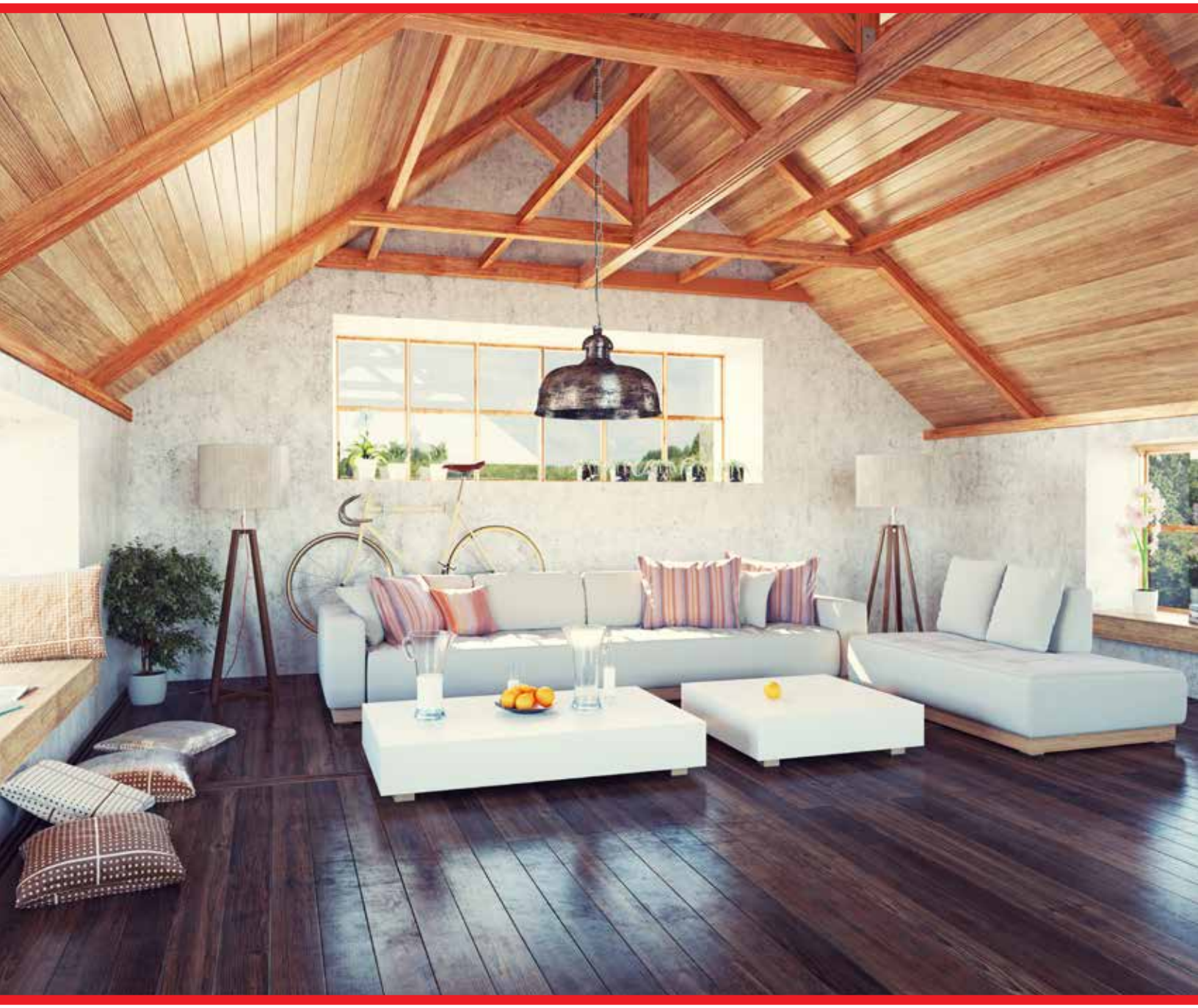
PHENOL

PRODUCT STEWARDSHIP MANUAL



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Introduction

Phenol is a versatile industrial organic chemical. The largest end use of phenol is in phenol-formaldehyde resins used in wood adhesives, as well as molding and laminating resins, paints, varnishes, and enamels.

Phenol, which is also referred to as carbolic acid, phenylic acid, hydroxybenzene and monohydroxybenzene, is used to produce a wide variety of chemical intermediates, including phenolic resins, bisphenol A, caprolactam, alkyl phenols, adipic acid, plasticizers and others.

Phenol is also used as an intermediate in the manufacturing of lubrication oils, herbicides, insecticides, pharmaceuticals and in many other applications.

Product Stewardship

Olin and its employees have a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our Product Stewardship philosophy by which we assess the health and environmental information on our products and take appropriate steps to protect employee and public health and our environment. Our Product Stewardship program rests with each and every individual involved with Olin products, from initial concept and research to the manufacture, sale, distribution, use, and recycling or disposal of each product.

Responsible Care®

Olin has a long-standing policy to ensure that its operations do not have an adverse impact on the community or the environment. To uphold this policy, Olin is committed to the guiding principles of Responsible Care®, a continuing effort by the chemical industry to improve the responsible management of chemicals.

Under Responsible Care®, Olin follows the 10 Guiding Principles and Codes of Management Practices that cover all aspects of research, development, manufacture, distribution, transportation, use, and disposal of products. These principles also extend to prompt reporting, customer counseling, community awareness, support of external research, participation with government and others, and promotion of Responsible Care worldwide.

Olin recognizes that no single entity can protect the quality of all of our air and water. However, by working together on a global basis, the public, industry, and government can make the future brighter and safer.

There are joint European Chemical Industry Council (CEFIC)/the European Association of Chemical Distributors (FECC) Responsible Care guidelines available via CEFIC's web page, www.cefic.org, and on www.responsiblecare.org.

Customer Notice

Olin strongly encourages its customers to review both their manufacturing processes and their applications of Olin products from the standpoint of human health and environmental quality. To help ensure that Olin products are not used in ways for which they are not intended or tested, Olin personnel are prepared to assist customers in dealing with ecological and product safety considerations. Your Olin representative can arrange the proper contacts. Also, Olin product literature, including Safety Data Sheets (SDS), should be consulted prior to use of Olin products. For copies, contact your Olin representative or the Olin location nearest you.

Olin believes the information and suggestions contained in this manual to be accurate and reliable as of publication. However, since any assistance furnished by Olin with reference to the proper use and disposal of its products is provided without charge, and since use conditions and disposal are not within its control, Olin assumes no obligation or liability for such assistance and does not guarantee results from use of such products or other information herein; no warranty, express or implied, is given nor is freedom from any patent owned by Olin or others to be inferred.

Information herein concerning laws and regulations is based on U.S. federal laws and regulations, except when specific reference is made to those of other jurisdictions. Since use conditions and governmental regulations may differ from one location to another and may change with time, it is the customer's responsibility to determine whether Olin's products are appropriate for the customer's use, and to ensure that the customer's workplace and disposal practices are in compliance with laws, regulations, ordinances, and other governmental enactments applicable in the jurisdiction(s) having authority over the customer's operations.

Typical Physical Properties

Phenol is a white, crystalline compound with an easily recognized aromatic odor. Typical physical properties of phenol are shown in Tables 1 and 2 and in the graphs on the following pages.

Phenol is soluble in acetone, alcohol, benzene, carbon tetrachloride, ether and methanol. In n-heptane, 4 grams dissolve in 100 grams at 25°C. See Figure 2, page 3, for solubility in water.

Note: The properties listed here are laboratory results typical of the material, but should not be confused with, or regarded as, specifications. No claim is made as to the suitability of this product for food or drug use.

The information in this bulletin regarding safety considerations, unloading, storage and transfer of phenol is based on extensive experience, and is provided in good faith. However, Olin Corporation makes no warranties and assumes no liability with respect to the completeness or accuracy of such information. Appropriate safe handling use, storage and disposal practices are the responsibility of the customer-user.

Table 1: Typical Physical Properties[1] of Phenol

Item	Value
Formula	C_6H_5OH
Molecular Weight	94.114
Congealing of Freezing Point (°C)	40.91
Boiling Point at 760 mm Hg (°C)	181.84
Specific Gravity Solid at 25/4°C Liquid at 41/4°C Liquid at 60/4°C	 1.132 1.0576 1.0413
Critical Point Critical Temperature (°C) Critical Pressure (Atmospheres)	 419 60.5
Specific Heat (cal/g/°C or Btu/lb/°F) Solid at 4.0°C Solid at 22.7°C Liquid at 70 – 74°C	 0.296 0.338 0.531
Viscosity (centistokes) at 60°C at 80°C at 100°C	 2.47 1.56 1.09
Heat of Fusion (cal/g) (Btu/lb)	 29.22 52.6
Heat of Vaporization at b.p. (cal/g)	116.6
Heat of Vaporization at b.p. (Btu/lb)	210.0
Heat of Combustion (cal/g) (Btu/lb)	 -7754 -13957
Flash Point (T.C.C.) (C.O.C.)	 79°C 185°F
Specific Gravity at 25/25°C 1% aqueous solution 3% aqueous solution 5% aqueous solution	 1.0009 1.0025 1.0044

[1]Typical properties; not to be construed as specifications/limits.

Figure 1: Congealing Points of Phenol-Water Mixture

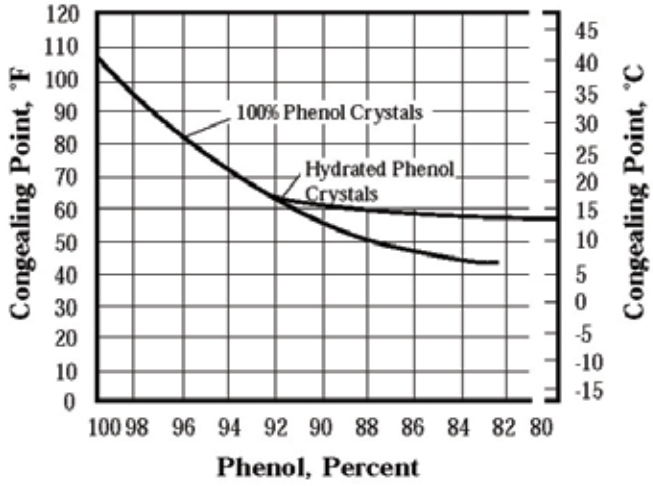


Figure 2: Phase Diagram for the Phenol-Water System

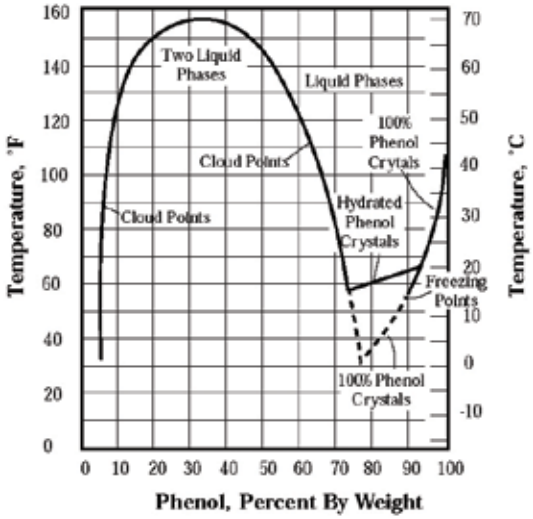
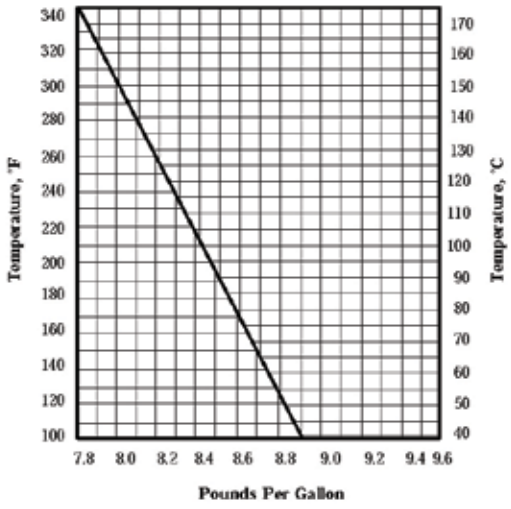


Figure 3: Weight Per Gallon of Phenol at Various Temperatures



Typical Physical Properties

Figure 4: Specific Gravity of Phenol Solutions at 20˚C And 25˚C

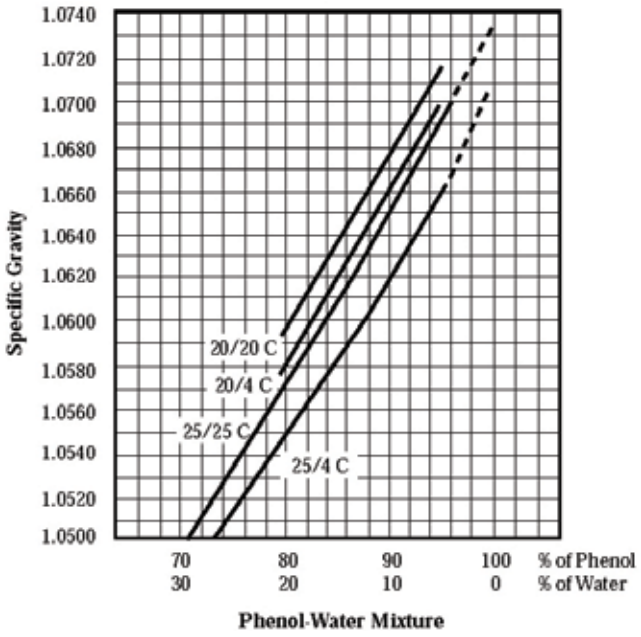


Table 2: Physical Properties that Vary with Temperature

Temp ˚C	Vapor Pressure mm Hg[1]	Liquid Density g/ml	Liquid Density lb/gal	Viscosity Centisokes	Latent Heat of Vapor Btu/lb[2]	Temp ˚F
41	1.3	1.0576	8.826		250.5	106
50	2.5	1.0499	8.762	–	248.8	122
60	4.7	1.0413	8.690	2.520	245.7	140
70	8.7	1.0327	8.618	–	243.2	158
80	15.2	1.0241	8.546	1.597	240.4	176
90	25.6	1.0154	8.474	–	237.7	194
100	41.1	1.0068	8.402	1.084	235.0	212
110	64.2	0.9982	8.330	–	232.3	230
120	97.3	0.9894	8.257	0.851	229.3	248
130	143.6	–	–	–	226.4	266
140	206.6	–	–	–	223.4	284
150	298.7	–	–	–	220.3	302
181.75	760.0	–	–	–	205.7	359.2

[1]Biddiscombe and Mar tin, Trans. Faraday Soc. 54 1316 (1958)
[2] Calculated from data in Andon et. al., J. Chem. Soc. (London) 1960, 5246

Figure 5: Refractive Index of Phenol Solutions at 25˚C

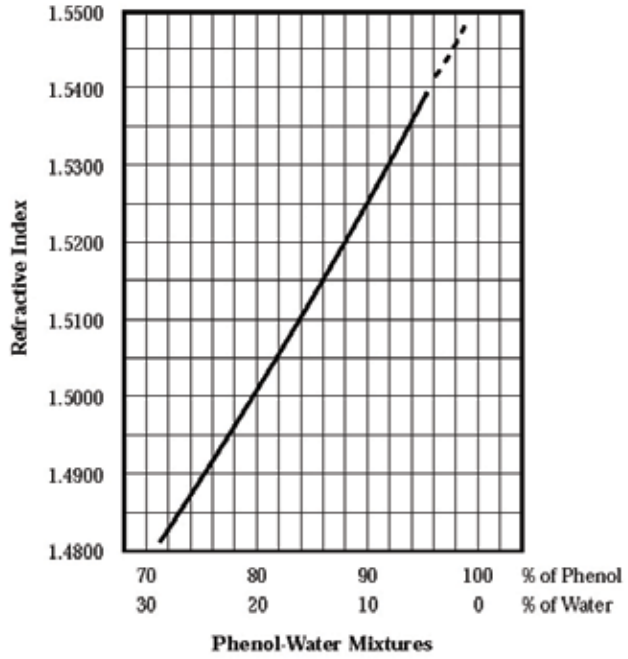
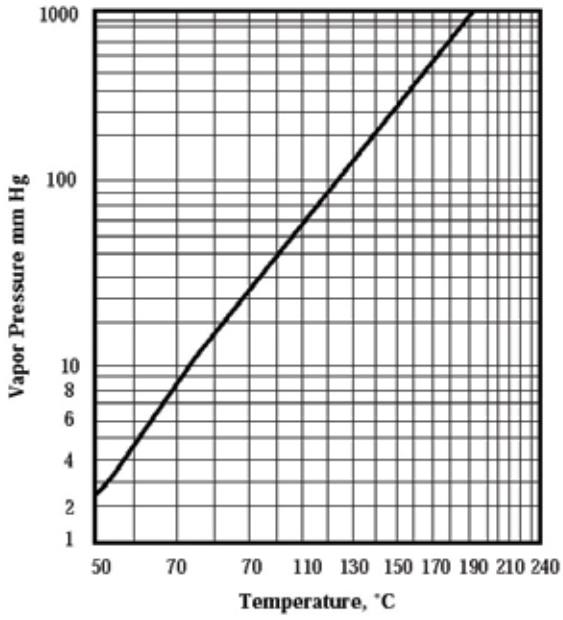


Figure 6: Vapor Pressure of Phenol at Elevated Temperatures



Applications[1]

Descriptions of Phenol Applications

Phenol-Formaldehyde Resins

The reaction product of phenol and formaldehyde has been in widespread use since the expiration of the basic patents in 1926. Phenolic resins, because of their tough, durable, wear-resistant nature and dielectric properties, are used as molding powders, laminates, adhesives and coating resins.

Molding Resins

Phenolic molding resins are normally produced as powders, which are molded into a number of products such as telephone housings and electrical outlets or plugs. Other substances such as lubricants, fillers, catalysts and dyes are incorporated into the molding resin. Fillers such as wood flour are used to extend and to impart special properties to the molding powder, while the lubricants – usually waxes or soaps – facilitate the removal of the molding piece.

Applications[1]

Laminates

These are produced by saturating or impregnating base materials with a solution of a phenol resin and, by the application of heat and pressure, curing the resin and bonding the base material. The most commonly used materials for the base are paper, cloth, wood and glass fibers. These laminates are normally characterized by the pressure at which they are molded.

High pressure lamination is generally used for structural parts such as rods, sheets, tubes, angles and channels, which are further fabricated into final form. These laminates find extensive use in the electrical industry and in such materials as panel boards, table and counter tops, wall panels and chemically resistant containers.

Low pressure lamination requires less complex equipment. A wide variety of products, including many large shapes, are produced by this method. These include boat hulls, airplane parts, luggage, building materials, and brake linings.

Adhesives

Wherever a strong, durable and water-resistant bond is required, phenolic adhesives can be used. By far the greatest use of these adhesives is in the manufacture of marine or exterior grades of plywood. In addition, phenol-formaldehyde adhesives are being used in increasing amounts by manufacturers of abrasive wheels and belts, insulation, brake linings and shoes, and gaskets. These resins have setting temperatures from room temperature to above 100°C.

Protective Coatings

The resistance provided by phenolic resins makes them useful in many coating applications, including varnish, enamel and lacquer formulations. Baked phenolic coatings are used for tank linings and similar applications because of their excellent resistance to heat and to most chemicals. The reaction of certain modified phenols with formaldehyde produces resins which form fast-drying, tough and chemical-resistant coatings. The use of dispersed but completely polymerized phenolic resins results in excellent primers for use on steel and aluminum.

Petroleum Industry

Phenol and phenol derivatives are used in both the refining and compounding of petroleum products. Phenol, alone or mixed with other solvents, is used in counter-current extraction to remove undesirable constituents from lube oil stocks.

Phenol is also a primary raw material for the production of many stabilizers or antioxidants for motor oils. These materials are thought to direct the oxidation to minimize sludge and to inhibit corrosion. The exact chemical composition of lube oil additives differs, but in general the additives are highly alkylated phenol sulfides.

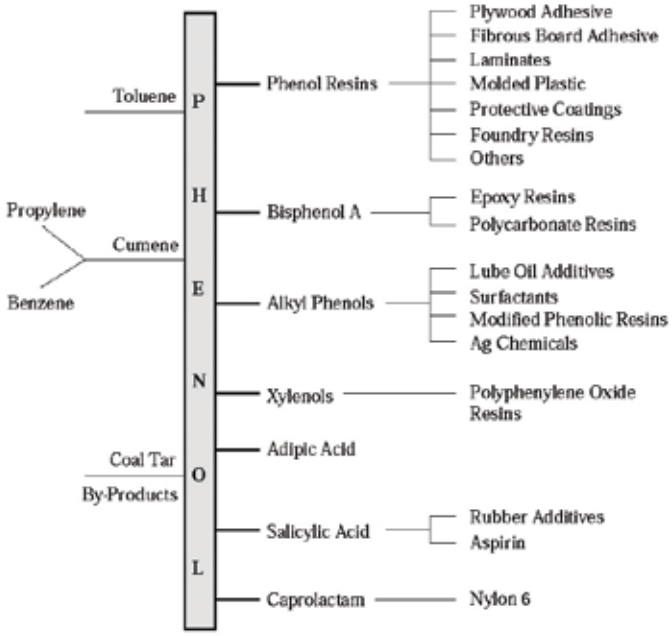
In the manufacture of toluene from petroleum fractions, a complex mixture of chemicals is produced which cannot be separated by normal distillation. With the addition of phenol to the reaction products, the higher fractions can be distilled and the toluene separated from the phenol.

Other Applications

Phenol is the starting material for the production of salicylic acid, a compound useful as a rubber vulcanization inhibitor and as an intermediate in the production of medicinal compounds, flavorings, and cosmetics. The alkylation of phenol yields substituted phenols, which are employed in the production of modified phenolic resins, surfactants, weed killers and fungicides. Chlorinated phenols find application as fungicides and germicides, and as intermediates for dyes, plasticizers, agricultural chemicals and veterinary medicines.

[1]Refer to the Phenol Safety Data Sheet for possible restrictions in certain jurisdictions.

Figure 7: Phenol Flow Chart



Health Hazards

Olin Corporation publishes and regularly updates a Safety Data Sheet (SDS) for phenol. The SDS is designed to help customers and others who handle phenol to meet both their own safe handling and disposal needs and those regulations and requirements promulgated by various governmental agencies, including the U.S. Occupational Safety and Health Administration (OSHA). Olin publishes a specific SDS in the local language for each jurisdiction where the product is sold.

A current copy of the SDS should be obtained and carefully read before Olin Phenol is handled, used, stored, shipped, or disposed of. The SDS should also be consulted for information and instruction on containing and cleaning up spills and leaks, personal protective equipment and clothing, and administering first aid. For current copies of your local SDSs, contact your Olin representative.

Potential Health Effects

Odor Threshold and Warning Properties

Phenol has a characteristic, sweet, tarry odor that can be detected in air at 0.04 ppm (0.012 mg/L); however most people detect phenol only at higher levels. Thus odor is not a reliable indicator of potential overexposure. Marked nose and eye irritation occur at higher exposure levels.

Acute Toxicity

In the context of the “dose-time relationship,” “acute” toxicity is the ability of a substance to cause harmful effects after only a single exposure – usually to a relatively high level or concentration of the substance in question.

Health Hazards

Contact Effects

All contact with phenol should be avoided. Phenol is rapidly absorbed by all routes of exposure (inhalation, dermal, and oral), thus all routes are potentially dangerous. Phenol is classified as corrosive. The following effects of phenol on the skin and eyes should be carefully noted by all individuals working with this material.

Skin Contact

All skin contact with phenol should be avoided. Short single exposure may cause skin burns. Phenol is absorbed rapidly through the skin in amounts which could cause death. The dermal LD50[1] value for phenol in animal models falls between 660-850 mg/kg bw. Human fatalities have occurred as early as 10 minutes following accidental skin contact. Signs and symptoms of excessive exposure may appear as effects to the central nervous system. Muscle weakness, convulsions, and coma are the predominant symptoms associated with lethal exposure to phenol.

Phenol did not cause dermal sensitization or allergic reaction when tested in mice.

Warning: Because phenol acts as a local anesthetic agent, reduction or disappearance of pain from skin contact does not indicate that the phenol is no longer present.

[1]LC50/LD50: estimated Lethal Concentration/Dose for fifty percent of animals exposed for specific time frame, or at a specific dose, typically during a two-week post-exposure observation time.

Eye Contact

All eye contact with phenol should be avoided. Short, single eye exposure to phenol may cause severe irritation with corneal injury, which may result in permanent impairment of vision, even blindness. Fumes are irritating to the eyes, nose, and skin.

Ingestion

Toxic if swallowed. Although single dose oral toxicity is considered to be moderate based on a rat oral LD50 value of 340 mg/kg bw, a human lethal dose has been estimated to be 140-290 mg/kg bw. Thus small amounts swallowed incidental to normal handling operations may cause serious injury; swallowing amounts larger than that may cause death. Oral exposure to phenol may cause severe burns of the mouth and throat.

Inhalation

Toxic if inhaled. A single prolonged (hours) excessive inhalation exposure may cause adverse effects. The calculated 4-hr inhalation LC50 value for phenol (mist) in rats is >1.13 mg/L, as no deaths occurred following an 8-hr exposure to 0.9 mg/L. Vapors or mists may cause irritation of the upper respiratory tract (nose and throat) and lungs. Signs and symptoms of excessive exposure may be central nervous system effects.

Chronic Toxicity – Systemic Effects (Other Target Organs)

"Chronic" toxicity describes the ability of a substance to cause harmful effects only after many repeated exposures over an extended period of time – usually to a lower level or concentration of the substance in question.

Repeated excessive exposure may cause central nervous system effects (including respiratory, motor difficulties and paralysis) digestive disturbances, liver and kidney effects. Symptoms can include headache, vertigo, and muscle pain; and vomiting and diarrhea. Muscle weakness, convulsions, and coma are the predominant symptoms associated with lethal exposure to phenol.

Mutagenicity and Cancer Information

Phenol did not cause gene mutations in bacteria but was weakly mutagenic/clastogenic when tested *in vitro*, inducing micronucleus formation in mammalian cells at cytotoxic doses. Phenol induces this same effect in mice *in vivo*, when dosed at very high levels; it is likely a threshold phenomenon given the effect of hypothermia these high doses cause, as hypothermia alone can result in this effect. Thus phenol is classified as mutagenic but it appears to be a high-dose phenomenon.

Phenol did not cause cancer in laboratory animals when tested in chronic lifetime studies, although tumor promoter effects were noted. Available epidemiology studies do not demonstrate an association between phenol exposure and increased cancer risk. IARC reviewed phenol data and determined there were inadequate data for classification for animals or humans, and that phenol was a Group 3 chemical *(not classifiable as to its carcinogenicity to humans)*.

Table 3: Key Regional/Country Occupational Exposure Level (OEL) Values for Phenol

Country/Region	OEL	Units	Comments
US: OSHA PEL	5	ppm	19 mg/m^3 TWA (8-hr work day; 40-hrs/week)
ACGIH	5 (19)	ppm (mg/m^3)	TLV-TWA (8 hr); A4 (Not classifiable as a human carcinogen) ACGIH, 2001
EU SCOEL	2 (8)	ppm (mg/m^3)	8-hr TWA; 'skin' notation due to potential for dermal toxicity; SCOEL, 2003
*DNEL	8	mg/m^3	Protective for systemic long term & local effects

*DNEL: Derived-No-Effect-Level: level of exposure to the substance above which humans should not be exposed; risk to humans is considered to be adequately controlled if the exposure levels do not exceed the appropriate DNEL.

Health Hazards

Teratology (Birth Defects) and Reproductive Effects Information

Phenol has been toxic to the fetus in laboratory animals but only at doses that were toxic to the mother. Birth defects (cleft palate) were seen in mice at maternally lethal doses. This is a common developmental abnormality in mice and is associated with stress to the maternal animals. Thus there is no indication that phenol targets the developing fetus.

In animal studies, phenol did not interfere with reproduction. Although systemic toxicity was identified at 1,000 mg/m^3, no impairment of reproductive capability or fertility was found at 5,000 mg/m^3 in a standard 2-generation test in rats. Toxicity to the newborn animals was observed only at doses that were toxic to the maternal animals.

Exposure

Occupational Exposure Levels (OELs) have been determined for phenol by various authorities and regions (see Table 3). The Occupational Safety and Health Administration (OSHA) has established its permissible exposure limit (PEL) of 5 ppm (19 mg/m^3). The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended a threshold limit valve (TLV) of 5 ppm phenol in air based on a time-weighted average (TWA) of an eight-hour workday. The European Union (EU) Scientific Committee on OELs (SCOEL) has recommended an 8-hr TWA of 2 ppm (8 mg/m^3), with a 'skin' notation and 4 ppm (16 mg/m^3) for a 15-minute short term exposure limit (STEL). The Derived-No-Effect-Level (DNEL) for phenol, described in the European Chemicals Agency (ECHA) IUCLID, developed under the EU Registration, Evaluation, and Authorization of Chemicals (REACH) regulation, is 8 mg/m^3 for long-term systemic effects, based on a 90-d study. Also, while phenol has a sweet, tarry odor, the odor threshold is not clearly defined; thus, olfactory detection of the presence of phenol is not adequate to protect against overexposure.

Environmental Information

Phenol is readily biodegradable. It has a low bioconcentration potential, meaning phenol does not accumulate in tissues of living organisms. Phenol is toxic to aquatic organisms on an acute basis. Care should be taken to prevent spills from entering waterways.

Precautions for Safe Handling and Use

Since the individual circumstances under which phenol may be used are beyond the control of Olin Corporation, the following recommendations for safe handling and use of this material are necessarily general in nature. Inquiries about specific operations and uses may be addressed to Olin Corporation. Also, assistance in evaluating particular plant conditions may be obtained from consulting laboratories and from state departments of health or labor, many of which offer industrial hygiene services. Ultimately, it is the responsibility of the owner and/or operator of each facility to ensure proper, safe handling of the material.

Safety Considerations

Users Should:

1. Periodically obtain a current Safety Data Sheet (SDS) on phenol from your Olin representative, and consult it for additional up-to-date information on physical properties, toxicity and handling recommendations.
2. Read and follow all current label directions and precautions.
3. Always wear chemical goggles, chemical resistant gloves and protective clothing as protection against accidental contact. Examples of gloves resistant to this material include neoprene, butyl rubber, and polyvinyl chloride. Wear a face shield which allows use of chemical goggles, or wear a full-face respirator, to protect face and eyes when there is any likelihood of splashes. In some situations, an acid hood may be a better option. Selection of specific personal protection items such as neoprene rubber boots, neoprene rubber aprons, full slicker suits and NIOSH-approved respiratory protection will depend upon the task. Use chemical protective clothing resistant to this material when there is any possibility of skin contact.
4. Install and maintain safety showers and eye wash fountains near all locations where phenol is handled. Workers must have immediate access to this equipment.
5. Provide sufficient ventilation to maintain employee exposures to phenol vapors below occupational exposure level (OEL) values on an eight-hour, time-weighted-average (TWA) basis for phenol as shown in Table 3.
6. Respiratory protection should be worn when there is a potential to exceed the exposure limit requirements or guidelines. In the absence of adequate environmental control, use approved respiratory protection. For emergencies, use a self-contained positive-pressure breathing apparatus approved by National Institute for Occupational Safety and Health (NIOSH) or in compliance with the European Standard EN 137:2006.
7. Use caution when handling phenol at elevated temperatures. Phenol presents no unusual fire hazard when handled at ambient temperature, but will burn if ignited or involved in a fire. The lower explosion limit for the vapor is 1.4% in air. Phenol will give off flammable toxic vapors at elevated temperatures.

Emergency Treatment/First Aid

Emergency Treatment/First Aid

Skin Contact

In case of accidental contact with phenol, it is essential that all phenol be thoroughly removed from the skin in the shortest time possible. **Remember, phenol is a local anesthetic. Loss of pain does not indicate phenol has been removed from the skin.**

- Initial decontamination of any exposure to phenol should immediately be flushed with copious amounts of water.
- All potentially contaminated clothing and shoes should be removed while the exposed individual is in the safety shower.
- A thorough washing using water and a non-abrasive soap should be done for a minimum of 30 minutes.
- Destroy contaminated leather items such as shoes, belts, and watchbands.
- At facilities with availability of a decontamination solution and delivery equipment, such systems can be used to supplement the initial soap and water decontamination.
- Exposed areas should be immediately washed with copious amounts of water and non-abrasive soap for 1-2 minutes prior to the use of Phenol Decontamination Equipment.
  - Spray mixture on affected body parts, from top to bottom (injured person's eyes should be closed). Immediately resume shower, wash off treatment mixture for 1-2 minutes.
  - Step out of shower stream or stop shower, and re-spray affected areas with treatment mixture.

Emergency Treatment/First Aid

  - Resume shower, wash off treatment mixture for 1-2 minutes; continue this cycle of spray and rinse until rescue services arrive.
  - Example decontamination mixtures include PEG 300/ethanol (or industrial methylated spirits) 2:1, or available polypropylene/ rapeseed oil proprietary mixtures, or polyvinylpyrrolidone/ detergent mixtures, or D-TAM™ Skin Cleanser.
  - Alternatively this material may be removed from the skin by repeatedly spraying/swabbing the skin with polyethylene glycol or polypropylene glycol mixture, alternating with rinsing with large quantities of water for 1-2 minutes.

NOTE: Protective gloves should be used when treating exposed areas. Do not rub the affected area as this can result in skin damage.

- This cycle of spraying/swabbing the skin and rinsing should continue for 30 minutes.
- **Phenol destroys the nerve endings in the skin; the absence of pain does not necessarily mean the skin has been properly decontaminated.**
- Suitable emergency safety shower facility should be immediately available.

Eye Contact

- Flush eyes immediately and continuously with plenty of flowing water for at least 30 minutes.
- Remove contact lenses after the first 5 minutes and continue flushing.
- Call a medical consultant, preferably an ophthalmologist, immediately.

Inhalation

- Remove the affected person immediately from the contaminated area to fresh air.
- Call a physician at once or transport to a medical facility.
- If breathing stops, give artificial respiration. If breathing is difficult, oxygen should be administered by qualified personnel.

Ingestion

- Phenol is toxic by ingestion. If swallowed, do not induce vomiting. Give the affected person large amounts of milk or water if available.
- Call a physician immediately.
- Never give anything by mouth to an unconscious person. Contact medical personnel.

A physician should always be called **immediately** to care for any person who has been in contact with phenol. Victims must rest immediately after receiving emergency care. Rest after exposure to phenol is important and should be enforced whether burns are present or not.

Physician Notes

Maintain adequate ventilation and oxygenation of the patient.

May cause asthma-like (reactive airways) symptoms. Bronchodilators, expectorants, antitussives and corticosteroids may be of help. Respiratory symptoms, including pulmonary edema, may be delayed.

Persons receiving significant exposure should be observed 24-48 hours for signs of respiratory distress.

Chemical eye burns may require extended irrigation. Obtain prompt consultation, preferably from an ophthalmologist.

If burn is present, treat as any thermal burn, after decontamination.

Due to irritant properties, swallowing may result in burns/ulceration of mouth, stomach and lower gastrointestinal tract with subsequent stricture. Aspiration of vomitus may cause lung injury. Suggest endotracheal/ esophageal control if lavage is done.

The determination of urinary phenols may be useful in determining the extent of exposure. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

Environmental Considerations

Spills

Make sure to use appropriate safety equipment and clothing (see "Precautions for Safe Handling and Use," page 8). Contain and isolate the spill. Thoroughly ventilate area. Allow small spills to solidify, then scoop into steel containers. Dike larger spills and recover into steel containers. Dispose of steel containers in compliance with local, state and federal requirements under the Resource Conservation and Recovery Act, or other regional legislation.

Flush the spill area with large quantities of water until all visible traces and odors have disappeared. Recover the water and dispose of properly.

Disposal Of Liquid Wastes

It is often necessary to install a waste disposal system when using phenol, because of the toxicity and taste of extremely low concentrations of phenol in water. Concentrations of phenols, as low as 10 ppm, are toxic to fish and aquatic life and even lower concentrations cause taste in water supplies. Chlorination of the phenol in water supplies greatly magnifies the taste problems.

A number of different methods of destroying or concentrating phenolic wastes have been developed. Olin can provide technical information on solving disposal problems.

Note: In disposal of any wastes, be certain all applicable federal, state and local regulations are satisfied.

Shipping Information

Phenol synthetic is a white crystalline compound at room temperature which exhibits properties as listed in Table 1, page 3. Phenol synthetic is loaded and shipped at elevated temperatures as a liquid.

Class 6.1, Packing group II, UN 2312 Phenol molten, uses as intermediate.

The tank cars and tank trucks used to ship phenol synthetic are insulated and equipped with steam coils. For sales specifications, contact the Olin Customer Information Group at 1-844-238-3445, or visit our website at www.olinepoxy.com.

Packages are required to bear the proper hazard warnings on the label and to comply with all local and regional transportation regulations. Bulk containers must be properly placarded and marked, and conform with all local and regional transportation regulations. Shipping papers must carry required information on classification, placarding, exemptions, etc.

Table 4: Phenol

Type Container	Net Weight (approx lbs)
Rail 23,000 Gallon Carbon Steel Tank Car (Lined, Coiled, and Insulated)	186,000
Truck 5,000 Gallon Stainless Steel Tank Truck	42,000

Unloading Shipping Containers

Tank Cars

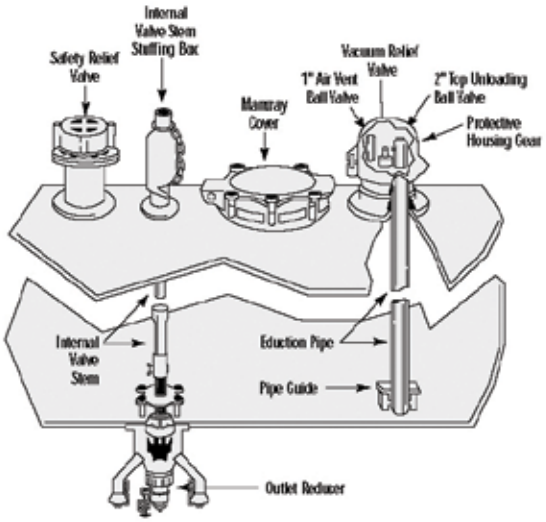
The phenolic-lined steel tank cars in which Olin ships phenol synthetic are insulated and equipped with external steam coils for melting the solid phenol. The tank car dome contains a two-inch top unloading valve, a one-inch air vent valve, a vacuum relief valve, a safety valve assembly and a valve operator and extension rod which operates an internal bottom valve attached to a bottom outlet reducer. Figure 8 shows a typical tank car top loading and unloading arrangement.

Tank cars put into service after 1999 do not have bottom valves or internal valves. These tank cars can only be unloaded through the two–inch top unloading valve.

Preparations for Unloading

The car should be accurately spotted on a level track, so that no tension is placed on the unloading line. The brakes should be set and the wheels blocked. Metal caution signs with dimensions of at least 12 x 15 inches bearing the legend "STOP. TANK CAR CONNECTED" should be placed in front of and behind the car, with one preferably positioned near the entering switch. The word "STOP" should be in letters at least 4 inches high and the other words in letters at least 2 inches high. If the car is to remain connected during the night in an unlighted area, a blue light should be placed by the sign.

The letters should be white on a blue background. Signs should not be removed until the car has been unloaded and all the pipelines disconnected.



Derailers should be placed at the open end of the unloading switch unless the car is protected by a locked switch or gate.

Precautions

Workers emptying tank cars should wear chemical workers' safety goggles, face shield, hard hats, neoprene rubber boots, neoprene rubber gloves and neoprene rubber suits. (Rubber suit should be worn outside boots.) A good seal between sleeves and gloves should be maintained.

Unloading Shipping Containers

NIOSH-approved respiratory protection should be worn when exposure to excessive vapor concentrations is possible.

A safety shower and eye bath that is protected against freezing should be installed at the unloading station and kept operational at all times during unloading. In case of accidental contact with phenol, immediately wash the affected areas thoroughly with large quantities of water while simultaneously removing clothing. (See pages 8 and 9 for more information on "Precautions For Safe Handling and Use" and "Emergency Treatment.")

Rubber protective equipment which has come in contact with phenol should be cleaned immediately or discarded.

The tank car and transfer pump should be on a concrete pad which can be washed with water in case of a spill. Follow local regulations regarding disposal of wash water contaminated with phenol. (See "Disposal of Liquid Wastes" on page 12.)

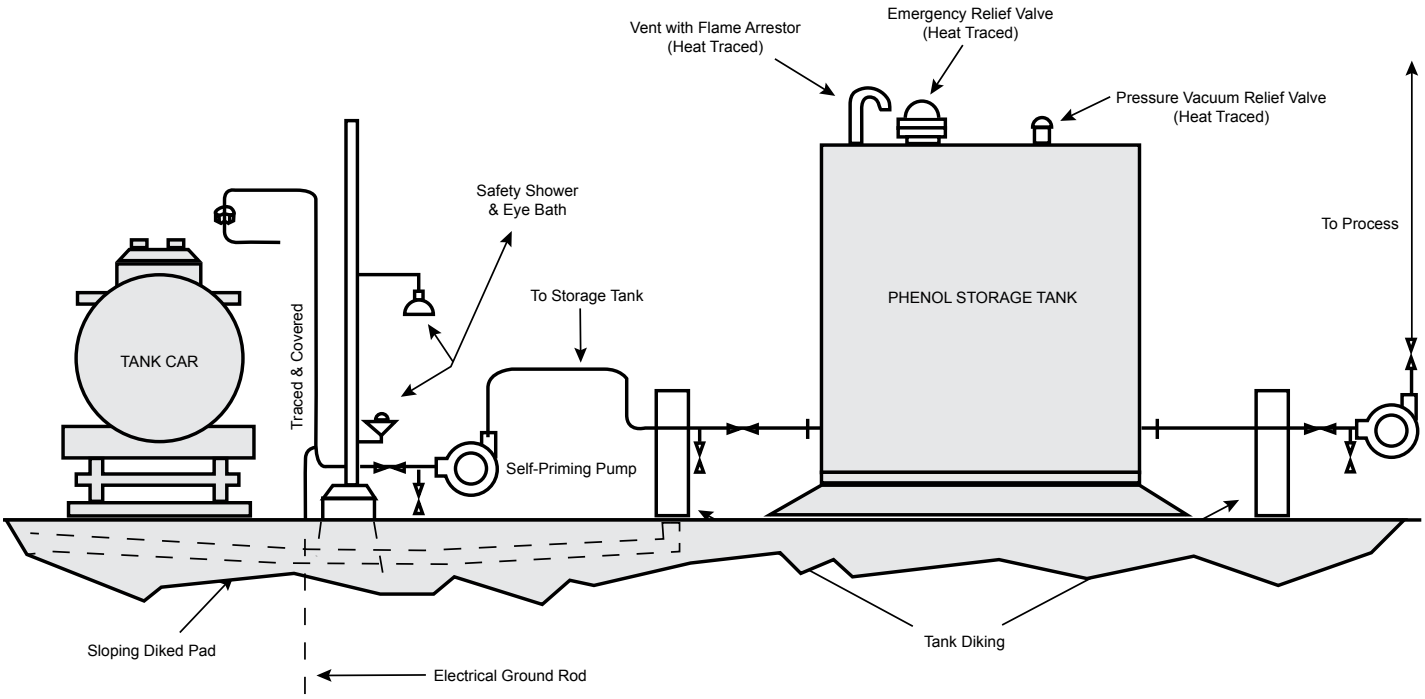
The tank car and unloading line should be electrically grounded.

No attempt should be made to connect or disconnect a tank car, open or close any attachments, or discharge the contents except in daylight or when adequate lighting is provided. Partially unloaded tank cars should not be moved unless it is absolutely necessary. If moving becomes necessary, all car openings should be closed tightly and all lines disconnected and drained.

Sampling

Face shields, neoprene rubber gloves and the other protective clothing required for unloading should be worn when sampling. Samples should be taken with a bottle held in a stainless steel or other suitable metal sheath and suspended by a stainless steel chain (in preference to wire). An ordinary three-gallon pail is useful to receive the dripping sampling bottle, metal cage and chain as they are withdrawn from the tank car of molten phenol. If temperature readings are desired, use an enclosed scale thermometer. Hot phenol soon removes the ink or paint from an ordinary scale thermometer, making it extremely difficult to read.

Figure 9: Typical Tank Car Unloading Installation



Note: All lines require heat tracing and insulation. Tank requires heat tracing. External electric heat pads are recommended. Heat tracing required on all relief devices and vents. Option: Nitrogen padding for color sensitive operations.

Unloading Shipping Containers

Unloading

Figure 9 shows a typical phenol tank car unloading installation. Unloading through the top of the car, preferably by pumping, is recommended.

Top Unloading by Pumping

This is considered the safest method of unloading phenol tank cars. The steps below should be followed carefully in sequence.

1. Make sure the storage tank is well vented and capable of holding the contents of the car. (See "Storage Tanks" on page 19.)
2. After the car has been placed on the unloading dock, remove the housing covering the one-inch air vent and the two-inch top loading valve.
3. Vent the car, carefully opening the one-inch air vent valve. If there is any reason to believe that the car is not thoroughly vented, venting may be accomplished by carefully loosening the manway cover bolts one turn at a time until the cover is loose. If no pressure is found, open the manway cover.
4. Connect low pressure steam (25 – 35 psig (1,724 – 2,413 mbar) is recommended) to the car heating coils. Steam flow should be started slowly to permit the coils to warm. Do not connect the outlet of the steam coil to a condensate return line or to a steam trap because over-heating may damage the car lining. Throttle the steam flow to the coils by means of a valve on the inlet to the coils until only a wisp of steam appears at the condensate outlet.
5. The contents of the car are ready for unloading when the phenol at the top of the car is at approximately 52ºC (125ºF). Continued heating after the phenol is liquefied will waste steam and may damage the special lining on the inside of the car. Also, color problems will occur from overheating. No steam should be applied during the unloading process, because the lining of the car can be damaged as the liquid level falls below the heating coils.
6. Remove the plug from the two-inch top unloading valve and run a light wooden or metal rod through the entire length of the education pipe to ensure that no unmelted phenol or foreign matter is obstructing the pipe.
7. Connect the unloading line to the two-inch top unloading valve. The manway cover may be left open for inspection during the unloading operation. Air or nitrogen must be allowed to replace the phenol as it is pumped from the car.
8. If leaks occur, unloading should be stopped.
9. After all has been pumped from the car, disconnect the unloading line. Close all dome openings. **Thoroughly wash off any phenol.** Blow out the steam coils with air to prevent any residual condensate from freezing and bursting the coils. Do not replace the steam inlet and outlet caps.
10. Tank cars should be closed and made ready in accordance with D.O.T. regulations prior to releasing.
11. Do not reverse placards.

CAUTION: Where leaking valves or fittings are to be tightened, it is desirable to externally presteam the repair area to melt any residual frozen phenol. Do not tighten under pressure.

Top Unloading by Nitrogen Pressure

This unloading procedure can be used safely, but there are hazards present which do not exist in "Top Unloading By Pumping." If this method is used, the steps below should be followed carefully and in sequence.

1. Make sure the storage tank is well vented and capable of holding the contents of the car. (See "Storage Tanks" on page 19.)
2. After the car has been placed on the unloading dock, remove the housing covering the one-inch vent and the two-inch top unloading valve.
3. Vent the car by carefully opening the one-inch air vent valve. If there is any reason to believe that the car is not thoroughly vented, venting may be accomplished by carefully loosening the manway cover bolts one turn at a time until cover is loose. If no pressure is found, open manway cover.
4. Connect low pressure steam (25 – 35 psig (1,724 – 2,413 mbar) is recommended) to the car heating coils. Steam flow should be started slowly to permit the coils to warm. Do not connect the outlet of the steam coil to a condensate return line or to a steam trap because overheating may damage the car lining. Throttle the steam flow to the coils by means of a valve on the inlet to the coils until only a wisp of steam appears at the condensate outlet.
5. Contents of the car are ready for unloading when the phenol at the top of the car is at approximately 52ºC (125ºF). Continued heating after the phenol is liquefied will waste steam and may damage the special lining on the inside of the car. Overheating will also discolor the phenol. No steam should be applied during the unloading process, because the lining of the car can be damaged as the liquid level falls below the heating coils.
6. Remove the plug from the two-inch top unloading valve and run a light wooden or metal rod through the entire length of the education pipe to insure that no unmelted phenol or foreign matter is obstructing the pipe.
7. Secure the manway cover.
8. Connect the unloading line to the two-inch top unloading valve.
9. Attach the nitrogen supply line to the one-inch nitrogen vent valve. This line should be equipped with a vent valve, a safety relief valve set at no more than 30 psig (2,069 mbar), a pressure gauge, a pressure-reducing valve set at no more than 28 psig (1,931 mbar), and a nitrogen shutoff valve.
10. Open the one-inch vent and slowly pressure the car. When the pressure on the car reaches 15 psig (1,034 mbar) open the two-inch top loading valve. Check the new connections, swing joints, and valves for leaks. If a leak occurs, depressure the system completely before attempting any repairs. When the car is empty, shut off the nitrogen supply and depressure the car. The car should be emptied to within 200 pounds of its tare weight.
11. Disconnect the piping. Close all dome openings. Thoroughly wash off any spilled phenol. Do not replace the steam inlet and outlet caps.
12. Tank cars should be closed and made ready in accordance with D.O.T. regulations prior to releasing.
13. Do not reverse placards

CAUTION: Where leaking valves or fittings are to be tightened, it is desirable to externally presteam the repair area to melt any residual frozen phenol.

Unloading Shipping Containers

Top Unloading by Both Pumping and Nitrogen Pressure

This method can be used where the customer does not have a self-priming pump capable of picking up prime from the tank car.

1. Make sure the storage tank is well vented and capable of holding the contents of the car. (See “Storage Tanks” on page 19.)
2. After the car has been placed on the unloading dock, remove the housing covering the one-inch vent and the two-inch top unloading valve.
3. Vent the car by carefully opening the one-inch air vent valve. If there is any reason to believe that the car is not thoroughly vented, venting may be accomplished by carefully loosening the manway cover bolts one turn at a time until cover is loose. If no pressure is found, open manway cover.
4. Connect low pressure steam (25 - 35 psig (1,724 – 2,413 mbar) is recommended) to the car heating coils. Steam flow should be started slowly to permit the coils to warm. Do not connect the outlet of the steam coil to a condensate return line or to a steam trap because overheating may damage the car lining. Throttle the steam flow to the coils by means of a valve on the inlet to the coils until only a wisp of steam appears at the condensate outlet.
5. Contents of the car are ready for unloading when the phenol at the top of the car is at approximately 52ºC (125ºF). Continued heating after the phenol is liquefied will waste steam and may damage the special lining on the inside of the car. Overheating will also discolor the phenol. No steam should be applied during the unloading process, because the lining of the car can be damaged as the liquid level falls below the heating coils.
6. Remove the plug from the two-inch top unloading valve and run a light wooden or metal rod through the entire length of the education pipe to insure that no unmelted phenol or foreign matter is obstructing the pipe.
7. Secure the manway cover.
8. Connect the unloading line to the two-inch top unloading valve.
9. Attach the nitrogen supply line to the one-inch nitrogen vent valve. This line should be equipped with a vent valve, a safety relief valve set at no more than 30 psig (2,069 mbar), a pressure gauge, a pressure-reducing valve set at no more than 28 psig (1,931 mbar), and a nitrogen shutoff valve.
10. Open the one-inch vent valve and slowly pressure the car. When the pressure on the car reaches 15 psig (1,034 mbar), open the two-inch top unloading valve. Check the new connections, swing joints, and valves for leaks. If a leak occurs, depressure the system completely before any repairs are attempted. When phenol reaches the suction side of the pump, open the vent valve located on the nitrogen supply line and close off the nitrogen supply. The car should be adequately vented which can be accomplished by loosening the manway cover. The car should be emptied to within 200 pounds of its tare weight.
11. Disconnect the piping. Close all dome openings. Thoroughly wash off any phenol. Blow out the steam coils with air to prevent any residual condensate from freezing and bursting the coils. Do not replace the steam inlet and outlet caps.
12. Tank cars should be closed and made ready in accordance with D.O.T. regulations prior to releasing.

CAUTION: Where leaking valves or fittings are to be tightened, it is desirable to externally presteam the repair area to melt any residual frozen phenol.

Tank Trucks

Bulk shipments of phenol synthetic are made in tank trucks having capacities of up to 5,000 gallons.

The same protective clothing and equipment should be used as for unloading tank cars (see “Precautions,” page 8), and all applicable precautions observed.

Storage and Transfer

Materials Of Construction

In applications where phenol color is unimportant, steel equipment gives years of satisfactory service.

When colorless phenol is required, 304L, 316L or duplex 2205 stainless steel tanks with 304L, 316L or duplex 2205 stainless steel fittings are recommended; however, unlined stainless steel or carbon steel tanks which have been lined with certain coatings have been found acceptable for storing the phenol used in most applications.

For maintaining low color phenol, the following lining, or their equivalent, is suggested:

- **Carbozinc™ CZ-11 with the sealer:** Solvent Based Inorganic Zinc. (Carboline Company)

For low color phenol, lines of 304L, 316L or duplex 2205 stainless steel are essential. Phenol contact with certain metals should be avoided. Phenol is highly corrosive to aluminum. Magnesium, lead and zinc are quickly attacked by hot phenol. Phenol is easily discolored by copper and copper alloys.

Storage Tanks

Storage tanks should be of welded construction. Both vertical and horizontal tanks are suitable for phenol storage. Underground storage tanks should not be used because of the difficulty of finding leaks. Diking, drainage and tank supports should be designed to conform with local regulations. A rule of thumb commonly used for determining the size of storage facilities suggests that storage facilities be 1 1/2 times the size of shipments received. Some processes may require larger inventories.

Relief devices should be installed to provide venting and to relieve excess pressure and vacuum. These devices and the associated piping should be traced & insulated with temperature readings and alarming for notification of potential freezing that would impair the safety device. Environmental considerations may dictate more elaborate venting equipment. In special applications where moisture content of phenol is important, special venting precautions or inert gas padding is required. Additional data covering these special situations will be provided upon request.

The storage tank inlet should be located at the bottom of the tank. Should a top inlet be desired, be sure to extend fill pipe nearly to the bottom of the tank to minimize static electricity during filling. The fill pipe should be connected electrically to both the tank flange and the transfer pipe line. The purpose of this electrical connection is to drain off any static charge which builds up during filling. A 1/4-inch (0.635 cm) hole should be drilled in the top of the fill pipe just inside the tank to prevent phenol from siphoning back through the fill line.

Phenol is usually stored as a liquid at temperatures between 45ºC and 55ºC (113-131ºF). If colorless phenol is required, storage temperatures

above 60ºC are not recommended. The tank should be nitrogen padded to prevent oxidation of phenol.

Olin Corporation recommends that storage tanks for phenol be equipped with external heating pads and insulation to maintain storage temperatures.

The heating pads can be steam or electric. Usually, heat padding is placed intermittently over the bottom fifth to third of the tank. In addition, a vertical column of padding running the entire height of the tank should be present. This allows a fluid upward corridor for any liquid phenol expanding from the tank bottom. The entire tank should be appropriately insulated.

Internal pencil coils can also be used to maintain temperature in phenol storage tanks. Coils offer the advantage of faster heat-up time than external pads – an advantage if phenol storage is less likely to be continuously maintained at elevated temperatures. But internal coil systems, if not properly operated and maintained, are more likely to develop leaks and cause product quality issues. If an internal coil system is preferable, low-pressure steam condensing inside horizontal 304L, 316L or duplex 2205 stainless steel pencil coils is recommended. Pencil coils are used because of the ease with which they can be removed for inspection. 304L, 316L or duplex 2205 stainless steel is recommended primarily, because it contributes the least to color development. Fabrication details for this type of heater are shown in Figure 10.

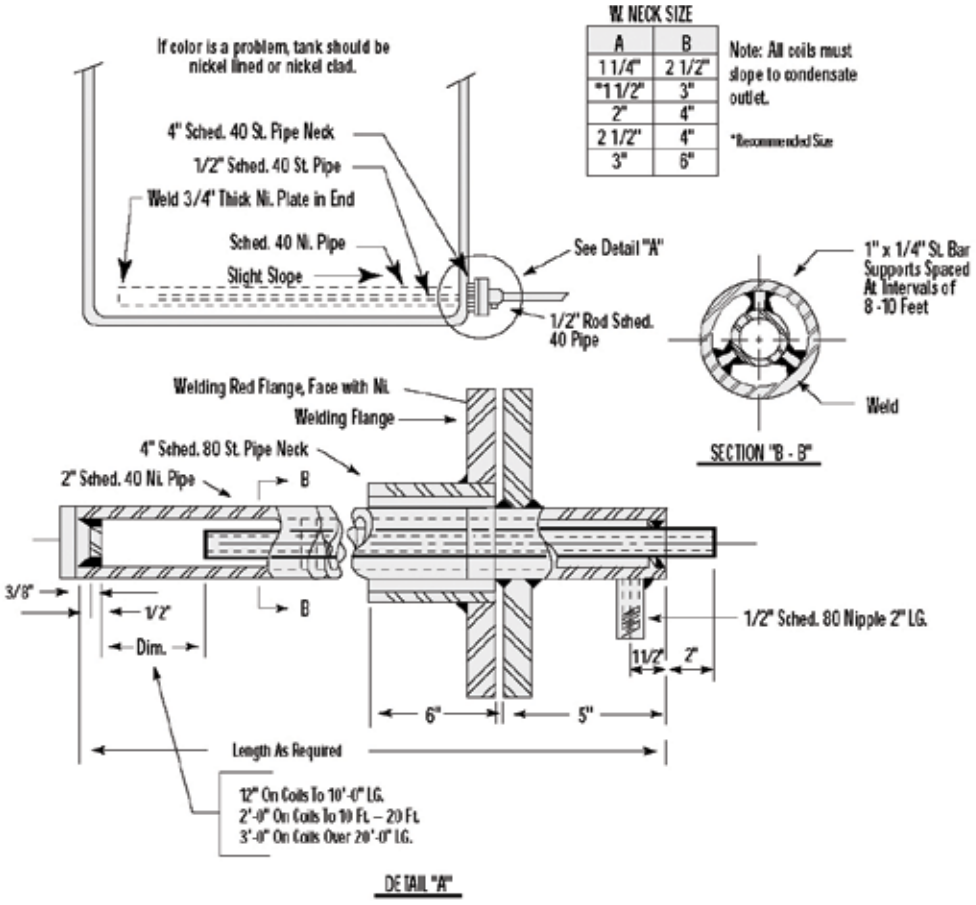
On large tanks, a vertical pencil coil projecting down from the top of the tank is recommended. If the tank is completely frozen, the vertical unit is used to melt a hole through the frozen phenol to allow expansion of the hot liquid around the horizontal heaters. The vertical coil should be installed with its lower end below the horizontal coils. The vertical coil is connected to a steam supply only during use and should be blown out with air following each use.

Agitation of phenol may be accomplished by a pump recirculation system.

Workers should never be permitted to enter an empty tank which has been used for phenol until it has been thoroughly cleaned and until the concentration of phenol in air is below the listed Occupational Exposure Level (OEL) listed in Table 3 in the Health Hazard Section.

A washing procedure may include thorough rinsing with warm or hot water, followed by a complete steaming for approximately 12 hours and then another washing.

Figure 10: Typical Pencil Coil for Phenol Storage Tank



Storage and Transfer

Pumps

Molten phenol can be transferred by pump or vacuum. For most phenol handling, centrifugal pumps with mechanical seals perform satisfactorily. The pump manufacturer can recommend the proper type of pump if the following parameters are known: flow in gallons per minute, the size and length of suction and discharge lines, the suction and discharge pressures, and the temperature of the phenol. A drain valve should be installed at the lowest point in the system so that the pump and all piping can be completely drained and washed before any maintenance work is done. Totally enclosed fan cooled (TEFC) motors are recommended; however, local fire and insurance codes should be consulted to determine if an explosion-proof motor must be used.

The following practices are recommended to minimize the possibility of pump leakage.

- Fully pressurized dual mechanical seals with proper instrumentation and alarm
- The pump shaft should be highly polished
- Extra care should be exercised to get the best possible alignment between motor and pump to insure seal life
- The pump should be designed so that pump bearings will be able to carry thrust at no flow
- If the bolts are removed from the suction and discharge flanges, the suction and discharge lines should remain in position. This test assures that the pump is not being strained by the lines
- Pumps should not be subjected to forces or moments beyond specified pump tolerances
- Pump deadhead evaluation and protection should be implemented

Pipelines

The following are recommended practices in engineering pipelines for phenol.

1. Lines smaller than one inch should not be used
2. A minimum of flanged connections should be used on phenol pipelines. Their use for connections to tanks, valves, pumps and other equipment is acceptable. Flanges used for connective piping should be avoided due to leak potential.
3. Phenol lines should never be buried because of the difficulty of checking for leakage, as well as the hazard involved in digging up a line surrounded by dirt soaked with phenol. All lines below grade should be in concrete troughs.
4. If overhead phenol lines cross walks or driveways, precautions must be taken to shield personnel from leaks and drips
5. All lines carrying phenol should be sloped so that they can be completely drained for maintenance
6. All newly installed phenol pipelines should be pressure-tested by an approved method before insulation is applied

Heat Tracing And Insulation

Heat-traced lines, valves, and pumps are necessary to prevent phenol from freezing during handling. Phenol should be kept at 52°C (125°F) during transfer operations. If temperatures during transfer are over 60°C, discoloration is likely to occur.

NOTE: Overheating may cause color (at ~150°C) due to reaction with O_2 or metals such as iron.

Lines can be traced either by steam or electrical tracing. Steam tracing frequently involves tracing two-inch lines with 3/8 to 1/2-inch copper or stainless steel tubing covered by insulation adequate for existing temperature and wind conditions. Electrical tracing of lines with appropriate insulation may also be used; however, lines heat up more rapidly to the temperature required for phenol transfer operations when traced with steam.

Horizontal pipes are traced by running the tracing along the bottom of the pipe. Vertical lines are traced by running the tracing line along the pipe. The pipe and tracing are then covered with suitable insulation. If steam tracing is being used, a minimum of one steam trap should be used for each tracer and every 150 feet of tracing. 60 – 75 psig (4,137 – 5,171 mbar) steam is recommended in the tracing.

NOTE: Special care should be taken when thawing piping systems with frozen phenol. As the phenol thaws and is heating up, it will expand and can result in catastrophic failure of the system if there is no place for to relieve this pressure. Long sections of piping can heat unevenly leaving plugs of frozen phenol that can be of particular concern.

Olin Product Stewardship

Olin encourages its customers and potential users of Olin products to review their applications of such products from the standpoint of human health and environmental quality. To help ensure that Olin products are not used in ways for which they are not intended or tested, Olin personnel will assist customers in dealing with environmental and product safety considerations. An Olin sales representative can arrange the proper contacts. Olin product literature, including Safety Data Sheets (SDS), should be consulted prior to use of Olin products. These may be obtained by contacting the Olin Customer Care at 1-844-238-3445 in the U.S. (See back page for additional contact information).

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