSPORT**  
Land Transport Directorate  
Hazardous Materials and Wastes Directorate  
Calz. De las Bombas No. 411-9 piso  
Coyoacan 04800, D.F.  
Mexico
APPENDIX 2: VISUAL QUICKTEST

To determine ppm of TBC inhibitor present in Styrene Monomer

Visual Method

Standard Solutions –
1. Prepare a series of solutions containing 5, 10, 15, 20 and 25 ppm (and others as necessary) TBC (4-tertiary-butyl catechol) in uninhibited styrene.
2. Prepare the uninhibited styrene by extracting inhibited styrene with successive portions of 4 percent potassium hydroxide until no pink color is produced in the caustic layer. These standards must be prepared at the time of each analysis.

Procedure:
1. Add 50 mL of the sample and of each standard to respective 125 mL separatory funnels by means of suitable graduates.
2. Add 25 mL of 4 percent potassium hydroxide to each funnel and shake for five minutes.
3. Allow the filtrates to stand for 15 minutes.
4. Compare the pink color of the sample solution with the standards.
5. Report the 4-tert-Butylcatechol content of the sample as the concentration of the standard which matches the sample. If the color of the sample is between two of the standards, report the content of the sample as between the concentration of these standards.

APPENDIX 3: GLOSSARY

ANSI – American National Standards Institute
API – American Petroleum Institute
ASME – American Society of Mechanical Engineers ASTM – American Society for Testing and Materials
ASTM – American Society for Testing and Materials
BOD – biochemical oxygen demand
Bonding – the connection of two or more conductive objects by means of a conductor (most commonly a wire or metal plate)
CANUTEC – Canadian Transport Emergency Centre
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
CFR – Code of Federal Regulations
CHEMTREC – Chemical Transportation Emergency Center
Confined space – any area that has limited access and egress, inadequate natural ventilation, and is not safe for continuous worker occupancy without supplied breathing air.
DOT – Department of Transportation, United States of America
EPA – Environmental Protection Agency, United States of America
Flash point – the minimum temperature at which a liquid gives off vapor in sufficient concentrations to form an ignitable mixture with air near the surface of a liquid
Grounding – the connection of one or more conductive objects to the ground; a specific form of bonding. Grounding is also referred to as earthing.
IM – intermodal
Appendix 4: Glossary

IMDG – International Maritime Dangerous Goods
IMO – International Maritime Organization
ISO – International Standards Organization
NFPA – National Fire Protection Association
Outage – a quantity or bulk of something lost in transportation or storage
ppm – parts per million
UL – Underwriters Laboratory
Ullage – amount by which a container falls short of being full
UN – United Nations
Vapor pressure – the pressure exerted by a volatile liquid while under defined equilibrium conditions. Vapor pressure is usually measured in millimeters of mercury (mm Hg), pounds per square inch, bar or Pascal.

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