ALLYL CHLORIDE

PRODUCT STEWARDSHIP MANUAL

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Introduction

This product stewardship manual on the safe handling and storage of Olin Allyl Chloride is offered by Olin Corporation as a service to its customers and others who handle, use, store, ship, or dispose of allyl chloride and/or allyl chloride-based products. Although allyl chloride has been used successfully – and safely – for more than four decades, its handling, use, storage, and disposal can present hazards to the health and safety of workers and the environment. Thus, this manual contains information on the physical and chemical properties of allyl chloride, health hazards, precautions for handling, first aid, personal protection, reactivity, fire and explosion hazards, containment and cleanup of spills and leaks, disposal, and procedures and equipment for safe handling and storage of bulk shipments. An index of equipment suppliers and products is also included.

Introduction

In addition to the information and data contained in this reference, Olin also offers the advice and assistance of the Epoxy Products and Intermediates R&D Group and of its Technical Service and Development staff. These service groups have extensive experience in the chemistry, formulation, and application of allyl chloride, allyl chloride-based products, and other allylics, and in their safe handling, use, and storage. In short, Olin is committed to providing world-class service both to its customers and to all those who handle, use, store, ship, or dispose of its products – including Olin Allyl Chloride.

Health and Safety

Safety is of the utmost concern to Olin Corporation. However, safety is also the responsibility of those who handle, transport, use, store, or dispose of Olin products, including Olin Allyl Chloride and the other members of Olin's large and varied family of allylic intermediates.

Broadly speaking, direct contact with these materials should be avoided. This is best accomplished through the use of a "closed" system. However, since customer/user needs vary so widely, such systems must be individually designed to meet the specific needs of each plant site. And while the resources and expertise of the Epoxy Products and Intermediates R&D Group are available to customers on an individual basis, Olin can make no warranty of any kind. Thus, final judgment on systems, procedures, and safe handling practices in use, storage, transportation, and disposal must be the sole responsibility of the customer/user.

To be of service in this regard, Olin publishes – and continually updates – a Safety Data Sheet (SDS) for each member of its family of allylic intermediates, including Olin Allyl Chloride. These sheets – which should be obtained and read before any of the allylic intermediates are used – are designed to help customers meet their safe handling and disposal needs. For current copies of SDSs for Olin Allyl Chloride or any of the other allylic intermediates, contact your Olin representative or local sales office. (Contacts and telephone numbers available on back cover.) Guidelines issued by federal, state, and provincial regulatory agencies and trade associations should also be consulted.

Note: Various reaction materials and other common ingredients in allylic formulations may also be hazardous. Information and recommendations on the safe handling and storage of each of these materials should be obtained from the appropriate supplier and should be carefully reviewed **before** these materials are handled and used. Also, unless stated otherwise, all references to specific governmental regulations on health, safety, handling, shipment, disposal, etc., are based on U.S. laws and regulations.

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 SDSs, 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 date. 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 assure 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.

Olin Allyl Chloride

Table 1: Physical Properties of Olin Allyl Chloride[1]

Chemical Formula	$CH_2 = CHCH_2Cl$
CAS No.	107-05-1
EC No.	203-457-6
EC Annex 1 No.	602-029-00X
Molecular Weight	76.53
Physical State/Appearance, STP	Colorless Liquid
Odor	Unpleasant, Pungent Odor
Boiling Point @ 760 torr (101.3 kPa)[a]	45.1°C (113°F)
Flash Point (TCC)	-32°C (-25°F)
Flammability Limits (by volume in Air) LFL	3.3%
UFL	11.1%
Azeotrope with Water (2.2% water in the azeotrope)	43°C (109°F)
Freezing Point	-134°C (-209°F)
Critical Pressure, atm	46.5 (4710 kPa)[a]
Critical Temperature	240.7°C (465°F)
Heat of Combustion, cal/g	5940 (24.8 kJ/g)
Heat of Vaporization, cal/g @ 20°C (68°F)	83.8 (351 J/g)[b]
Refractive Index @ 15°C (59°F)	1.4153
Electrical Resistivity, ohms/cm^3	10^7
Autoignition Point	392°C (738°F)
Specific Gravity @ 25/25°C (77/77°F)	0.932
Specific Heat (liquid) cal/g @ 20°C (68°F)	0.315 (1.32 J/[g•°C])[b]
Liquid Density @ 25°C (77°F), g/ml	0.931
@ 25°C (77°C) lbs/gal	7.77
Vapor Density (air = 1)	2.64
Vapor Pressure @ 20°C (68°F)	5.801 psia (297 mm Hg)
@ 30°C (86°F)	8.601 psia (445 mm Hg)
Expansion Coefficient, 0-30°C (32-86°F)	1.41 K^{-1}
Liquid Viscosity, mPa•s (=cP)	
0°C (32°F)	0.4070
25°C (77°F)	0.3136
50°C (122°F)	0.2519
Solubility, Water in Allyl Chloride @ 20°C (68°F)	0.08%
Solubilities @ 20°C (68°F)	
In Water	0.33%
Acetone	Infinite
Ethyl Ether	Infinite
Methanol	Infinite
Benzene	Infinite
Carbon Tetrachloride	Infinite
n-Heptane	Infinite

[1]Typical physical properties; not to be construed as specifications
[a]To convert kPa to atm, divide by 101.3
[b]To convert J to cal, divide by 4.184

Physical Properties

Olin Allyl Chloride (or 3-chloropropene or 1-chloropropene-2) is a highly reactive organic intermediate, which is available from the Epoxy Products & Intermediates Business of Olin Corporation. It may be represented by the following structural formula: $CH_2 = CHCH_2Cl$.

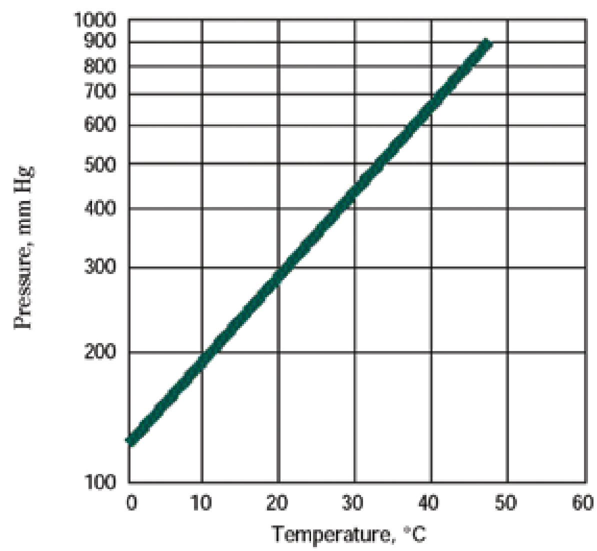
In its pure form, allyl chloride is a clear, colorless, highly flammable liquid, possessing an unpleasant, pungent odor. Although miscible in typical compounds, such as alcohol, chloroform, ether, acetone, benzene, carbon tetrachloride, heptane, and toluene, allyl chloride is only slightly soluble or miscible in water. The presence of both a primary halogen atom and an olefinic double bond makes allyl chloride a uniquely versatile material that can undergo reactions both as an alkyl chloride and as an unsaturated hydrocarbon. Depending on the reagents used and the conditions under which the reactions are effected, either group may react separately or they may react simultaneously.

Note: Its activity as an alkyl chloride is enhanced by the presence of the double bond, but its activity as an olefin is somewhat less than that of propylene. Allyl chloride participates in most types of reactions characteristic of either functional group; reactions can be directed by control of conditions, selection of reagents, and provision of suitable catalysts.

Olin Corporation produces an anhydrous (dry) grade of allyl chloride, available in 10,000- and 20,000-gallon[1] pressurized tank cars (rail cars) and in 45,000-pound[2]-capacity tank trucks.

Table 1 lists the typical physical properties of Olin Allyl Chloride. For data on vapor pressures and densities at various temperatures, see Figures 1 and 2, respectively. Also, for typical chemical reactions, see Table 2.

Figure 1: Vapor Pressure of Allyl Chloride



[1]40,000 and 75,000 liters
[2]20.5 metric tons

Figure 2: Density of Allyl Chloride

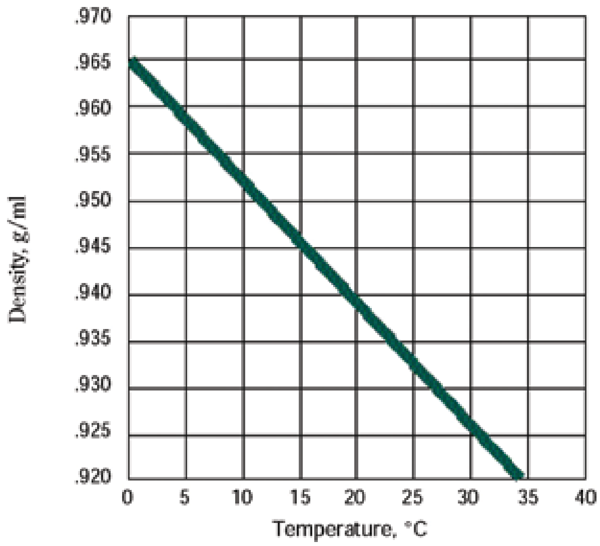


Table 2: Typical Reactions of Allyl Chloride

Peroxidation

$CH_2=CHCH_2Cl + H_2O_2 \rightarrow CH_2OHCHOHCH_2Cl$

Halogenation

$CH_2=CHCH_2Cl + Cl_2 \rightarrow CH_2\,ClCHClCH_2Cl$

$CH_2=CHCH_2Cl + Cl_2 \xrightarrow{500°C} CHCl=CHCH_2Cl + HCl$

Hypochlorination

$CH_2=CHCH_2Cl + ClOH \rightarrow CH_2OHCHClCH_2Cl + CH_2ClCHOHCH_2Cl$

$CH_2OHCHClCH_2Cl + CH_2ClCHOHCH_2Cl + NaOH \rightarrow \overset{O}{CH_2\text{–}CH}\text{–}CH_2Cl + NaCl + H_20$

Addition of Hydrogen Halides

$CH_2=CHCH_2Cl + HX \rightarrow CH_3CHXCH_2Cl$

(Where X is Cl, Br or I)

$CH_2=CHCH_2Cl + HBr \xrightarrow{\text{Catalyst}} CH_2BrCH_2CH_2Cl$

Reactions With Water

$CH_2=CHCH_2Cl + H_2O \xrightarrow{H_2SO_4} CH_3CHOHCH_2Cl$

$CH_2=CHCH_2Cl + H_2O \rightarrow CH_2=CHCH_2OH + HCl$

Reaction With Base

$CH_2=CHCH_2Cl + NaOH \rightarrow CH_2=CHCH_2OH + NaCl$

Reactions With Cyanides and Cyanates

$CH_2=CHCH_2Cl + CuCN \rightarrow CH_2=CHCH_2CN + CuCl$

$3CH_2=CHCH_2Cl + CH_3CN + 3NaNH_2 \rightarrow (CH_2=CHCH_2)_3C\text{–}CN + 3NaCl + 3NH_3$

$CH_2=CHCH_2Cl + KSCN \rightarrow CH_2=CHCH_2NCS + KCl$

Reactions With Sulfur-Containing Compounds

$nCH_2=CHCH_2Cl + nSO_2 \rightarrow \left[\begin{array}{l}\text{–}SO_2 \\ CH_2CHCH_2Cl\end{array}\right]_n$

$CH_2=CHCH_2Cl + Na_2SO_3 \rightarrow CH_2CHCH_2SO_3Na + NaCl$

$CH_2=CHCH_2Cl + Ag_2SO_4 \rightarrow (CH_2=CHCH_2)_2SO_4 + 2AgCl$

$CH_2=CHCH_2Cl + Na_2S_2O_3 \rightarrow CH_2=CHCH_2S\text{–}SO_2\text{–}ONa + NaCl$

$2\,CH_2=CHCH_2Cl + K_2S \rightarrow CH_2=CHCH_2SCH_2CH=CH_2 + 2KCl$

$CH_2=CHCH_2Cl + KHS \rightarrow CH_2=CHCH_2SH + KCl$

$CH_2=CHCH_2Cl + HSCH3 \rightarrow CH_2=CHCH_2SCH_3 + HCl$

Reactions With Ureas

$CH_2=CHCH_2Cl + NH_2CONH_2 \rightarrow H_2C=CHCH_2NHCONH_2$

$CH_2=CHCH_2Cl + NH_2CSNH_2 \rightarrow H_2C=CHCH_2NHCSNH_2$

Reactions With Nitrogen-Containing Compounds

$CH_2=CHCH_2Cl + NH_3 \rightarrow CH_2=CHCH_2NH_3Cl$

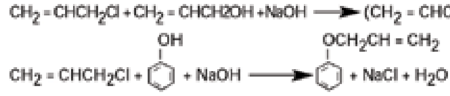
$CH_2=CHCH_2NH_3Cl + NH_3 \rightarrow CH_2=CHCH_2NH_2 + NH_4Cl$

$CH2=CHCH_2Cl + C_6H_5NH_2 \rightarrow CH_2=CHCH_2HNC_6H_5 + HCl$

$CH_2=CHCH_2Cl + AgNO_2 \rightarrow CH_2=CHCH_2NO_2 + AgCl$

Reactions With Alcohols

$CH_2=CHCH_2Cl + CH_2=CHCH2OH + NaOH \rightarrow (CH_2=CHCH_2)_2O + NaCl + H_2O$



Preparation of Acrylates

$CH_2=CHCH_2Cl + CH_2=CHCOOH \rightarrow CH_2=CHCH_2OOCCH=CH_2 + HCl$

$CH_2=CHCH_2Cl + CH_2=C(CH_3)\,COOH \rightarrow CH_2=CHCH_2OOCC(CH_3)=CH_2 + HCl$

Preparation of Grignards

$CH_2=CHCH_2Cl + Mg \rightarrow CH_2=CHCH_2MgCl$

$CH_2=CHCH_2MgCl + (C_2H_5)_2NCH_2CH_2Cl \rightarrow (C_2H_5)_2N(CH_2)_3CH=CH_3 + MgCl_2$

$4CH_2=CHCH_2Cl + 4Mg + SiCl_4 \rightarrow (CH_2=CHCH_2)_4Si + MgCl_2$

Reactions With Inorganics

$2\,CH_2=CHCH_2Cl + 2Pd \rightarrow (CH_2=CHCH_2PdCl)_2$

$CH_2=CHCH_2Cl + Na_3AsO_3 + 2HCl \rightarrow CH_2=CHCH_2AsO(OH)_2 + 3NaCl$

Reactions With Benzene

$CH_2=CHCH_2Cl + Li(C_6H_5) \xrightarrow{\text{Ether}} CH_2=CHCH_2C_6H_5 + LiCl$

$CH_2=CHCH_2Cl + C_6H_5Cl \rightarrow p\,ClC_6H_4CH(CH_3)CH_2Cl$

Preparation of Oligomers

$2CH_2=CHCH_2Cl \xrightarrow[100\text{-}250°C]{Cu} CH_2=CHCH_2CH_2CH=CH_2 + CuCl_2$

$2CH_2=CHCH_2Cl + 2\,NaNH_2 \rightarrow CH2=CHCH=CHCH=CH_2 + 2NaCl + 2NH_3$

$nCH_2=CHCH_2Cl \xrightarrow{BzO_2} \left[\begin{array}{l}CH_2\text{–}CH\text{–} \\ \quad\;\; CH_2 \\ \quad\;\; Cl\end{array}\right]_n$

Uses

Allyl chloride has found widespread use as a chemical intermediate in many industries and applications, including the preparation of polymers, resins, and other plastic materials, increased oil production, the preparation and modification of catalysts, and the manufacture of pesticides, adhesives, flame retardants, chelating agents, detergents, dyestuffs, flavorings, metal brighteners, perfumes, pharmaceuticals, and urethanes.

Note: A number of these applications are discussed below; however, for more detailed information on these and other applications, contact the Olin customer care group. Also, see Table 2, "Typical Reactions of Allyl Chloride," page 6.

Note: Olin Corporation produces only an anhydrous (dry) grade of allyl chloride, available in 10,000- and 20,000-gallon pressurized tank cars and in 45,000-pound-capacity tank trucks.

Epichlorohydrin

Allyl chloride is widely used in the production of epichlorohydrin, an important monomeric intermediate that is used as a basic building block in the production of epoxy resins. The monomer itself is made by controlled caustic epoxidation of the glycerol dichlorohydrin, the chief product of the hypochlorination of allyl chloride.

Note: Epoxy resins are generally produced by reacting a polyhydric phenol with an aliphatic chlorohydrin or simple aliphatic epoxide. The most familiar epoxy is obtained by condensing epichlorohydrin with bisphenol A, which results in a basic epoxy resin molecule.

Allylic Esters

Allylic esters, which can be cross-linked, may be prepared by reacting allyl chloride with the alkaline salt of either aromatic or aliphatic carboxylic acids. Also, polymers with pendant allyl groups can be prepared by reacting allyl chloride with polymers containing acid groups, such as copolymers of acrylic or methacrylic acid.

Allylic Ether Resins

Allyl chloride is a commonly used "starting material" for the production of various allyl or allylic ethers of bisphenol A, novolac phenolic resins, etc. These products are cured through allylic unsaturation to make coatings and molding resins. Also, allylic ethers of alcohols and polyglycols can be produced by reacting allyl chloride with an alkoxide.

Alkyl and Allylic Silanes

Alkyl silanes, which can be prepared with allyl chloride, are compatible with many resin systems and can provide improved surface properties, including resistance to water and solvents, low surface tension, thermal stability, excellent adhesion, electrical insulation, and low-temperature flexibility.

Uses

Considerable interest has also been shown in the production of allylic silanes. The preparation of these silanes involves the reaction of the active chloride group with a hydrogen of an organic silane. The resulting product contains the allylic unsaturation attached to the Si atom. These allylic silanes can be further processed to prepare higher molecular weight polymers. The use of a platinum catalyst will cause the silane to add across the allylic bond to form a 3-chloropropyl silane. These products, in turn, can be added to other polymers by reacting with the chloride group.

Diene Catalysts

Compounds containing two or more sites of unsaturation polymerize in a fashion that is analogous to vinyl compounds. (An example is the formation of 1,5,9-cyclododecatriene by trimerizing butadiene.) Thus, by using another allyl-chloride-modified metal catalyst, butadiene can be polymerized to cis-1,4-polybutadiene, one of the important elastomers for making tire rubber.

Polymers and Copolymers of Allyl Chloride

Many studies have been conducted on the polymerization and copolymerization of allyl chloride. Briefly, allyl chloride can be copolymerized with a number of different unsaturated monomers, such as vinyl chloride, maleate esters, maleic anhydride, and vinyl acetate. The allyl chloride content is generally rather low; however, if the allyl chloride is high, the resulting polymer will have a low molecular weight. Allyl chloride is also generally considered an excellent chain-transfer agent.

Allyl Chloride Polymers and Copolymers in Plastics

Extensive work has been done on the use of polyallyl chlorides as additives to other polymers. Since the polyallyl chlorides are lower in molecular weight, they can function as plasticizers and flexibilizers in hard polymers, such as polyvinyl chloride. Still other polymers of allyl chloride have been reported to be useful as coatings and films. Also, cationic surfactants and soaps are formed by reacting the polymers containing allyl chloride with alkyl amines. These products can be used as emulsifiers during polymerization of other monomer systems.

The use of higher-molecular-weight copolymers of allyl chloride for the production of coatings, laminating resins, molding resins, and the like, has also been studied. These copolymers are used "as is," without further reaction of the pendant chloride group. Such copolymers offer many opportunities for blending with other reactive polymers (such as amine-containing polymers) to form stable formulations that can be reacted at elevated temperatures.

Chelating Agents

Allyl chloride has also been reported to have been used successfully in preparing chelating agents. Again, advantage is taken of the difunctionality of the molecule. For example, allyl chloride is copolymerized with other vinyl monomers. Then the chloride group is reacted with trimethylamine to form a polymer containing quaternary groups. Allyl chloride is also used to form quaternary groups on a polyamine, which is then cross-linked to form a resinous product.

Quaternary Ammonium Salts

An interesting application of allyl chloride is described in U.S. Patent 3,288,770. By reacting two moles of allyl chloride with dimethylamine, a quaternary salt containing two methyl groups and two allylic groups results. In the presence of a peroxide catalyst, the allylic groups react to form a high-molecular-weight cationic polymer containing repeating quaternary piperidine units. The polymer has use in water clarification and sewage sludge flocculation.

In another process, allyl chloride is reacted with trimethylamine to form a quaternary salt containing one allyl group and three methyl groups. This quaternary salt is hypochlorinated with chlorine in water to form 3-hydroxy-2-chloropropyl trimethyl ammonium chloride. This monomer is used to form cationic starch by adding the quaternary salt to the starch alkoxide. U.S. Patent 3,346,563 covers the processes involved.

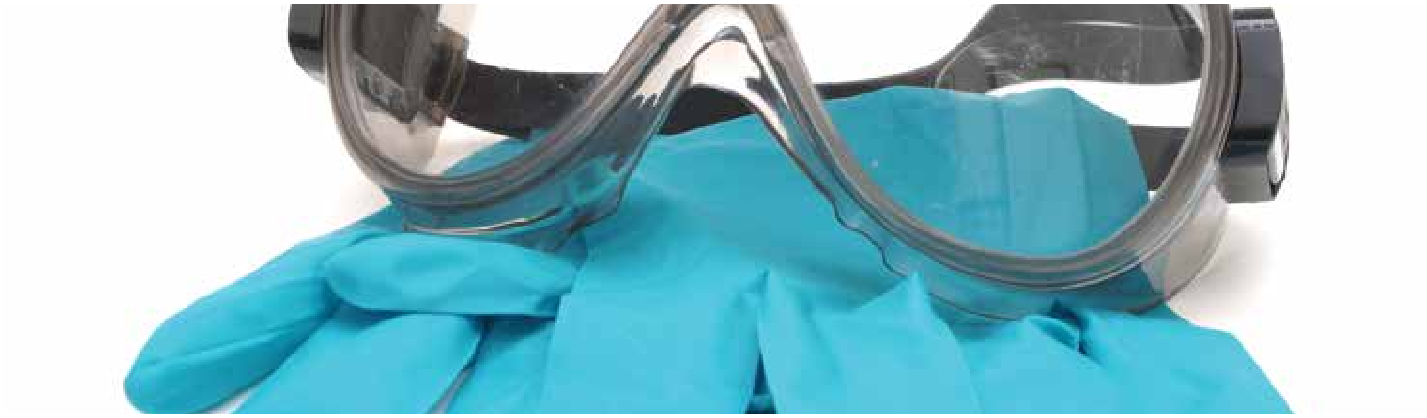
Other Applications

Current literature offers numerous uses and applications for allyl chloride and allyl-chloride-based derivatives and compounds. For example, sodium allyl sulfonate, which can be made from allyl chloride, may be used as a metal brightener in electroplating baths. Still other potential applications include:

- Adhesives
- Biodegradable detergents
- Dyestuffs
- Flame retardants
- Ziegler catalyst modification
- Oil production
- Pesticides
- Urethanes

The extraordinary usefulness and versatility of allyl chloride is evidenced by the large number of patents that have been issued world-wide on a wide range of reactions, applications, and processes. For more information on these and related patents, customers and other interested parties are urged to contact any of the various firms that provide patent search services. These firms can generally search both U.S. and international patent records for a complete and comprehensive report. Some firms may also provide abstracts or complete copies of individual patents. Fees for these and other services (including translations) will vary, depending on the nature and number of services requested and on how quickly the various services are needed.

Health Hazards



Olin publishes and regularly updates a safety data sheet (SDS) for allyl chloride. The SDS is designed to help customers and others who handle allyl chloride 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).

A current copy of the SDS should be obtained and carefully read **before** Olin Allyl Chloride 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 protection equipment and clothing, and administering first aid. (Also consult "area-specific" SDSs for information on local laws, ordinances, regulations, etc.)

For current copies of SDSs, contact your Olin representative.

Potential Health Effects

Odor Threshold and Warning Properties

Allyl chloride has an irritating, pungent, garlic-like odor, with an odor threshold of around 1 ppm; however, most people detect allyl chloride at around 3-6 ppm. Thus odor is not a reliable indicator of potential overexposure. Marked nose and eye irritation occur at higher exposure levels.

ATTENTION: Workers must not rely on odor, or on eye and nose irritability, as a warning or indicator of potential overexposure.

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.

Contact Effects

All contact with allyl chloride should be avoided. The following effects of allyl chloride on the skin and eyes should be carefully noted by all individuals working with this material.

Skin Contact

All skin contact with allyl chloride should be avoided. Allyl chloride is extremely irritating and potentially damaging to the skin and mucous membranes, particularly when contact is repeated or prolonged (i.e., for several minutes or longer). In fact, repeated or prolonged contact – even with relatively low concentrations — may result in severe chemical burns. The effects, however, may be delayed for several hours or longer. Thus, the immediate absence of irritation, tissue damage, or pain may not be reliable evidence that a damaging or toxic exposure has not occurred.

Allyl chloride may also be absorbed through the skin in toxic or harmful amounts. The LD50[1] for toxicity through skin absorption in rabbits is 400-2,200 mg/kg body weight. In addition to localized irritation and possible burns, prolonged skin contact with the liquid product can result in significant kidney and liver damage. (See "Chronic Toxicity – Systemic Effects," page 10.)

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

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

Eye Contact

All eye exposure to allyl chloride should be avoided. Exposure of the eyes to liquid allyl chloride may result in significant irritation and pain. Repeated or prolonged contact, however, may result in severe irritation and possible corneal injury, which could result in permanent impairment of vision, even blindness. Exposure to the vapors of allyl chloride, especially heated vapors, may cause severe irritation and, with high concentrations, significant corneal injury.

ATTENTION: As with skin contact, the effects of eye exposure may be delayed. Also, solutions of allyl chloride may be even more hazardous or harmful, especially if the solvent carrier is miscible in water.

Inhalation

All inhalation exposure to allyl chloride should be avoided. Exposure to the vapors of allyl chloride may cause severe irritation to the mucous membranes of the upper respiratory tract and lungs, especially if prolonged or repeated. However, a single acute exposure to an excessively high concentration could result in unconsciousness and even death. The 1-h maximum survival for rats is estimated to be 2900 ppm (9100 mg/m^3). A 6-h inhalation exposure study demonstrated that the LC50 likely fell between 1000 ppm and 2000 ppm, equivalent to a calculated 4-h LC50 >3.58 mg/L and <7.2 mg/L. These values indicate moderate acute inhalation toxicity in rats.

ATTENTION: Signs and symptoms of excessive exposure may include anesthetic or narcotic effects; however, lung injury and other respiratory effects may be delayed. Other effects from repeated or prolonged exposure to the vapors of allyl chloride may include possible liver and/or kidney damage, with kidney damage potentially severe in acute exposures. Excessive exposure may also cause peripheral neuropathy – i.e., injury to the nerves of the extremities. (See "Chronic Toxicity – Systemic Effects," page 10.)

In short, a single prolonged or excessive inhalation of a high concentration of vapor, or an extensive and prolonged exposure of an equally high concentration to the skin, may cause serious adverse health effects, including death.

WARNING: Inhalation of allyl chloride vapors, mists, and/or aerosols should be avoided through the use of adequate ventilation and appropriate respiratory protective devices, including a self-contained, positive-pressure breathing apparatus. (See "Personal Protection," page 14.)

Ingestion

While allyl chloride does display moderate to high acute oral toxicity (the LD50 = 275-455 mg/kg body weight in rats), it is unlikely that acutely toxic amounts would be ingested in the course of ordinary operations. However, should significantly larger amounts be willfully or accidentally ingested, serious injury – including death – could result. Thus, allyl chloride should be kept in tightly closed, properly labeled containers, which should be stored away from workers and others who are inexperienced or untrained in safe handling practices.

Chronic Toxicity – Systemic Effects

Systemic effects from the inhalation of high concentrations of vapors or from repeated or prolonged exposure to the skin may involve both organ-specific effects (including the lungs, kidneys, and liver) and central nervous system depression and/or injury. Repeated inhalation exposure to allyl chloride can cause kidney and liver damage. Signs and symptoms of central nervous system depression, in order of increasing exposure, are headache, dizziness, drowsiness, incoordination, and unconsciousness. Neurological damage involving the nerves of the hands and feet has also been reported. Peripheral neuropathy (affecting extremities) has been reported in one group of workers who were repeatedly exposed to relatively high air concentrations (mean of 2,966 mg/m^3) and in laboratory animals that were administered exaggerated doses. Peripheral neuropathy effects are not, however, expected to occur with exposures at or below the recommended TLV.

Mutagenicity and Carcinogenicity

Allyl chloride caused gene mutations, heritable changes in genetic material, in some *in vitro* test systems and not in others. When tested in rats up to 25 ppm, the results were negative, as were results from fruit flies tested up to 150 ppm; however, current guidelines would test higher doses. Based on the mixed *in vitro* results, allyl chloride is classified as mutagenic.

Available data are currently inadequate to evaluate carcinogenicity. Some animal testing data are suggestive that allyl chloride may be carcinogenic in mice; however, there is no indication of a carcinogenic risk to humans. Evaluation by the International Agency on Research for Cancer (IARC) determined that allyl chloride was a Group 3 chemical, one cannot be classified as to its potential for carcinogenicity in humans. ACGIH has designated allyl chloride as an A3 or animal carcinogen.

Teratological and Reproductive Effects

Allyl chloride was not considered teratogenic or embryo-lethal based on current studies with laboratory animals; thus birth defects are unlikely as a consequence of exposing the mother to allyl chloride. Effects were only seen in the fetus at doses that caused toxic effects to the mother. Furthermore, allyl chloride has shown no evidence of effects on fertility or reproductive organs.

Exposure

Occupational Exposure Levels (OELs) have been determined for allyl chloride by several authorities and regions (see Table 3, page 11). The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended a threshold limit value (TLV) of 1 ppm allyl chloride in air based on a time-weighted average (TWA) of an 8-hour workday, with a short-term exposure limit (STEL) of 2 ppm; ACGIH has assigned a SKIN notation to ally chloride. OSHA has established its permissible exposure limit (PEL) at this same level. The National Institute for Occupational Safety and Health (NIOSH) recommends that exposure to allyl chloride be controlled to a concentration no greater than 1 ppm in air by volume, which is the TWA for up to a 10-hour workday in a 40-hour work week, and a short term exposure limit of no more than 2 ppm for any 15-minute period. The Derived-No-Effect-Level (DNEL) for allyl chloride, described in the European Chemicals Agency (ECHA) IUCLID, developed under the EU Registration, Evaluation, and Authorization of Chemicals (REACH) regulation, is 1.1 mg/m^3 for long term systemic effects, based on neurotoxicity. Also, while allyl chloride has a disagreeable, pungent odor, the odor threshold has been estimated at approximately 3-6 ppm. Thus, olfactory detection of the presence of allyl chloride is not adequate to protect against overexposure.

Exposure Controls

Attention must also be given to the vapors of any solvents used in formulating or processing allyl chloride. The existing occupational exposure levels (OELs) must be adhered to for workers' safety.

In addition, it should be noted that although allyl chloride has a strong, disagreeable, pungent odor, the odor threshold (which has been estimated at 3 to 6 ppm) is not an adequate means of warning against overexposure. Also, personal protective and emergency safety equipment should not be relied on as the primary means of protection against exposure to allyl chloride. Rather, prevention of exposure should be the preferred precautionary measure.

Health Hazards

Table 3: Key Regional/Country Occupational Exposure Level (OEL) Values for Allyl Chloride.

Country/Region	OEL	Units	Comments
US: OSHA PEL	1	ppm	3 mg/m^3 TWA (8-hr work day)
US: NIOSH	1	ppm	For a maximum of 10-hr work day; 40-hr/week
ACGIH	1 (3)	ppm (mg/m^3)	TLV-TWA (8-hr); A3 (Confirmed Animal Carcinogen with Unknown Relevance to Humans) ACGIH, 2011
*DNEL	1.1	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.			

However, if exposure to concentrations above the various guidelines is unavoidable, an approved positive-pressure, air-supplied, or self-contained breathing apparatus with full face piece should be used.

Note: Tanks and reactors must not be entered until they have been thoroughly washed, purged, and tested for the presence of allyl chloride vapor. Also, the presence of an adequate concentration of oxygen (i.e., 21 percent) should be demonstrated with an oxygen meter test.

Finally, while good ventilation is important, it cannot replace a closed, leak-tight system. All aspects of the handling operation – from delivery through reaction –must be carefully evaluated for the potential of exposure.

For example, such activities as sampling should receive particular attention. Procedures that prevent exposure should be thoroughly explored, tested, and evaluated, and, if found effective, should become established practice. These include the use of vapor return lines during product transfer, the use of dry disconnect fittings for transfer hoses, the use of closed loop sampling systems, and the like.

Note to Physician

Allyl chloride is extremely irritating to the skin, eyes, and the mucous membranes of the upper respiratory tract; however, symptoms and effects may be delayed. Excessive exposure to the skin may result in severe irritation, chemical burns, and possible systemic injury, particularly to the liver and kidneys. Repeated or prolonged inhalation of high concentrations of vapors may result in irritation of the upper respiratory tract and lungs, systemic effects (including possible liver and kidney damage), and central nervous system depression and injury (including peripheral neuropathy). However, even a single inhalation exposure at toxic concentrations can have severe adverse health effects, including the possibility of death. For specific treatment suggestions, see "Note to Physician," page 13.

General Precautions

Although allyl chloride has been widely and safely used for almost half a century, Olin strongly encourages its customers to develop plant systems designed to protect personnel against the hazards to health and safety associated with the handling, use, storage, shipment, and disposal of this important and highly useful chemical compound. In short, the goal should be to avoid direct contact with this material. This is best accomplished by handling allyl chloride in a "closed" system. If this is not possible or feasible, the following precautions and recommendations may be helpful in minimizing the hazards and in preventing potential health and safety problems.

Note: Before being assigned to handling operations involving allyl chloride, workers should be screened and given a complete preplacement physical examination. Individuals with alcoholism or any disease of the liver, kidneys, heart, or respiratory system should not be assigned to operations where exposure to allyl chloride might occur. Workers who are assigned to handling operations should be carefully monitored and given annual physical examinations, with special attention to lung, liver, and kidney function.

- Avoid skin and eye contact. Remember, allyl chloride may cause severe burns and corneal injury, even blindness.
- Avoid breathing vapors, mists, or aerosols
- Avoid working in poorly ventilated environments
- Do not take internally. Do not smoke, eat, drink, or store foodstuffs where allyl chloride is handled, stored, or processed.
- Avoid contact with clothing and shoes. Do not wear or reuse contaminated clothes until they have been thoroughly cleaned. Destroy contaminated leather goods, such as shoes, belts, watchbands, wallets, etc.
- Practice strict personal cleanliness and careful housekeeping at all times
- Wash hands, forearms, face, and neck thoroughly before taking a break, eating, drinking, or using toilet facilities. There should be no smoking, eating, or drinking in allyl chloride work or storage areas.
- Separate all allyl chloride work areas from other work areas to limit the exposure of employees who are unfamiliar with proper handling practices for allyl chloride and who may be exposed to contaminated tools and equipment
- Educate all personnel on the potential consequences of exposure
- Make certain all personnel are familiar with recommended handling procedures and precautions and are fully trained in the administration of first aid
- Make certain all personnel – including janitorial workers – are familiar with recommended disposal procedures and techniques
- Clearly label containers that contain, or have contained, allyl chloride or contaminated waste, including rags, contaminated clothing, utensils, etc.
- Use volatile agents only in properly and adequately ventilated areas

First Aid

The following is a brief overview of emergency or first aid procedures to be used in the event of exposure to allyl chloride. Be sure, therefore, to seek the services of a physician once first aid has been administered.

First Aid

Skin Contact

If contact with the hands should occur, promptly remove rings and watches. The hands should then be immediately, thoroughly, and continuously washed for at least 15 minutes with a mild soap and flowing water. When decontaminated, dry the skin with clean, disposable cloth towels. Call a physician or obtain medical assistance immediately thereafter.

ATTENTION: Shop solvents or solvent-based hand cleaners should not be used. The presence of solvents may facilitate the absorption of allyl chloride through the skin.

If gross contact with the body and clothing should occur, promptly remove all contaminated clothing – including undergarments, rings, watches, and shoes while under a safety shower. The affected skin should be immediately, thoroughly, and continuously washed for at least 15 minutes with large amounts of mild soap and flowing water. When decontaminated, dry the skin with clean, disposable cloth towels. Medical attention should be obtained immediately.

Note: Safety showers, eye baths, and fire extinguishers should be located in close proximity to all work sites, unloading stations, and storage areas and should be protected against freezing. They should also be tested periodically and kept in good working order. Portable equipment may be used in remote areas or in the event of a freeze. It is also recommended that all employees have a second set of clothes on hand to change into before going home. Finally, contaminated clothing should not be reused until the articles have been thoroughly laundered and are entirely free of allyl chloride. Contaminated leather items (such as shoes, belts, watchbands, wristbands, wallets, bill-folds, etc.) must be destroyed and discarded.

Eye Contact

If the eyes are contaminated, they should be immediately and continuously flushed for 30 minutes with a continuous stream of low-pressure water. Medical attention should be obtained at once.

Note: To facilitate flushing of the eyes, the eyelids should be spread apart and held open with the thumb and index finger. The eyes should then be “rolled” or moved from side to side and up and down until all surfaces of the eyelids and the eyeballs have been thoroughly flushed and decontaminated. Consult an ophthalmologist.

Inhalation

If a person should experience any ill effects while working with allyl chloride, he or she should be immediately removed to an area of fresh air. Medical attention should be obtained immediately. Keep the affected person quiet and warm. If breathing stops, administer artificial respiration at once. If breathing is difficult, oxygen may be administered. Call a physician or transport to a medical facility.

Ingestion

If allyl chloride is ingested or swallowed, induce vomiting at once, as directed by medical personnel. Note: Never give anything by mouth to an unconscious person.

Physician Notes

If respiratory distress develops, rest and oxygen administration may be helpful.

Exposure to allyl chloride vapors may cause moderate to severe irritation of the upper respiratory tract, including the nose, throat, and bronchioles. The lungs may also be affected. Lung function should be assessed following a significant single or intermittent inhalation exposure. Also, any significantly exposed individual should be monitored for liver and kidney function for at least 60 days. If evidence of liver or kidney damage is present, treatment should be symptomatic and supportive.

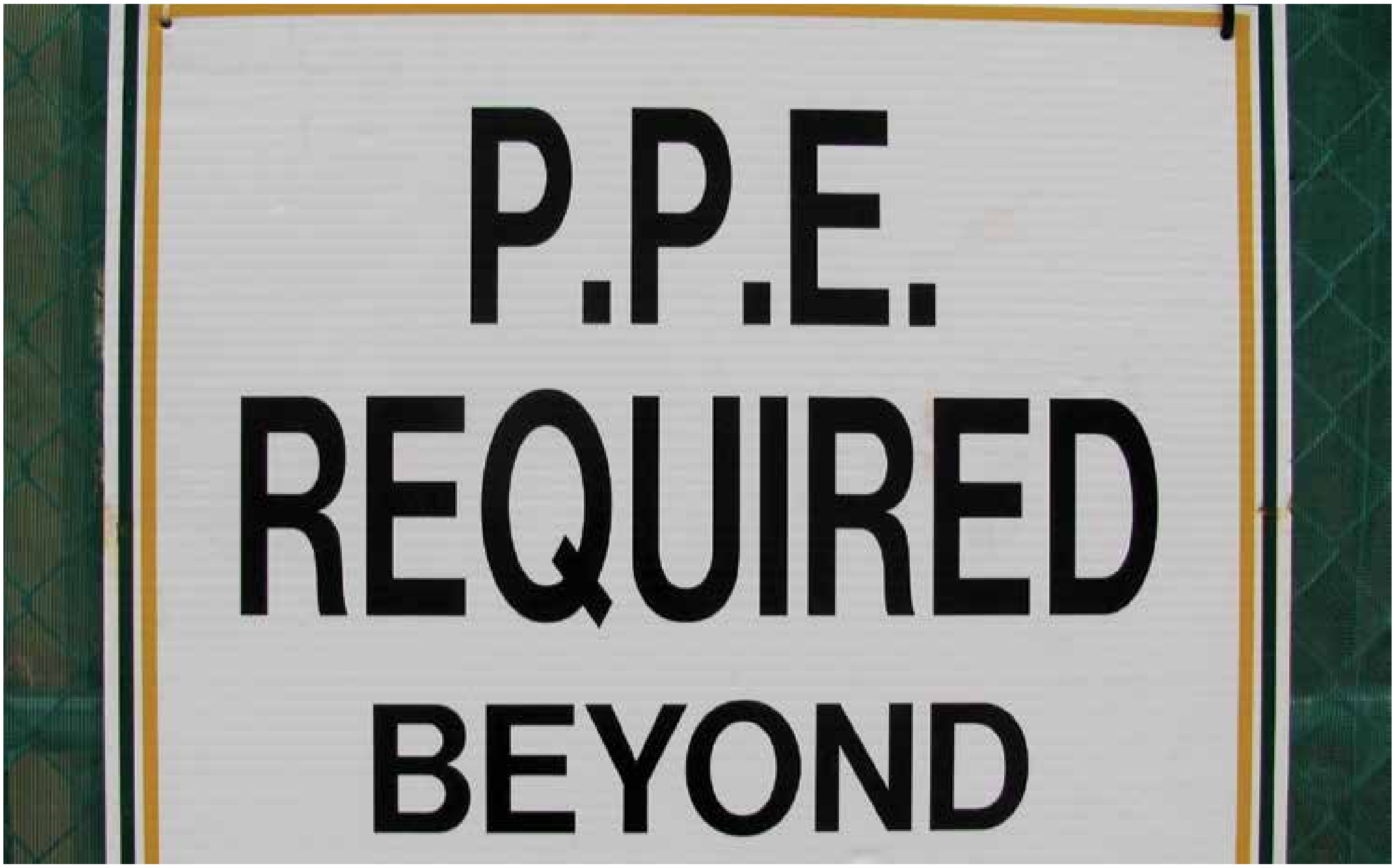
Chemical burns of the eye(s) should be treated by an ophthalmologist or other physician with experience in treating chemical eye injuries, but only after immediate and adequate decontamination with water.

Allyl chloride is highly irritating to the mucous membranes and can burn the membranes of the mouth and throat and, if aspirated, the membranes of the airway and bronchioles. It may also cause tissue destruction leading to stricture. If lavage is performed, endotracheal and/or esophageal control is suggested. The danger of lung aspiration must be weighed against the toxicity of the ingested product when considering the emptying of the stomach. Effects may be delayed.

No specific antidote is known. Offer supportive care. Consult standard literature. Treatment should be based on the judgment of the physician in response to the reactions of the patient.

Conditions vary from one location to another; thus, any given situation or plant environment may require precautions, equipment, protective clothing, training, or ventilation beyond that which is indicated in the following discussion. In short, customers and others are cautioned not to use this document as an exclusive guide in selecting personal protective equipment or in developing safety and quality procedures for their particular operations.

Personal Protection



Protective Equipment

The principal goal of any system or plant operation design should be to minimize the need for personal protective equipment. However, personal protective equipment may be necessary in certain operations or in areas where vapor or liquid exposure is possible. The selection and use requirements of this equipment require careful management considerations. For example, an overall appraisal of plant operations, exposure potential, the nature and duration of possible exposure, the level of training provided to workers on the use of personal protective equipment, etc., must be made. This appraisal should be conducted by a qualified industrial hygienist in conjunction with engineering, maintenance, and the supervisory and management staff. Upon completion of the appraisal, a comprehensive program of personal protection should be prepared. As part of this program, specific approved equipment (including manufacturer, make, and model) should be identified. The plan should also cover equipment maintenance and repair, cleaning, and storage, as well as training on use, effectiveness, etc.

Among the specific issues or questions that should be considered in the selection of personal protective equipment and in the management of the personal protection program are the following:

- Are there practical ways to reduce or minimize exposure by changes in equipment and/or procedures?
- Is any anticipated exposure likely to be at levels above occupational exposure limits?
- What is the probable length of the anticipated exposure – will it be short (after which decontamination can be immediately accomplished) or will it be lengthy?
- Is the exposure likely to occur only once or twice a month (as when product is sometimes spilled during unloading or transfer operations), or is it expected to occur more frequently?
- Is "single-use" equipment desirable and/or available?
- What is the most effective and efficient respiratory protective equipment for a given exposure period and concentration?

Note: The safety data sheet suggests that air-purifying respirators, supplied-air devices, or self-contained breathing apparatuses be used, depending on the nature and duration of the exposure.

Areas in which allyl chloride is stored or used (including processing areas, workstations, laboratories, etc.) should be equipped with the following:

- Eye wash fountain
- Safety shower
- Ventilation system capable of safely carrying away noxious fumes and odors, and with the ability to provide an adequate supply of fresh air
- Fire extinguishing and personal protection equipment, including water fog, foam, alcohol foam, CO_2 or dry chemical fire extinguishers, and self-contained, positive-pressure breathing apparatus
- Clean cloth towels, soap, and water

Personal Protection

- Disposable bench paper and utensils to minimize contact and reduce the possibility of contamination

Note: Take care that contaminated disposable items and materials do not become a fire or health hazard to other employees, including janitors and persons in charge of disposal.

Protective Clothing

Even well-engineered systems will generally require the use of some personal protective clothing, especially in the event of spills, leaks, or other events and activities where there is a possibility of exposure.

For personnel who unload tanks, tank cars, tank trucks, sampling lines, etc. – or when there is other potential for gross contact – proper protective clothing and equipment should include:

- Chemical workers goggles (mono-goggles)
- Hard hat and face shield
- Impervious gloves and boots
- Chemical-impervious suit (coat and trousers – trouser legs should be worn outside of the boots and sleeves should be taped to gloves to prevent chemical contact with the skin)
- Full-face respirator with approved organic vapor cartridges (for low, short-term exposure) or positive-pressure, supplied-air, or self-contained, positive-pressure breathing apparatus (for unknown concentrations or for those substantially above the threshold limit values); for emergency situations, use a self-contained, positive-pressure breathing apparatus

When working with relatively small quantities of allyl chloride, as in a laboratory, suggested employee clothing should include:

- Chemical workers goggles (mono-goggles)
- Impervious gloves, apron, and boots

When working with heated agents — i.e., above 60˚C (140˚F) — proper protective clothing and equipment should be worn to protect against thermal burns and the inhalation of fumes or vapors. This should include:

- Chemical workers goggles (mono-goggles)
- Hard hat and face shield
- Chemical-impervious slicker suit (coat and trousers) of acceptable materials of construction (see Table 4)
- Impervious gloves that provide thermal burn protection
- Impervious boots
- Self-contained, positive-pressure breathing apparatus

Employees should be taught the proper method of putting on and taking off protective clothing and equipment. For example, contaminated protective clothing can be a source of skin contact. Thus, care should be taken to remove gloves and other protective clothing without exposing clean skin to contact with allyl chloride.

It may be helpful to use "tapered plastic glove inserts." The insert is placed inside the glove. The glove is then inserted down through the sleeve and taped in place on the outside. In this way, the gloves remain attached to the jacket sleeves, preventing any product from getting between the sleeve and the glove. This also allows the jacket and gloves to be removed in one piece. The jacket should then be placed on a hanger, sprayed with clean water, and hung up to dry, ready for reuse.

Clothing type, make, and materials of construction should be evaluated using an "exposure control management" approach that evaluates each potential exposure situation. For example, protective clothing for splash protection (that is disposed of or immediately cleaned after exposure) may not need to be as durable as protective clothing for continuous exposure conditions. It is also important to recognize the hazards associated with each kind of material. For example, leather goods can be hazardous when they have been contaminated. That is, leather can absorb allyl chloride and maintain a continuous low level of exposure over a prolonged period of time. The result can be a serious burn. In fact, such burns have been severe enough to require skin grafts. Thus, leather clothing and other leather items should be promptly destroyed if they become contaminated.

In short, when choosing impervious protective clothing, the intrinsic barrier property of the material is only one factor to consider. Other factors that affect performance include:

- Thickness of the material
- Fabrication techniques, with particular reference to the closing or sealing of the seams
- Whether or not the material or garment is lined, laminated, or treated
- Physical strength of the material, including resistance to abrasion, tearing, etc.
- Resistance to damage or loss of effectiveness due to exposure to heat, cold, water, and/or chemicals

Finally, it is suggested that customers obtain information from manufacturers and/or suppliers of protective clothing and equipment about the performance of their products under various work-related conditions. Also, customers should ask specifically about the resistance of these items to Olin Allyl Chloride.

Training

Training for personal and plant safety has value only to the extent that it is fully and properly implemented and practiced by all personnel involved. Thus, a comprehensive and on-going training program in the handling, use, storage, and disposal of allyl chloride is strongly recommended. Additional training – and periodic retraining – in emergency procedures is also recommended.

Finally, both employees and supervisors should be familiar with:

- Health hazards associated with allyl chloride
- First aid procedures
- Spill and leak containment and cleanup
- Disposal methods and regulations
- Fire and explosion hazards and preventive measures
- Personal protection and plant safety

In addition, all workers must be thoroughly trained – and periodically retrained – in the nature, use, and effectiveness of the various items of personal protective equipment. Training should also be documented and reviewed with the worker on a periodic basis. Workers should also be instructed on how to wear, use, clean, and maintain all items of protective equipment.

Note: The use of air-purifying respirators requires medical approval of the worker. Also, a "fit test" should be conducted to ensure effective protection.

Remember...

- Training of personnel in the correct use of protective equipment is the key to a successful program of personal protection. Without a thorough understanding of how protective equipment works, its limitations, and correct maintenance procedures, the required levels of personal protection and safety are not likely to be achieved.
- Specific issues, such as the toxicity of allyl chloride vapors via the skin and the various protective measures that should be taken to avoid exposure, should be a part of the employee training program.

Table 4: Protective Equipment Parameters

Item	Considerations
Respiratory Protection	• When low, short-term exposures are anticipated, use a full-face respirator with approved organic vapor cartridges • For unknown concentrations or those substantially above the threshold limit values, use a positive-pressure, supplied-air, or self-contained, positive-pressure breathing apparatus • For emergency situations, use a self-contained, positive-pressure breathing apparatus
Eye Protection	• Chemical workers goggles (mono-goggles)
Clothing, Gloves, Boots	• Polyethylene (PE)/polyethylene vinyl alcohol/ polyethylene laminate, Teflon[1] FEP (poly[hexa-fluoro-propylene-cotetra-fluoroethylene]), and Teflon provide outstanding inherent barrier properties • Polyvinyl alcohol (PVA), chlorinated polyethylene (CPE), and butyl rubber (polyisobutylene) can be designed to provide various levels of barrier properties • Viton[2] fluoroelastomers, polyvinyl chloride (PVC), and neoprene rubber are penetrated more readily

Note: Protective rubber clothing gives adequate protection for occasional liquid contact. However, liquid in continuous contact, even with heavy rubber, neoprene, or equivalent (20 mils or greater), may penetrate in as little as 15 minutes. Do not use thin rubber clothing. Frequent washing of allyl chloride from the rubber greatly increases use time before penetration. Wash contaminated rubber clothing with soap and water and dry, at least overnight, in a moving stream of air. Polyethylene and polyvinyl chloride give very short-term protection. Do not wear leather articles, including shoes. Leather cannot be decontaminated.

[1]Teflon™ is a registered trademark of E.I. du Pont de Nemours and Company or its affiliates
[2]Viton™ is a registered trademark of The Chemours Company

Ventilation

Good mechanical ventilation is the standard method for controlling employee exposure to the airborne vapors of allyl chloride and/or solvents. Take care that the ventilation system design does not place workers between the source of vapors and the exhaust duct. A constant supply of fresh, uncontaminated air should always be available to all work areas.

Attention must also be given to the vapors of any solvents used in formulating or processing allyl chloride. PELs established by OSHA or threshold limit values (TLV) established by ACGIH should be strictly observed. For example, the ACGIH has established a TLV of 1 ppm allyl chloride in air, based on a time-weighted average (TWA) of an 8-hour workday, and a short-term (i.e., 15-minute TWA) exposure limit of 2 ppm. OSHA has established its PEL at this same level. The National Institute for Occupational Safety and Health (NIOSH) recommends that exposure to allyl chloride be controlled to a concentration no greater than 1 ppm of air by volume, which is the TWA for up to a 10-hour workday in a 40-hour work week, or a short-term exposure limit of 2 ppm for any 15-minute period.

In addition, it should be noted that although allyl chloride has a strong, disagreeable, pungent odor, the odor threshold (which has been estimated at 3 to 6 ppm) is not an adequate means of warning against overexposure. Also, personal protective and emergency safety equipment should not be relied on as the primary means of protection against exposure to allyl chloride. Rather, prevention of exposure should be the preferred precautionary measure.

However, if exposure to concentrations above the various guidelines is unavoidable, an approved positive-pressure, air-supplied, or self-contained breathing apparatus with full face piece should be used.

Note: Tanks and reactors must not be entered until they have been thoroughly washed, purged, and tested for the presence of allyl chloride vapor. Also, the presence of an adequate concentration of oxygen (i.e., 21 percent) should be demonstrated with an oxygen meter test.

Finally, while good ventilation is important, it cannot replace a closed, leak-tight system. All aspects of the handling operation – from delivery through reaction – must be carefully evaluated for the potential of exposure.

For example, such activities as sampling should receive particular attention. Procedures that prevent exposure should be thoroughly explored, tested, and evaluated, and, if found effective, should become established practice. These include the use of vapor return lines during product transfer, the use of dry disconnect fittings for transfer hoses, the use of automated sampling systems, and the like.

Table 5: Key Regional/Country Occupational Exposure Level (OEL) Values for Allyl Chloride.

Country/Region	OEL	Units	Comments
US: OSHA PEL	1	ppm	3 mg/m³ TWA (8-hr work day)
US: NIOSH	1	ppm	For a maximum of 10-hr work day; 40 hr/week
ACGIH	1 (3)	ppm (mg/m³)	TLV-TWA (8 hr); A3 (Confirmed Animal Carcinogen with Unknown Relevance to Humans) ACGIH, 2011
*DNEL	1.1	mg/m³	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.

Fire and Explosion Hazards

Flammability

Although allyl chloride has many useful and important properties and characteristics, it should be noted that the product is "extremely flammable" and that its vapors can, under certain conditions, cause flash fires and explosive mixtures with air. In addition, certain chemical components used in processing and/or formulating with allyl chloride may also pose a hazard of fire and explosion. Also, in a fire situation, sealed or tightly closed containers of allyl chloride or other formulating materials could rupture. The ignition of the contents could then significantly increase the magnitude of the fire.

A common measure of flammability is flash point temperature. This value indicates the minimum temperature at which flammable conditions are produced under controlled laboratory or experimental conditions at atmospheric pressure. These values for allyl chloride are as follows:

Flammable Properties

- Flash Point -32˚C (-25˚F)
- Method Used Tag Closed Cup
- Autoignition Temperature 392˚C (738˚F)

Flammability Limits

- Lower Flammability Limit 3.3% by volume in air
- Upper Flammability Limit 11.1% by volume in air

Also, under fire conditions, high-temperature polymerization may occur, accompanied by the exothermic release of still more heat and higher temperatures.

Products of Decomposition

Caution is needed in predicting the byproducts of thermal decomposition. The products generated, and their concentrations, depend on whether pyrolysis or combustion, or a combination of the two, occurs. Also important is the temperature of the decomposing materials and whether the surrounding atmosphere is oxygen rich or oxygen poor.

The byproducts expected in the combustion of allyl chloride may include carbon dioxide and carbon monoxide, as well as undetermined amounts and concentrations of unidentified organic compounds. Thus, the thermal decomposition products of allyl chloride should be considered potentially hazardous and appropriate precautions should be taken, including the wearing of full protective clothing and respiratory protective equipment.

Note: Full protective clothing and equipment should include a hard hat, a self-contained, positive-pressure breathing apparatus, and a minimum of a slicker suit or bunker coat and pants, fire fighter's boots, and fire-resistant gloves.

Extinguishing Fires

General Comments

- At the first report of a fire, an appropriate alarm should be sounded and all non-firefighting personnel should immediately leave the affected area

Note: Be sure to evacuate personnel upwind and well away from possible exposure to vapors, fire, and/or explosion.

- Any leaks or open vents or valves should be immediately shut off or closed
- Any nearby containers – including small tanks or drums – exposed to excessive heat should be cooled with a heavy cold water spray

Note: Do not attempt to put out fires at open vents, spigots, or valves until the flow of product has been shut off.

- If a small puddle or pool of product from a leak or spill has not caught fire, use water spray to disperse the vapors and to provide protection for those attempting to stop the leak. Water spray may also be used to flush product away from possible exposure to sources of ignition.

Small Fires

- Use a dry chemical or CO_2 extinguishing agent

Large Fires

- Use a water fog, water spray, or CO_2 extinguishing agent

Very Large or Massive Fires

- Use unmanned or remote control hose holders or monitor nozzles. If this is not possible, withdraw from the affected area and allow the fire to burn itself out.
- If additional product is leaking or spreading, attempt to contain the leaked material by constructing a dike. Be sure, however, to prevent runoff from entering sewers and natural water sources.

Caution

- Given that allyl chloride is lighter than, and only slightly miscible in, water, it will float on water surfaces. Thus, water may spread the product and increase the potential for a more widespread fire.

Fire and Explosion Hazards

Note: The miscibility of allyl chloride in water is 0.33% at 20˚C [68˚F].

- Water fog is recommended primarily for cooling containers; it is not, however, recommended for extinguishing ditch (or deep) fires, involving a large quantity of product.
- Firefighters must be appropriately dressed and equipped. This should include a full complement of protective clothing (including rubber gloves and chemical workers boots) and respiratory protective equipment (including a positive-pressure, self-contained breathing apparatus).
- For allyl chloride to remain below the flammable range in a tank or other vessel, the oxygen content in the vessel must be below 10.3 mole percent; however, allowing for any possible analytical, instrument, or operational errors, it is strongly recommended that the oxygen content be 8.0% or less.
- The vapors of allyl chloride are heavier than air and may travel a considerable distance, undetected, to a source of ignition and then flash back. The result could be a large fire and/or explosion.
- At elevated temperatures, as in fire conditions, heat-activated polymerization may occur. If polymerization takes place in a sealed or tightly closed container, there is a strong possibility of a violent explosive rupture.

Static Electricity

Many operations in processing and/or formulating with allyl chloride can generate static electricity, and static charges can, under certain conditions, cause fires and explosions, especially in areas where flammable solvents or other materials are used or stored.

For example, static charges can sometimes be generated when the product is transferred from a tank or other container to a storage vessel or processing line. Thus, tanks and lines should be well bonded and grounded. A nitrogen pad in storage tanks is also recommended, as this can prevent oxidation of the product.

Note: Submerged filling is required for all flammable liquids. To accomplish this, the inlet line should discharge at, or near, the bottom of the tank and should make electrical contact with the tank to prevent uncontrolled static buildup.

Operators wearing rubber-soled shoes may pick up considerable static electricity, particularly on certain composition floors made of effective insulating materials. Thus, attention should be given to the:

- Grounding of all process equipment
- Use of static collectors and eliminators
- Use of adequate ventilation and good housekeeping to reduce vapor concentrations
- Use of conductive flooring materials

Reactivity

Allyl chloride is a highly reactive organic intermediate and, as such, must be handled, used, and stored with care. For example, exposure to certain materials (such as aluminum) and/or heat can cause exothermic or heat-generating polymerization and other reactions that pose the threat of fire and explosion. Thus, contact with these materials and exposure to excessive heat must be avoided.

Also, and given that all allyl chloride reactions are exothermic, take care to control excessive exotherms, which could result in overheating of the product and possible thermal decomposition. Variables that directly affect the degree of temperature rise include:

- Amount and configuration of the formulated product
- Temperature of the formulation
- Charge ratio of allyl chloride and other formulation ingredients
- The degree of reactivity of the various formulation ingredients
- Conditions of temperature and pressure to which the formulation, or certain of the ingredients, are exposed
- The kind and quantity of chemicals and other materials (including the materials of construction) to which allyl chloride, or the allyl chloride formulation, is exposed

Before changing any one of these six variables, the process should be carefully reviewed to determine the effect of the change. For example, one potential for an excessive temperature rise is related to batch size. While a small amount (25 to 50 grams) of formulated allyl chloride rarely causes excessive temperature rise problems, even with fairly reactive ingredients, large batches (i.e., 10-20 gallons [38-76 liters] or larger) may cause significant problems. This is because the heat of reactivity builds up, causing a faster reaction rate, which can result in a still greater rate of heat generation. However, excessive temperature rises can be avoided by taking two precautions:

- Knowing and understanding the effects, and potential effects, of formulation changes
- Designing the process to anticipate the worst possible conditions – e.g., having a cooling system capable of removing heat generated by a double charge or an agitator or pump failure

It is also suggested that whenever a major formulation change is made, a small test batch should be compared to the original formulation for temperature profile changes. If there is a significant or excessive temperature rise, minimize employee exposure to decomposition products and, if possible, create a heat sink. The exact procedure depends on both the size of the batch and the nature of the formulation. Emergency procedures used to cool an exotherming mass include covering the mass with water or spreading the mass over a large surface area. Take care, however, to prevent the mass from flowing down drains. To minimize employee exposure to decomposition products, evacuate personnel from the immediate area and, if possible, transport the mass to a well-ventilated area.

Back flow of one material into another through piping systems must also be prevented by good design.

Finally, the proper sequence of formulating or compounding must be followed. There is no substitute for a well-trained – and knowledgeable – workforce in preventing dangerous and costly mishaps. Training should include knowledge of what will happen when certain equipment fails and/or incorrect formulations are prepared. Proper discipline in handling, storing, labeling, and confirming raw material analyses can prevent mixing together the wrong materials.

Spills and Leaks

Personnel must be thoroughly trained in safe procedures for handling spills and leaks and for the disposal of wastes. In disposing of wastes, be certain that all applicable federal, state, provincial, and local laws and regulations are fully met.

Spills and Leaks

Spill Containment and Cleanup

The primary concerns in any spill, large or small, are:

- To protect all personnel from eye and skin contact, from exposure to vapors, and from the possibility of fire and/or explosion
- To keep the spilled material from entering ground water, water supplies, or waterways
- To keep the spilled material from coming into contact with reactive chemicals or other reactive materials
- To prevent the spilled product from coming into contact with a source of excessive heat or ignition
- To make certain that all persons engaged in spill containment and cleanup are adequately trained in the proper (i.e., safe) methods and techniques of containment, collection, cleanup, and disposal

To meet these concerns:

- All personnel engaged in spill cleanup should wear appropriate protective clothing (including impervious gloves and boots) and a self-contained, positive-pressure breathing apparatus
- For small spills (less than 5 gallons [19 liters]), apply an absorbent or high-surface-area material (e.g., sand or ground polyolefins, such as polyethylene or polypropylene), leave in place until all traces of liquid product are gone, and then shovel the mass into a suitable container for disposal

Note: Dry sand, polyethylene, or propylene-based absorbents are suitable for use with allyl chloride. The advantage of polypropylene-based absorbents lies in their ability to be incinerated without creating a large ash load in the incinerator. Two specific polypropylene absorbents tested by Olin are HazMat Pig® absorbent – from New Pig Corp., One Pork Ave., Tipton, PA 16684-0304, (814) 684-0101 – and Polysorb® absorbent – from Lab Safety Supply, Inc., P.O. Box 1368, Janesville, WI 53547-1368, (608) 754-2345. Other absorbents may be suitable, but should be tested prior to use for reactivity with allyl chloride.

Avoid contact with absorbent materials such as a clay-based absorbent.

- In the event of a larger spill (greater than 5 gallons [19 liters] or more), evacuate and rope off the spill area; keep all employees upwind and away from the spill. Have properly trained and equipped personnel shut off all leaks and potential sources of ignition. The spill should then be contained with a dike to prevent water pollution. For more volatile compounds or ingredients, dilute vapors with water fog or spray. Then, with an air-driven pump, collect as much of the spilled allyl chloride as possible and place in an appropriate container for final disposal.

Note: Suppliers and products identified in this manual are referred to in good faith, but no endorsement is made. It is the customer's responsibility to research available suppliers and products and to make the appropriate selection.

- The use of organic solvents during cleanup is hazardous and should be avoided. If the allyl chloride is in a solvent solution, be aware of the potential increased possibility of fire. Use cleanup tools that are non-sparking. Also, remove all possible sources of ignition from the spill area and have firefighting personnel – trained in fighting chemical fires – near at hand.
- For final cleanup, scrub the floor with soap and water, then rinse with very hot water

Note: Wash/rinse water should be contained and collected for proper disposal. Also, prevent wash/rinse water from entering natural waterways or public water supplies. Advise appropriate authorities if spilled product or wash/rinse water enters public land, water supplies, or waterways.

Self-Protection

Skin

Wear appropriate protective clothing. Specific protective clothing depends on the nature and size of the spill and on the potential for exposure, but should, at a minimum, include clothing that covers the body and protects the skin, such as chemical-impervious suits, gloves, and boots.

Note: If the allyl chloride has been heated, be sure to protect against the possibility of thermal burns and the inhalation of vapors.

Eyes

Wear, at the very least, chemical workers goggles or mono-goggles.

Inhalation

Suitable respiratory equipment should be used depending upon the potential for exposure. When exposure to unknown concentrations of allyl chloride is imminent or anticipated, as in a spill or leak, workers should wear a self-contained, positive-pressure breathing apparatus, or its equivalent. If solvents have been used to prepare a formulation, take precautions to avoid overexposure to solvent vapors.

Extinguishing Fires

If possible, shut off or remove all ignition sources. Have firefighting equipment and personnel trained in its proper use nearby. (See "Fire and Explosion Hazards," page 18.)

Distribution Emergency Response

Distribution Emergency Response (E/R) is the Olin system for advising and assisting carrier, warehouse, terminal, or public emergency service personnel when they are confronted with an emergency that occurs in the distribution of Olin products. E/R is a part of Olin's commitment to Product Stewardship. Through E/R, timely advice can be provided in an emergency situation. This is essential if persons involved are to regain control of the situation and minimize harmful effects. Key E/R personnel include:

- Phone personnel – trained in obtaining and relaying information during emergencies, and able to provide immediate response information, if needed
- Medical personnel – knowledgeable in what to do if there have been exposures or injuries involving Olin products
- Technical personnel – familiar with Olin products, transportation equipment, and handling emergencies in public areas

Note: See back cover for country-specific telephone numbers. A call to any of these numbers will immediately put you in touch with knowledgeable and experienced persons who can assist in solving emergency-related problems. Always consult the appropriate and most current safety data sheet prior to handling emergency responses.

Disposal

Olin Allyl Chloride is best disposed of by controlled burning in an approved incinerator, equipped with a hydrochloric acid scrubber. However, whatever method is ultimately used, be certain that it is in full compliance with all federal, state, provincial, and local laws and regulations governing the identification and disposal of hazardous wastes. Refer to 40 CFR[1], Section 261. For additional information, see "Reactivity" (Section 10) or "Regulatory Information" (Section 15) in the current Olin Allyl Chloride safety data sheet.

[1]Abbreviation for U.S. Code of Federal Regulations.

Check the Safety Data Sheet for Country Specific Regulatory information or contact Olin Customer Care at info@olinbc.com.

Other Regulatory Acts and Information

Superfund Amendments and Reauthorization Act

Allyl chloride is subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act

(SARA) of 1986 (CFR 40, Part 372). Also, allyl chloride has been reviewed according to the EPA "hazard categories" promulgated under SARA, Sections 311 and 312, and is considered (under applicable definitions) to be:

- An immediate health hazard
- A delayed health hazard
- A fire hazard

Occupational Safety and Health Administration

Allyl chloride is a "hazardous chemical," as defined by the Occupational Safety and Health Administration's (OSHA) "Hazard Communication Standard," CFR 29, 1910.1200.

National Fire Protection Association

According to the various definitions, categories, and ratings developed by the National Fire Protection Association (NFPA), allyl chloride is rated as follows:

Category	**Rating**
Health	3
Flammability	3
Reactivity	1

California Safe Drinking Water and Toxic Enforcement Act

The following statement is made in order to comply with "California Proposition 65" of the California Safe Drinking Water and Toxic Enforcement Act of 1986: "This product contains a chemical(s) known to the State of California to cause cancer."

Note: If you have questions about specific regulatory requirements or if you need information about disposal procedures, facilities, etc., please contact your Olin sales representative or call the nearest Olin Customer Information Center. (See back cover for country-specific contacts and telephone numbers).

Laboratory Disposal

If a facility generates less than 1,000 kilograms of hazardous waste per month, it may be exempt from most RCRA requirements.

Note: The determination of regulatory status and waste characterization are the sole responsibility of the generator.)

However, even small amounts of Olin Allyl Chloride must be disposed of properly. For example, laboratories using allyl chloride should have a container for the collection of wastes. This should be located away from the workstation in an area with adequate ventilation for vapor removal. The container should also be properly grounded. In addition, wastes should be segregated according to reactive hazards and recommended disposal procedures. Contaminated articles, such as plastic beakers, should be collected in a plastic-lined container. All wastes should be clearly labeled to protect personnel who may be unfamiliar with the hazards associated with the handling of allyl chloride.

Note: If a facility generates, treats, stores, or disposes of more than 1,000 kilograms of hazardous waste per month, the facility is subject to the applicable RCRA rules. See 45 CFR 33066, et al.

Environmental Information

Allyl chloride is moderately toxic to aquatic organisms on an acute basis. Fish appeared to be the most sensitive species to allyl chloride and harmful effects were found. It has to be noted that for most of the tests, volatility was not taken into account and that test results may have underestimated the intrinsic toxicity of allyl chloride.

Allyl chloride is considered moderately biodegradable. The potential for mobility of allyl chloride in soil is high. Because of its high vapor pressure, it tends to accumulate in the air.

Storage Equipment and Design Considerations

The product storage guidelines in this section are only general in nature and should be used in conjunction with the advice and assistance of storage equipment manufacturers and qualified professional engineers who have had experience in designing chemical storage facilities and off-loading stations and systems. To be of service in this process, Olin Product Stewards can help evaluate engineering suggestions and can assist with ecological and product safety considerations. Olin Product Stewards can also provide technical assistance during equipment installation, can review or evaluate off-loading and storage sites prior to first delivery, and can assist off-loading and storage personnel with the requirements for a safe delivery and storage system.

For information, advice, and/or assistance, contact your local Olin representative or call the nearest Olin sales office.

Tanks

Tank Types and Models

The suggested storage tank for allyl chloride is an American Petroleum Industry (API) Type 620 tank that uses a nitrogen pad of approximately 6-10 psi (400-700 mbar). American Standard Mechanical Engineering (ASME) code vessels with higher pressure ratings are also excellent choices. Whichever tank model is chosen, however, it should be designed, constructed, installed, and used in accordance with the appropriate national codes for allyl chloride.(National Fire Protection Association [NFPA] codes are appropriate for North America.) The tank should also meet all local codes and ordinances.

Although horizontal tanks may be used, vertical tanks are suggested because they are usually more economical to install, occupy less space, and provide more accurate tank gauging. Since vertical tanks are available in a variety of diameters, heights, and plate thicknesses, prices will vary. Before purchasing a tank, therefore, furnish the tank supplier with the required capacity and the physical properties of the product to be stored (i.e., allyl chloride), including the flash point, viscosity, specific gravity, etc., and any other design and product information needed for safe storage.

To ensure safe and orderly delivery, the capacity of the storage tank should be large enough to hold the amount of allyl chloride normally shipped in a maximum capacity tank car or tank truck, plus additional working inventory. Also, consider oversizing the tank sufficiently to create a space to accommodate a gas pad and any bubbles that may be created by the gas flow used to clear the lines and piping. And finally, a suitable foundation is required for all sizes and models of allyl chloride tanks.

Materials of Construction

Carbon steel that meets API specifications is normally suitable for tank storage of allyl chloride. Steel (i.e., ordinary, mild, or carbon) is also suggested for tank lines, valves, and fit-tings; however, Monel[1] metal and nickel may also be used.

Note: The use of lined vessels is also suggested, especially if any discoloration or the trace presence of metals is undesirable in the intended use or application of the product. Also, if a coated tank is required, Olin's preference is for a high-baked phenolic coating; however, satisfactory service has also been achieved with ambient-temperature-cured phenolic linings.

There are a number of widely used materials that should be avoided. Their use with allyl chloride can result in varying degrees of hazard:

[1]Trademark of Inco Alloys International.

- Stainless steel – Although used for product transport, stainless steel is **not** recommended as a material of construction for allyl chloride service. This concern about stainless steel is prompted by the fact that chlorinated hydrocarbons and moisture can lead to damaging corrosion, including chloride stress cracking. That is, when a chlorinated hydrocarbon – like allyl chloride – comes in contact with moisture (which can sometimes enter or invade the storage/transfer system), HCl is liberated. The result is often the presence of a Cl ion, which can then lead to chloride stress cracking. Thus, if stainless steel **is** used in allyl chloride storage/transfer systems, great care should be taken to receive **dry** allyl chloride into a moisture-free environment. It must also be **kept dry** during its stay in storage. A well-designed nitrogen pad/depad system can help minimize the amount of moisture or moisture-laden air that might enter the system and the amount of hydrogen chloride that might be formed as a consequence. Finally, the storage/transfer system should be carefully designed (to prevent the entry of moisture or moisture-laden air), carefully monitored for evidence of corrosion and/or chloride stress cracking, and periodically tested.
- Aluminum – This material can cause decomposition and exothermic polymerization, with release of hydrogen chloride. Its use, therefore, must be avoided in storage vessels, piping, fittings, valves, and any part of a relief device or instrument.
- Zinc – Carbonaceous buildup on galvanized parts, along with a release of hydrogen chloride, has been observed in storage
- Alloys containing aluminum and zinc – These alloys include many bronzes and some brass compositions. The hazard may be comparable to exposure to the pure metals (aluminum and zinc).

Storage Equipment and Design Considerations

- Cadmium, copper, and lead – These are not recommended, largely because they produce various degrees of product discoloration
- Cast iron – The use of cast iron for auxiliary equipment, such as pumps and valves, is not recommended because of the brittleness of cast iron

Design Considerations

- Storage tanks must be equipped to relieve excessive pressure and to prevent a vacuum from forming in the tank during filling or emptying. This can be best achieved through the use of pressure relief valves or emergency relief valves of adequate capacity to relieve over-pressure, and vacuum relief valves to prevent the formation of a vacuum.

Note: Open vents – through which allyl chloride could be released into the atmosphere – should not be used.

- Storage tanks must be diked or otherwise contained. Positive drainage to an impound area that avoids exposure to personnel, equipment, or the environment is suggested. The minimum distance from the tank shell to the dike wall should be great enough to prevent trajectories of escaping liquid (from possible leaks) from clearing the dike. Dikes should be designed with adequate capacity to hold a maximum spill – conceivably, the entire contents of the tank itself – and with additional capacity to contain water or foam from vapor suppression and/or fire extinguishing operations.

Note: To avoid overfill, tanks should be equipped with level measurements, alarms, and automatic shut-downs.

- The shell-to-shell separation of tanks should be based on loss prevention principles. Also, water spray rings around the tank are suggested to provide a water deluge when fighting a fire; they can also provide additional cooling for the tank in the event of a fire.

Note: Tanks containing allyl chloride should be isolated or placed widely apart from storage areas containing other reactive chemicals.

- Water spray rings can also be used to deliver foam by injecting a foaming agent into the water supply. Also, the installation of firefighting monitors around the tank and other storage facilities should be considered when developing a total storage system. Again, the fire protection system must be carefully designed by engineering experts who specialize in this service.
- The storage tank should also be equipped with a dry nitrogen gas padding system. An effective system can be incorporated by installing a pressure control or regulator valve on a nitrogen supply line to maintain a minimum pressure or pad. The use of a pad/de-pad system can also serve as a first means of pressure control or pressure relief. This system will not only provide a minimum positive pressure or pad, and protect against excessive pressure buildup, but will also conserve nitrogen. The gas padding system should be designed to provide a source of dry nitrogen in sufficient volume to allow for emptying the tank, for small leaks, and for temperature variations. The presence of the gas pad can also minimize the possibility of oxidation, flammability, and/or polymerization by preventing air and moisture from entering the vapor space over the liquid. A nitrogen pad can also prevent a possible fire hazard by preventing the buildup of flammable concentrations of vapors. Finally, to determine appropriate valve pressures, consult with a qualified engineering service.
- Allyl chloride should be introduced into the storage tank through a dip pipe having a small weep hole near the top. The dip pipe prevents free-fall, and restricts the buildup of static electricity. Also, allyl chloride should only be stored in tanks that have been thoroughly cleaned and dried (i.e., buffed and steamed, water-washed, and dried with an inert gas such as nitrogen).
- Olin suggests that vented material be handled by vapor return, incineration with an acid scrubber, or condensation. Any of these systems will require a careful design by a qualified engineering service.
- Additional features and equipment should include adequate manholes or entrance passages that allow workers to clean or repair tanks, a bottom drain to completely empty tanks when necessary, and two independent level measurement devices. Also, be sure the tank, piping, and pumps are electrically grounded.
- Great care must be taken to prevent "back flow" or the inadvertent addition of any contaminating materials to the storage tank. Prior to start-up, a process hazards analysis should be performed to identify flow, temperature, pressure, equipment failure, operating errors, or other conditions that could create an unexpected hazard.

Auxiliary Equipment

See Table 6, "Auxiliary Equipment and Specifications for Tank Storage of Allyl Chloride," pages 26-27. Please note, however, that the information in the following sections and in Table 6 is not offered as a recommendation of any specific type or model of equipment or as an endorsement of any particular manufacturer or product. Also, the customer is advised to employ a qualified and experienced professional engineering service to design and build its allyl chloride storage and unloading facilities.

Pumps

Pumps used for allyl chloride may be magnetic-drive, seal-less pumps or mechanical seal pumps (centrifugal) with double seal, using a non-toxic inert barrier fluid or N_2 purge, with a dry outer seal. Pump bodies may be plate steel or ductile iron.

Note: Pumps must be of stainless steel only if iron contamination is to be avoided; however, if some iron contamination and/or discoloration are acceptable, ordinary carbon steel, plate steel, or ductile iron may be used. Do not, however, use aluminum, zinc [or alloys containing aluminum or zinc], cadmium, copper, lead, or cast iron.

If a positive displacement rotary gear or screw-type pump is used, it should have either built-in or external relief valves to maintain a safe operating pressure. Also, a combustion gas detector should be located near each allyl chloride pump to detect possible seal leaks.

Gauges

Although there are a number of different methods and techniques for gauging, the standard method involves the use of a differential pressure cell. Also, small tanks can be installed on scales. Other methods, such as differential pressure with a pneumatic or electrical read-out system, electronic probe-type, or weigh cells, also work well but are more expensive. Most applications use a 3-inch (75-mm) diameter differential pressure cell located at the bottom of the tank. For nitrogen padded tanks, an additional 3-inch (75-mm) reference nozzle is located at the top of the tank.

Knowing the temperature of the allyl chloride is necessary to calculate accurately the quantity of allyl chloride in the tank. A dial thermometer in a thermowell at least 36 inches (900 mm) from the bottom of the tank is suggested. The thermometer should extend into the tank at least 18 inches (450 mm).

Storage Equipment and Design Considerations

Gaskets

Commonly accepted gasket materials and products for process lines and equipment include spiral wound, 304 stainless steel or Monel[1] winding, with polytetrafluoroethylene (PTFE) or flexible graphite filler (API 601) for ASME/ANSI flanges with carbon steel centering rings, or filled PTFE or reinforced graphite flat-ring gaskets. For specific product suggestions and product specifications, see Table 6.

Grounding

Storage tanks (including reactors and formulating vessels) must be grounded to prevent static electricity buildup. Loading lines should have an anti-siphon hole or weep hole and a dip leg inside the tank that extends to near the bottom of the tank. Also, provisions should be made for positive attachment of all grounds to ensure dissipation of all static charges. Unsecured grounds should not be permitted. An automatic ground indicator (such as the Crouse-Hinds Automatic Ground Indicator, Model EGL 210-J1-J3 or equivalent) is suggested. (See Table 6, pages 26-27.)

Filtration

Olin Allyl Chloride is filtered at the time of loading for shipment. This filtration removes suspended particles that are 25 microns or larger in size. However, even after this careful filtering, foreign particles are sometimes picked up during handling. It is suggested, therefore, that a filter be installed as close to the point of use as is practical in the pump discharge line leading from the storage tank.

Ful-Flo[2] filter cartridge number 13R10ZV or equivalent can supply allyl chloride that is technically free of insoluble particles. This filter cartridge will have a voile cover on the core, which prevents the filter fibers from coming through with the allyl chloride, and a wire core, which is desirable when using a positive displacement pump.

Note: It is necessary to advise the filter manufacturer of the operating pressure of the system if it is in excess of 100 psig [7 bar].

Finally, bag-type filters may also be suitable. They are, in many cases, easier to handle than cartridge filters.

Piping

Extra strong, butt-welded, seamless carbon steel piping with exterior painting is suggested for permanent installations. Such a system reduces maintenance costs, leakage, spills, fugitive emissions, and the long-term cost of ownership. Flanged pipes, valves, and fittings are the most efficient – but most expensive – system that can be used. Steel pipe with welded steel fittings is more economical but requires more maintenance. Also, threaded connections tend to leak more frequently than flanged connections. Therefore, flanged and welded connections are strongly suggested. However, if threaded connections on steel pipe are used, be sure to apply an effective thread compound, such as thread tape made of Teflon[1] polymers. Also, no steam tracing should be used on piping.

The design of a piping system should prevent excessive strain by including proper support for the pipe. Provisions must also be made for contraction and expansion. If possible, install the lines with small drain valves at the low points to make it easy to drain the lines completely. Also, the piping system should be pressure checked before being placed in service, and the lines should be cleaned and dried (i.e., -40°C dew point) before filling them with allyl chloride. Exterior painting is also suggested.

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[1]Trademark of E.I. du Pont de Nemours & Company.

For allyl chloride, flanged ductile iron plug valves with plastic sleeves made of Teflon are more economical than flanged ball valves. If, however, flanged ball valves are chosen, valves of 2 inches (5.08 cm) or more in size are suggested; also, screwed steel ball valves are best in 1.5 inches (3.81 cm) or less. Also, gear-operated handles are suggested on plug valves over 3 inches (7.62 cm). Air pistons allow the valves to be operated remotely and are both efficient and convenient. Standard filled Teflon or reinforced graphite flat-ring gaskets for pipe flanges are satisfactory. (See Table 6, pages 26-27.)

Note: For specific information on pipe size, types of valves, etc., see Table 5; also, consult with a professional engineering firm. You may also wish to discuss pipe and valve specifications with an Olin Product Steward or Technical Service representative. If so, contact your local Olin representative or call, fax, or write your nearest Olin location.

Loading and Unloading Hoses

Polypropylene hoses with an inner wire construction or with polyvinyl chloride (PVC) linings and a galvanized outer wire are suggested. Stainless steel flexible hoses may also be used; however, hoses containing aluminum, zinc (alloys containing aluminum or zinc), cadmium, copper, lead, or cast iron should **not** be used. Also, do not use hoses made of rubber or Viton[1] fluoroelastomers.

Note: Tank loading lines may connect at the top or bottom of the tank. With a top connection, the allyl chloride should be fed through a dip pipe (equipped with an anti-siphon hole) toward the bottom of the tank. This will help reduce electrostatic charge (see "Grounding"). Block valves are suggested on all tank line connections. A bottom drain valve is also desirable for draining the tank.

Caution

Storage systems should be designed to prevent drainage of spilled or waste product into sewers, waterways, or other areas where environmental damage or accidental contact with persons could occur. Also, it is recommended that a tank be restricted (or dedicated) in its use to allyl chloride. Product mixing in a tank or in lines and hoses can negatively affect both product purity and performance. It can also be dangerous, especially if the product in question should be highly reactive to allyl chloride. In such cases, a highly exothermic reaction could occur, which, in turn, could lead to a pressure increase sufficient to rupture the tank.

Specifications/Schematics

Upon receiving a bulk shipment of allyl chloride, customers should take a sample of the product from the tank truck or tank car for positive identification. This should be done before any of the product is transferred to the storage tank. Also, before using transfer lines that have been used for other chemicals, consult with an Olin Product Steward or an Olin Technical Service representative. Technical Service and Development (TS&D) personnel may be contacted by calling the Olin location nearest you. (See back cover for country-specific contacts and telephone numbers.)

(See Table 6 and Figure 3, "Bulk Storage and Tank Truck Off-Loading Schematic for Allyl Chloride," pages 25-26.)

Storage Equipment and Design Considerations

Table 6: Auxiliary Equipment and Specifications for Tank Storage of Allyl Chloride

Item	Size	Description
Pipe	1/2" – 1-1/2" 1" – 4" 2" – 36"	Extra strong, seamless ASTM A-106 GR B, carbon steel Schedule 40, ERW, ASTM A-587, carbon steel Standard weight, ER W, ASTM A-53 Type E GR B or API 5L GR B, carbon steel
Fittings[1] E, L, T, R E, L, T, R C C PC PC SC	 1/2" – 1-1/2" 2" – 24" 1/2" – 1-1/2" 2" – 24" 1/2" – 1-1/2" 2" – 24" 1" – 4"	 Butt welding, extra strong, seamless, ASTM A-234 GR WPB, carbon steel, ASME B16.9 Butt welding, standard weight, seamless, ASTM A-234 GR WPB, carbon steel, ASME B16.9 Butt welding, extra strong, forged, ASTM A-105, carbon steel, ASME B16.9 Butt welding, standard weight, forged, ASTM A-105, carbon steel, ASME B16.9 Butt welding, extra strong, seamless, ASTM A-234 GR WPB, carbon steel, ASME B16.9 Butt welding, standard weight, seamless, ASTM A-234 GR WPB, carbon steel, ASME B16.9 Stub end, standard weight, ASTM A-234 GR WPB, carbon steel, ASME B16.9 *Note: Test or drain connections can be provided using 3,000#, 3/4" forged steel thredolets, which are closed with a threaded carbon steel hex plug during actual service; instrument connections shall be 1" flanged minimum*
Flanges	1" – 4" 1/2" – 1-1/2" 2" – 24" 1/2" – 24"	Lap joint, class 150, ASTM A-105, carbon steel, ASME B16.5 Welding neck, class 150, raised face, ASTM A-105, carbon steel, ASME/ANSI B16.5, bore to match extra strong Welding neck, class 150, raised face, ASTM A-105, carbon steel, ASME/ANSI B16.5, bore to match standard weight Slip-on, class 150, raised face, ASTM A-105, carbon steel, ASME/ANSI B16.5
Branch Connections	–	Branch lines shall be standard tees, reducing tees, or connections welded without reinforcement for all sizes
Gaskets	–	Spiral-wound, 304 stainless steel or Monel winding, PTFE or flexible graphite filler, 0.175" thick, API-601 for ASME/ANSI B16.5 flanges, carbon steel centering ring, no inner ring Flat ring: filled PTFE, 1/16" thick, Garlock Gylon 3510 or Durabla Durlon 9000 flat-ring gaskets
Flange Bolts	–	ASTM A-198 Grade B7 liquid-quenched and tempered alloy steel stud bolts with ASTM A-194 Grade 2H heavy hex nuts (or fluoropolymer-coated version) *Note: Apply bolt lubricant to full length of threads (on uncoated bolts only)*
Bolt Lubricant	–	Fel-Pro C5-A, jet lube SS-30, Federal Process Co. Thred-Gard Copper/Never Seez, Dow Corning BR-2 Plus Mult-P, Lawson Lubritemp Mark XXII
Gate Valves	1/2" – 1-1/2" 2" – 24"	Class 150, raised face, flanged, ASTM A-105, forged carbon steel body, OS&Y, rising stem, reduced port type, bolted bonnet Class 150, raised face, flanged, ASTM A-216 GR WCB cast carbon steel body, OS&Y, rising stem, full port type, bolted bonnet; PTFE or flexible graphite packing
Globe Valves	1/2" – 1-1/2" 2" – 14"	Class 150, raised face, flanged, ASTM A-105, forged carbon steel, OS&Y, rising stem type, bolted bonnet Class 150, raised face, flanged, ASTM A-216 GR WCB cast carbon steel body, OS&Y, rising stem type, bolted bonnet
Ball Valves	1/2" – 4"	Class 150, raised face, flanged, ASTM A-216 GR WCB cast carbon steel body, top entr y, bolted bonnet, ASTM A-193 GR B7 liquid-quenched and tempered bolting, flexible graphite body seal, 316 stainless steel stem, 316 stainless steel ball, reinforced PTFE seating, fire safe rating
Plug Valves	1/2" – 4"	Class 150, raised face, flanged, ASTM A-395, ductile iron body, bolted bonnet, ASTM A-193 GR B7 liquid-quenched and tempered bolting, ductile iron plug, PTFE or PFA diaphragm, PTFE sleeve, wrench-operated
Check Valves	1/2" – 1-1/2" 2" – 24"	Class 150, ASTM A-216 GR WCB, cast carbon steel body, wafer insert type, PTFE seating, 316 stainless steel spring Class 150, raised face, tapped lub/lfg, ASTM A-216 GR WCB, cast carbon steel body, wafer type, disc carbon steel, metal seating, spring, Inconel, ASME B16.5/B16.47 Series A
Multiport Ball Valves	1-1/2" – 4"	Transflo, Class 150, raised face, flanged, ASTM A-216 GR WCB, cast carbon steel body, 3-way, 2-port, 90 degree turn, full-port type, ASTM A-193 GR B7 liquid-quenched and tempered bolting, PTFE body seal, 316 stainless steel stem, 316 stainless steel ball, PTFE seating, PTFE stem seals or packing
Dry Break or Dry Disconnect Valves	1-1/2" – 2"	CIVACON, Part numbers 1775D-0150 and 1673AN-0150 and 1775D-0200 and 1673AN - 0200 for the 1-1/2" and 2" female couplers and male adaptors respectively
"O" Rings	–	PTFE, EPDM, EPR, Kalrez 4079
"V" Rings	–	PTFE
Pumps	–	Seal-less pump, preferably magnetic drive used in clean service Mechanical seal pumps (centrifugal), double seal using non-toxic purge or N2 with a dry outer seal Pump body duplex stainless steel; CD4M (cast) or 2200 series (plate) stainless steel, or ductile iron or 316 stainless steel; volute case gasket, glass-filled PTFE or PTFE envelope
Seal Hard Faces	–	Carbon/tungsten

[1]E=90˚ ELL, L=45˚ ELL, T=Tee, R=Reducer, C=Coupling, PC=Pipe Cap, SC=Stub End

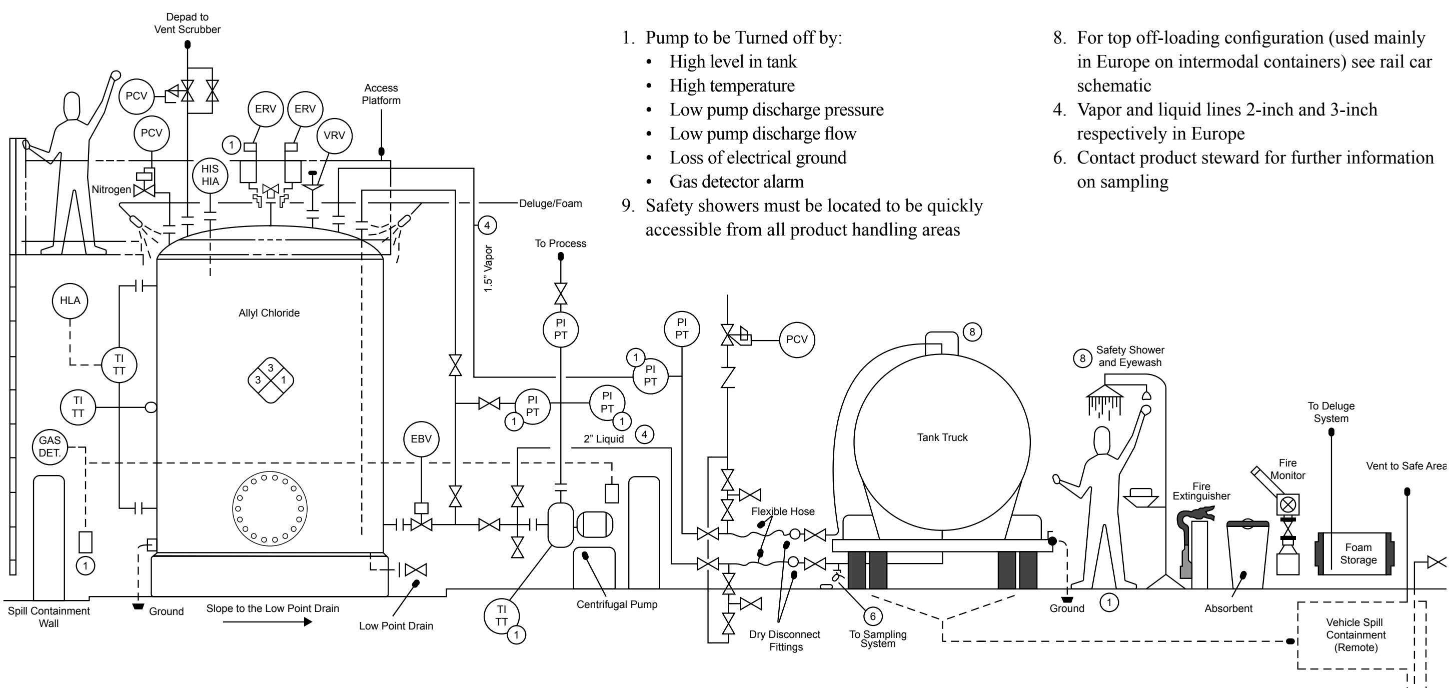
Table 6: Auxiliary Equipment and Specifications for Tank Storage of Allyl Chloride – Continued

Item	Size	Description
Hoses	–	Polypropylene lined with inner wire construction of 316 stainless steel (Wilcox type 4091 or equivalent) Polypropylene with PVC linings and galvanized outer wire (Chemoflex 0416-PG)
Tank Linings	–	Unlined carbon steel acceptable for most applications Phenguard 7436, Plasite 3066, Plasite 9570, Phenoline 302, Phenoline 373, Amercoat 346 coatings Liners tend to flake off after long service
Electrical Classification	–	Minimum-Class I, Division II, Group C Maximum-Class I, Division I, Group C Electrical motors should have individual high temperature protection All equipment should be grounded
Ground Indicator	–	Crouse-Hinds Automatic Ground Indicator, Model EGL210-J1-J3 or equivalent; (Note: Specify class, division, and group); Crouse-Hinds, P.O. Box 4999, Syracuse, NY, 13221

Note: The customer is advised to employ a qualified engineering service to design and build its storage and handling facilities. Since any assistance furnished by Olin, with reference to the safe delivery, storage, use, and disposal of its products, is provided without charge, Olin assumes no obligation or liability.

Figure 3: Bulk Storage and Tank Truck Off-Leading Schematic for Allyl Chloride

This schematic drawing is provided in good faith by Olin Corporation. However, as delivery, storage, use, and disposal conditions are not within its control, Olin does not guarantee results from the use of the schematic. Customers are advised to employ a qualified engineering service to design and build their storage and handling facilities. Since any assistance furnished by Olin, with reference to the safe delivery, storage, use, and disposal of its products, is provided without charge, Olin assumes no obligation or liability.



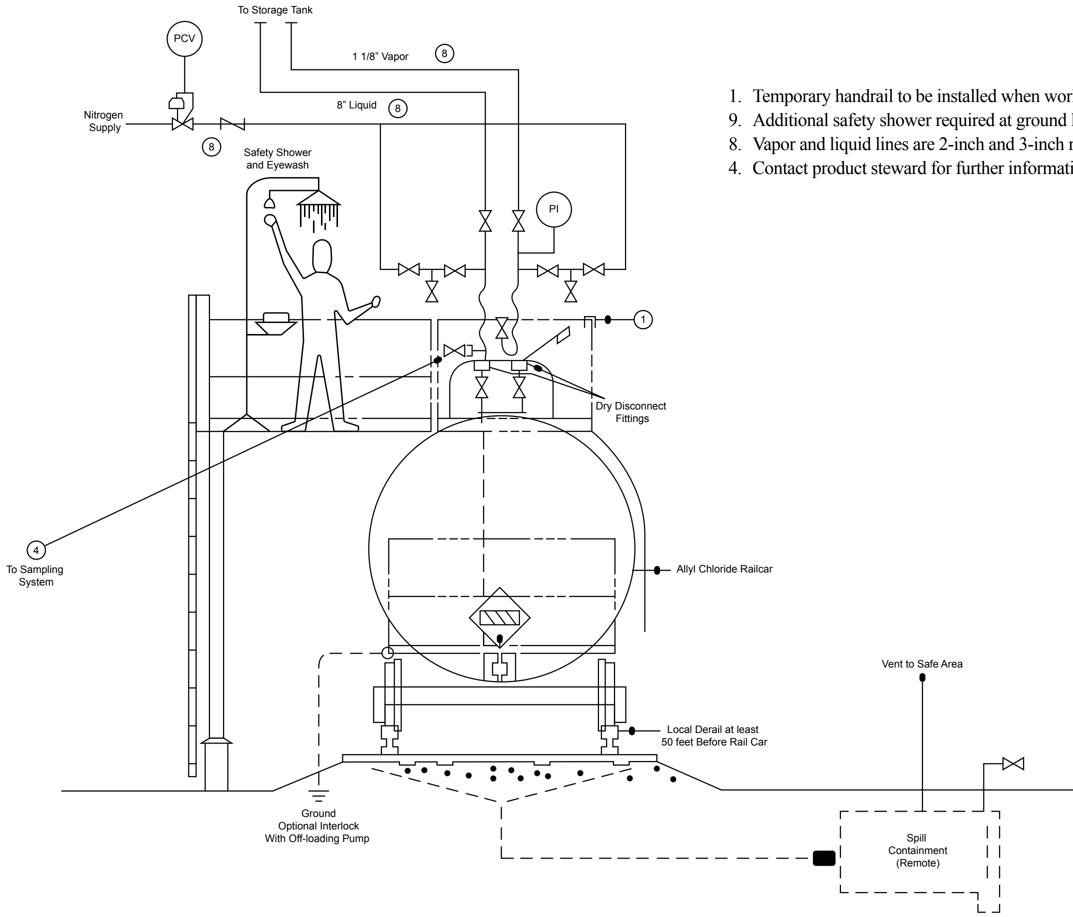
1. Pump to be Turned off by:
   - High level in tank
   - High temperature
   - Low pump discharge pressure
   - Low pump discharge flow
   - Loss of electrical ground
   - Gas detector alarm
9. Safety showers must be located to be quickly accessible from all product handling areas
8. For top off-loading configuration (used mainly in Europe on intermodal containers) see rail car schematic
4. Vapor and liquid lines 2-inch and 3-inch respectively in Europe
6. Contact product steward for further information on sampling

LEGEND

EBV – Emergency Block Valve	Gas Det – Flammable Gas Detector	LT – Level Transmitter	PT – Pressure Transmitter
ERV – Emergency Relief Valve	HLA – High Level Alarm	NIT – Nitrogen	TI – Temperature Indicator
FI – Flow Indicator	HLS – High Level Switch	PCV – Pressure Control Valve	TT – Temperature Transmitter
FT – Flow Transmitter	LI – Level Indicator	PI – Pressure Indicator	VRV — Vacuum Relief Valve

Figure 4: Rail Car Off-Loading Schematic for Allyl Chloride

This schematic drawing is provided in good faith by Olin Corporation. However, as delivery, storage, use, and disposal conditions are not within its control, Olin does not guarantee results from the use of the schematic. Customers are advised to employ a qualified engineering service to design and build their storage and handling facilities. Since any assistance furnished by Olin, with reference to the safe delivery, storage, use, and disposal of its products, is provided without charge, Olin assumes no obligation or liability.



1. Temporary handrail to be installed when working on top of rail car
9. Additional safety shower required at ground level to be quickly accessible from all product handling
8. Vapor and liquid lines are 2-inch and 3-inch respectively in Europe
4. Contact product steward for further information on sampling

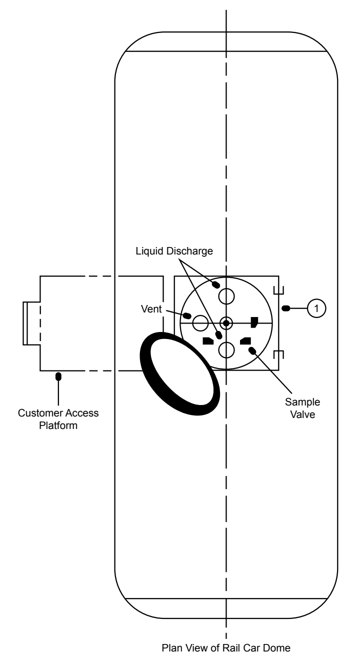
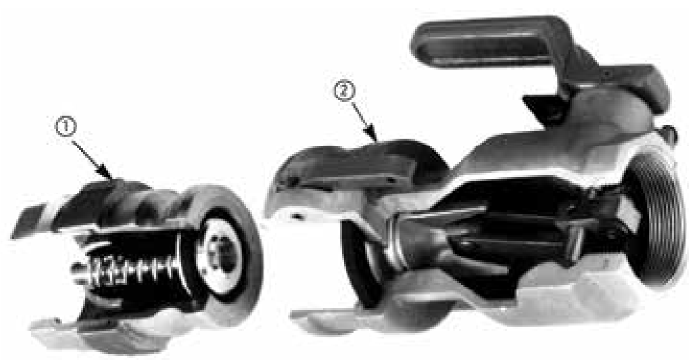


Figure 5: Dry Disconnect Style Fitting



1. Comes Attached to Bulk Delivery Vehicle Off-Loading Line
2. Connect to Flexible Hose
3. Parts Shown Are:
   - 1676-AN-0200 — 2-inch (5.08-cm) Stainless Steel Adapter With Female National Pipe Thread and Chemraz Seals
   - 1775D-0200 — 2-inch (5.08-cm) Stainless Steel Coupler With Female National Pipe Thread and Chemraz Seals
4. Parts Not Shown Are:
   - 1676-AN-0150 — 1-1/2-inch (3.81-cm) Stainless Steel Adapter With Female National Pipe Thread and Chemraz Seals
   - 1775-D-0150 — 1-1/2-inch (3.81-cm) Stainless Steel Coupler With Female National Pipe Thread and Chemraz Seals
5. Photograph Courtesy of: Civacon
   P.O. Box 54907 Cincinnati, OH 45254 (513) 528-2700

Bulk Transportation and Unloading Considerations

This section reviews both road and rail shipments. It also contains a "delivery checklist" for first-time deliveries and a detailed outline of unloading considerations for tank trucks and tank cars or rail cars.

Bulk Shipments

Olin Allyl Chloride is supplied – and shipped – only in bulk; i.e., in 45,000-pound[1]-capacity tank trucks and in 10,000- and 20,000-gallon[2] pressurized tank or rail cars. Bulk shipments are also available by barge, ship, and intermodal ISO containers.

Note: Small quantity samples – usually 0.5 liters — are also available after a screening process has assured Olin that the person requesting the sample is knowledgeable about the hazards to the health and safety of both personnel and the environment, is equipped to handle the product safely, and will not be using allyl chloride for applications that the product is not intended or has not been tested.

All bulk vehicles are designed to provide a vapor-balanced or closed-loop vent return from the storage tank. This is necessary in order to minimize vent flow and the need for fresh pad gas. Bulk vehicles in North America are also equipped with a "dry disconnect" or "dry break" fitting on both the vapor return line (1.5 inch [3.81 cm]) and the liquid off-loading line (2 inch [5.08 cm]), the purpose of which is to contribute to an exposure-free transfer of product[3]. Dry break fittings are very effective at reducing spillage during connection and disconnection to only a few droplets. Of course, this feature requires that the customer have a matching fitting.(For a description of this device, see Figure 5, page 27.)

A filter on the discharge side of the unloading pump is not generally required because Olin Allyl Chloride is carefully filtered prior to shipment. However, such a filter would serve to keep back any foreign particles (from hoses and other equipment) that might enter the system – and the product – during unloading.

Also, an inert gas source (such as dry nitrogen) should be available to provide gas padding and to blow the unloading lines clear of allyl chloride after the tank truck or tank car has been emptied.

Tank Trucks

Olin Allyl Chloride is generally shipped under an inert gas pad (usually dry nitrogen) in single-compartment, stainless steel tank trailers (specification MC 307 or MC 407) having a net capacity of approximately 45,000 pounds (20.5 metric tons). Because of the toxicity and flammability of allyl chloride, tank trucks must be unloaded with all hatches and domes closed and with an inert gas pad applied. It is required that customers have their own unloading equipment. It is also required that the customer provide – and maintain – equipment specifically dedicated to the off-loading and storage of allyl chloride.

[1]20.5 metric tons
[2]37,854 and 75,708 liters
[3]In Europe, bulk delivery vehicles are equipped with a 2 inch (5.08 cm) dry disconnect on the vapor line and a 3 inch (7.62 cm) dry disconnect on the liquid line

Tank Cars

Olin Corporation ships allyl chloride in pressure-type, plain or carbon steel tank cars, lined with a high-baked phenolic coating. The tank cars have capacities of either 10,000 or 20,000 gallons or 40,000 or 75,000 liters). These DOT 105A-100-W rail cars are equipped with a reinforced covered dome containing two 2 inch (5.08 cm) liquid outlet valves with internal dip pipes; one 1-1/2 inch (3.81 cm) vent valve connection; one sample valve; a gauging device; and a spring-loaded safety valve set at 75 psig. A thermocouple is located in the dome to measure the liquid temperature.

Preparations for Unloading

Personnel involved in unloading should have a thorough knowledge of both the configuration and equipment of chemical tank trucks and tank cars. They should also be thoroughly educated in both the hazardous properties of allyl chloride and in the proper use of personal protective clothing and equipment.

A written and detailed (or step-by-step) unloading procedure (prepared and tested by experienced and knowledgeable professionals) should be provided to all personnel involved in tank truck and/or rail car unloading. In addition, a thorough program of training, testing, and retraining should be instituted by the customer, and only those employees who demonstrate complete mastery of the many tasks and responsibilities involved in unloading should be assigned to this particular operation.

First-Delivery Shipments

Because the degree of hazard in unloading and handling allyl chloride varies from one operation or storage site to another, individual unloading stations and storage facilities must be carefully evaluated to determine necessary safety measures. Thus, Olin will not make deliveries to sites with which it is not familiar or where it has not been assured that personnel are adequately trained and appropriately equipped to safely receive and unload allyl chloride. In general, this means that Olin will not deliver to a site that has not been visited and reviewed by an Olin representative. Also, prior to receiving products in bulk, customers should make certain that their facilities are adequately and appropriately equipped to safely store the products received. They must also make certain that all personnel involved in the handling, unloading, and storage of allyl chloride have been carefully instructed on the hazardous properties of this material. Finally, and upon request, Olin technical personnel will review the engineering plans for any new or proposed facility and will provide both feedback and suggestions.

First-Delivery Checklist

The following checklist is designed to help customers prepare for a first delivery of either a tank truck or rail car shipment to a new facility. For specific information about hardware, procedures, etc., see the "Storage Equipment and Design Considerations" section (page 24), or consult with your Olin representative or Product Steward.

Prior to a first delivery, customers should be prepared to safely receive and off-load Olin Allyl Chloride by carefully considering each of the following questions and comments:

- Has an Olin Product Steward visited your plant and reviewed your bulk allyl chloride off-loading and storage facilities?

Note: Olin will not deliver to a facility without first performing an on-site review to verify that it meets Olin's specifications for equipment, personnel, and off-loading practices and procedures.

- Have provisions been made and appointments set for the mandatory attendance of an Olin Product Steward at the first delivery?
- Has a detailed, step-by-step off-loading procedure been prepared, tested, and distributed to all appropriate personnel?
- Has the off-loading procedure been reviewed by the off-loading operator? Does the operator plan to use it as a checklist for the off-loading?
- Have all unloading personnel been fully instructed on the hazards to health and safety associated with allyl chloride? Have they read the appropriate and most current copy of the safety data sheet and other relevant safety literature?

Note: Olin strongly suggests that unloading personnel attend a product safety training session conducted by an Olin Product Steward.

- Has a written procedure been prepared for checking, cross-checking, and recording all pertinent documents, identification numbers, codes, etc. (including vehicle numbers, product identification tags, invoice numbers, and Certificates of Analysis), before off-loading begins?
- Have all off-loading personnel been properly equipped with all necessary protective clothing and equipment (including an appropriate breathing apparatus), and have they been carefully instructed on the correct use of this equipment?
- Have adequate provisions been made for spill containment?

Note: Olin suggests a spill containment volume great enough to hold the entire contents of a tank truck or tank car.

- Have all "confined spaces" and other areas that could hold toxic concentrations of vapors or oxygen-deficient atmospheres been identified and made inaccessible?

Bulk Transportation and Unloading Considerations

- Have the off-loading piping, valving, and pumping systems been pressure-tested to ensure that they are leak-free?

Note: If water was used in pressure testing, be sure the systems are absolutely dry and water- or moisture-free. Also, be certain all gasket materials used in the off-loading and storage systems are compatible with allyl chloride.

- Has all off-loading and storage equipment (including instruments and relief devices and valves) been carefully examined and found to be free of aluminum, zinc, brass, bronze, copper, cadmium, lead, cast iron, stainless steel, or other unreliable or reactive materials?
- Have safety showers and eyewash fountains been installed and tested, and are they readily accessible from all areas of the off-loading site?

Note: Olin suggests that safety showers, eyewash fountains, and fire extinguishers be located in close proximity to the off-loading site.

- Have provisions been made for cordoning off the off-loading area and for warning unauthorized personnel and vehicles not to enter the area?

Note: Olin suggests using a derail, a warning sign with the words "Tank Car Connected," and a warning light to protect the rail car unloading site.

- Have written procedures for spotting, chocking, and brake securement been prepared, reviewed, tested, and distributed to the various carriers and all appropriate personnel?

Note: Olin suggests that tank truck drivers be instructed to surrender their keys and to leave the truck cab before off-loading of the product begins.

- Have provisions been made for properly grounding the off-loading vehicle and all other off-loading equipment?
- Have you specified a center- or rear-unloading tank truck or trailer? If so, do you have the appropriate length hoses for the various types of vehicles?

Note: Olin requires customers to have a mechanism for off-loading that does not require the use of a truck pump.

- Do you have a procedure to verify the content in the delivery vehicle to be Allyl Chloride?
- Have all lines, valves, pumps, and vessels been properly identified and clearly labeled?
- Has a comprehensive emergency response plan been developed and reviewed by local emergency response officials? Are all unloading and other personnel fully familiar with the company's emergency response plan? Has the plan been tested as part of a simulated emergency, such as a large (or massive) spill, fire, and/or explosion?

Note: Olin also suggests that customers adhere to the various Principles and Codes of Practice outlined in the American Chemistry Council (ACC) Responsible Care® program.

- Are equipment and procedures in place to supply and regulate the pressure of nitrogen for providing gas pads and for blowing clear the liquid off-loading lines prior to disconnection?

Note: Olin also requires customers to have a closed loop vent return or a less preferred nitrogen make-up system to supply an inert pad to tank trailers. Caution: Oxygen content in storage tanks and in the delivery vehicles should be less than 8.0%. Also, the pressure of the nitrogen supply must be carefully controlled and regulated to <15 psi. If it is not, it could exceed the pressure at which the vehicle's safety system begins to relieve. Finally, hoses should never be left hydraulically full.

- Have all terminal lines been plugged (blinded) to prevent spills from an accidental valve opening?
- Are a fire extinguisher and suitable absorbent material stored in the immediate area of the off-loading site, and are they readily accessible? (See "Spill Containment and Cleanup," page 20.)
- Is the off-loading area equipped with an effective communication system so that personnel can communicate with the control room and each other?
- Has a procedure been developed and put in place to determine the exact amount of space left in the storage tank before off-loading begins?
- Has an appropriate procedure been developed, and appropriate equipment installed, to monitor the movement of product through the lines and to verify that the product is being transferred to the correct location or storage tank?

Note: If a vapor return line is used, can the movement of the vapors through the vapor return line be verified? In North America, the vapor return line must be 1-1/2 inches (3.81 cm) and the liquid line 2 inches (5.08 cm). Olin also requires that the unloading facility be equipped with a 2 inch (5.08 cm) dry disconnect on the customer-supplied liquid transfer hose, and a 1-1/2 inch (3.81 cm) dry disconnect on the vapor return/vent line.

- Are there effective warning devices and/or automatic shut-off or shut-down valves, etc., in place in the event of an unloading malfunction?
- Are detectors in place to sound an alarm in the event of a leak?
- Is there equipment in place to measure and monitor tank, pump, and line pressures, and is there effective emergency relief valving?
- Have all unloading operators been instructed to stay within sight of, and monitor, the line connections until the transfer has been completed and the off-loading process has been shut down?

Note: In the U.S., this is required by law.

- Has equipment been installed to signal when the vehicle is completely empty?

Note: This is essential so that the pump can be turned off as soon as it loses suction.

- Have procedures been developed to ensure that all valves are in their correct positions (i.e., fully or partially open or closed, etc.) before, during, and after off-loading? Also, is there an equally effective procedure for ensuring that all instruments and regulating devices have been properly set and are functioning correctly before, during, and after off-loading?
- Is there a procedure and appropriate equipment in place to measure and regulate the pressure in the tank?

Note: Olin suggests a tank pressure no greater than 25 psi (1,724 mbar) when unloading tank trucks and 75 psi (5,171 mbar)when unloading rail or tank cars.

Also, have procedures been developed to detect and prevent backflow?

- Are all allyl chloride tanks located at a safe distance from tanks holding other reactive chemicals?

Note: a "safe distance" is one that is far enough away to make accidental contact between the allyl chloride and "other reactive chemicals" virtually impossible.

- What provisions have been made to prevent falls when unloading tank or rail cars?
- When dry disconnects are connected, are they locked in place by securing the arms in the locked position?
- When a sample is taken, have workers been instructed to don appropriate protective clothing and equipment and to avoid exposure?
- Are procedures and personnel in place to ensure that all liquid and vapor return lines on the tank car and the piping system are correctly blown clear, depressurized, and blocked, etc.?

Note: Tank truck and tank car securement must be conducted only by specially trained and licensed workers.

- Are procedures and policies in place to ensure that all systems are shut down properly; that hoses are secured to keep them clean and free of contamination; that fall restraints, chocks, ground straps, and barricades have been removed, and (for rail cars) that placards have been reversed and that derails and warning signs and lights have been removed?
- Have policies and procedures been developed and put in place for product and waste disposal? If so, are these policies and procedures in full compliance with all federal, state, provincial, and local laws and regulations?
- Are policies and programs in place to ensure continuous training and improvement?

Note: For further information and/or assistance on off-loading tank trucks or tank cars, contact the Olin Customer Information Center (1-800-441-4369 in the U.S.) or your Olin Sales or Technical Service representative. For country-specific contacts and phone numbers, see back cover.

Preparations for Tank Maintenance and Cleaning

Note: Detailed written procedures should be prepared by qualified personnel to cover all aspects of vessel preparation, cleaning, inspection, and recommissioning. Following are some general suggestions to consider when preparing these procedures.

The allyl chloride should be pumped or pressured out of the tank until the pump loses prime, or pad gas flows out of the drain line (product off-loading line). The pump should not be run for an extended period after it has lost prime; shut it off and block it in. All process piping on the tank should be removed and all vent valves opened. At this point, the cleaning procedure for an allyl chloride tank will depend somewhat on whether the tank is lined and on the physical properties of the lining, if, in fact, one has been used. Mechanical tank washers are acceptable, provided wastewater treatment facilities are available to handle the contaminated water generated by the cleaning process.

Tank Cleaning Considerations

The following are suggested steps for cleaning an uninsulated, unlined tank holding allyl chloride. Remember, however, that these are merely general suggestions; they should be used only as a guide in preparing a more detailed procedure that is specific to the size and configuration of the customer's tank and to the presence or absence of wastewater facilities, etc.

- Empty the tank of all liquid
- Open all drains and vent valves. Physically isolate the tank from any connection to processing or other equipment by disconnecting and/or dismantling all connecting lines, pipes, electrical connections, etc.
- Connect a water hose to the tank and, after closing the drains, fill the tank with water. Then drain the tank and repeat the process once again.
- Install a rotating wash nozzle, similar to those used for truck or rail car washing. Water pressure should be sufficient to enable the water to reach all the internal surfaces of the tank. Wash continuously for approximately 24 hours.
- When the washing is done, connect an air mover to the tank and purge the tank with a large volume air flow
- When the tank has been well purged, test the air from one of the vents for any residual vapors. If the gas detector shows any trace of organic vapor, disconnect the air mover and resume the water wash.
- Repeat the testing and washing steps until the gas detector shows that all traces of vapors in the tank have been eliminated
- If vessel entry is required, a detailed, written procedure should be prepared by a qualified person. The procedure should cover all aspects of safety, communication, emergency response, industrial hygiene, personal protective clothing and equipment, and specific job procedures.
- Any personnel directly or indirectly involved in vessel entry should be thoroughly trained (and tested) on the written vessel entry procedure
- Finally, and before vessel entry, be certain there are no traces of residual vapors and that the oxygen content of the air in the tank is not less than 21%

Olin Product Stewardship

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 prod 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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