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Advancing Possible

Allyl Alcohol

Product Safety Bulletin

Foreword

Lyondell Chemical Company and Lyondell Chemie Nederland BV ("Lyondell"), LyondellBasell companies, are dedicated to continuous improvement in product, health, safety and environmental performance. Included in this effort is a commitment to support our customers by providing guidance and information on the safe use of our products. For Lyondell, environmentally sound operations, like environmentally sound products, make good business sense.

Lyondell Product Safety Bulletins are prepared by our Product Stewardship Team. The data reflect the best information available from public and industry sources. This document is provided to support the safe handling, use, storage, transportation and ultimate disposal of our chemical products.
This Product Safety Bulletin should be evaluated to determine applicability of your specific requirements. The government regulations, industry standards cited in this bulletin are primarily applicable within the United States. Please make sure you review the corresponding government regulations, industry standards and guidelines for your specific country or region as that might have an impact on your operations.

Lyondell's ready to support our customers' safe use of our products. For additional information and assistance, please contact your Lyondell customer representative.

Telephone numbers for transport emergencies:

CHEMTREC 1-800-424-9300
International (call collect) 202-483-7616

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

SETIQ (in the Mexican Republic) 01-800-00-214-00
(Calls originating in Mexico City or the Metropolitan Area) +5-559-1588
(Calls originating elsewhere) +52-555-559-1588

LyondellBasell TDI (Transportation Distribution Incident) reporting Hotline

1-800-245-4532 (North America)
+32-3-575-1235 (Europe)

Contact information for additional product information:

LyondellBasell Customer Service
+1-888-777-0232 (North America)
+31-10-275-5500 (Europe)
or visit www.lyb.com

Revision: March 2019

Contents

1. General Information

1.1 Product Identification

Chemical Name:	Allyl Alcohol
Chemical Family:	Aliphatic Alcohols
Common Names:	Propenol
	Propen-1-ol-3
	Vinyl Carbinol
	3-Hydroxypropene
	2-Propen-1-ol
	2-Propenyl alcohol
CAS Number:	107-18-6
Formula:	C3H6O

1.1.1 Chemistry

Lyondell produces allyl alcohol using a commercially-proven technology developed over 30 years. The basic technology is the isomerization of propylene oxide at elevated temperature using a lithium phosphate catalyst.

1.1.2 Applications

Allyl alcohol is an important raw material in Lyondell's production of 1,4-butanediol (BDO) and MPDiol glycol (2-methyl-1,3-propanediol). Other commercial uses of allyl alcohol include the production of allyl diglycol carbonate (ADGC), used in optical resins; allyl diglycidyl ether (AGE) and allyl methacrylate (AMA) used as silane coupling agents for a multitude of applications, such as water treatment and glass adhesion; allyl isoamyl glycolate, which imparts a fruity note to fragrances; diallyl phthalate (DAP), which may be used as a plasticizer; and styrene allyl alcohol (SAA), a resinous polyol used as a resin modifier and in a variety of coating and ink applications.

1.2 Typical Values

Allyl Alcohol	99.3 wt. percent minimum
n-Propanol	0.75 wt. percent maximum
Water	0.10 wt. percent maximum
Propionaldehyde	< 50 ppm
Acidity (as acetic acid)	< 0.001 wt. percent
Color	< 10 APHA

These are typical values and should not be construed as product specifications. Please visit www.lyb.com for the allyl alcohol sales specifications in your region.

1.3 Instability Hazards

Allyl alcohol is stable and will not readily decompose under normal conditions. It is not a polymerization hazard although it will slowly polymerize over a long period of time (i.e., several years) to form a thick, syrup like material. Avoid heat, sparks and contact with strong acids and oxidizing materials.

1.4 Reactivity Hazards

Allyl alcohol has the potential to react violently and explosively with oxidizing materials. It also reacts violently and explosively with anhydrous metal halides such as ferric chloride and aluminum chloride,chemically active metals such as sodium, magnesium and potassium, strong acids such as nitric and sulfuric acid, and strong bases such as sodium hydroxide.

Allyl alcohol gives off toxic vapors and forms explosive mixtures with air. When heated with caustic soda, it produces an exothermic reaction.

Lyondell Technology -
Allyl Alcohol Process Chemistry

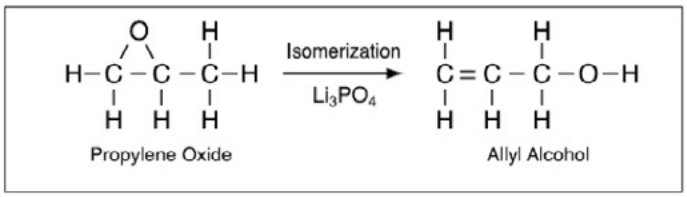


Figure 1-1

MPDiol and SAA are trademarks owned or used by LyondellBasell group companies. Trademark MPDiol is registered in the U.S. Patent and Trademark Office

1. General Information

1.5 Physical Properties

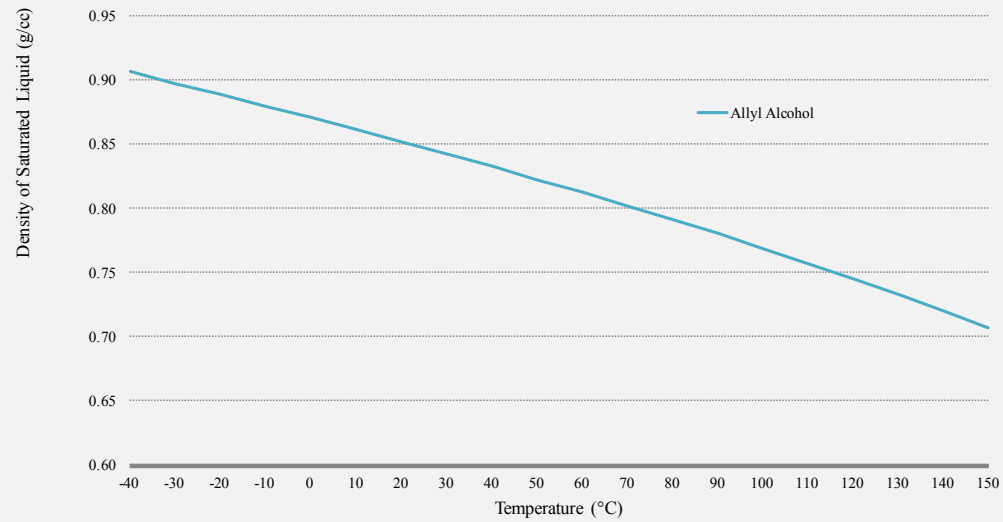
Table 1-1 Allyl Alcohol Physical Properties

Property	Value
Physical State	Liquid
Color	Colorless
Molecular Weight	58.08
Boiling Pt.	97.1°C (206.7°F)
Freezing Pt.	-129°C (-200.2°F)
Density@ 25°C (7.07 lb/gal)	0.847g/cc -0.852 g/cc
Density of Sat'd Liquid	See Figure 1-2 and Table 1-2
Vapor Density	See Figure 1-3
Vapor Pressure	See Table 1-3
Viscosity of Sat'd Liquid	See Figure 1-4
Visc. of Vapor	See Figure 1-5
Index/Refraction	1.4135 @ 20°C
Coeff. of Cubical Expansion @ 20°C	0.00112°C -1
Crit. Temperature	271.9°C (521.4°F)
Crit. Pressure	5.62 MPa 815.1 psia
Crit. Volume	3.5813 cc/g 0.0574 ft 3/lb
Crit. Compress.	0.258
Heat/Combustion, Liquid @25°C	-445.50 Kcal/mol

Property	Value
Heat of Formation, Liquid@25°C	-41.60 Kcal/mol
Heat/Fusion @-129°C	1223.7 cal/mol7 2202.7 BTU/lbmol
Heat/Vaporization	See Figure 1-6
Heat Capacity of Sat'd Liquid	See Figure 1-7
Enthalpy of Sat'd Liquid	See Figure 1-8
Heat Capacity of Vapor	See Figure 1-9
Enthalpy of Sat'd Vapor	See Figure 1-10
Surface Tension	See Figure 1-11
Thermal Conduct. of Sat'd Liquid	See Figure 1-12
Thermal Conduct. of Vapor	See Figure 1-13
Flash Point (TCC)	20.9°C (70°F)
Auto Ignition	378°C (712°F)
Upper Explo. Limit	18 vol%
Lower Explo. Limit	2.5 vol%
Solubility@20°C	Water: ∞ Alcohol: ∞ Ether: ∞
Sat. Conc. in Air	6.48 wt% 3.35 mol%
Acentric Factor	0.5688

1. General Information

Figure 1-2 Density of Saturated Liquid as a Function of Temperature



1. General Information

Table 1-2 Allyl Alcohol Density as a Function of Temperature

Temperature		Lbs. Per U.S. Gallon	Sp. Gr. to 60°F	Temperature		Lbs. Per U.S. Gallon	Sp. Gr. to 60°F
°C	°F			°C	°F		
4.4	40	7.235	1.0121	21.7	71	7.099	0.9932
5.0	41	7.230	1.0115	22.2	72	7.095	0.9926
5.6	42	7.226	1.0109	22.8	73	7.090	0.9920
6.1	43	7.222	1.0103	23.3	74	7.086	0.9914
6.7	44	7.217	1.0097	23.9	75	7.082	0.9907
7.2	45	7.213	1.0091	24.4	76	7.077	0.9901
7.8	46	7.209	1.0085	25.0	77	7.073	0.9895
8.3	47	7.204	1.0079	25.6	78	7.068	0.9889
8.9	48	7.200	1.0073	26.1	79	7.064	0.9882
9.4	49	7.196	1.0067	26.7	80	7.059	0.9876
10.0	50	7.191	1.0061	27.2	81	7.055	0.9870
10.6	51	7.187	1.0055	27.8	82	7.050	0.9864
11.1	52	7.183	1.0049	28.3	83	7.046	0.9857
11.7	53	7.178	1.0043	28.9	84	7.041	0.9851
12.2	54	7.174	1.0037	29.4	85	7.037	0.9845
12.8	55	7.170	1.0031	30.0	86	7.032	0.9839
13.3	56	7.165	1.0024	30.6	87	7.028	0.9832
13.9	57	7.161	1.0018	31.1	88	7.023	0.9826
14.4	58	7.157	1.0012	31.7	89	7.019	0.9820
15.0	59	7.152	1.0006	32.2	90	7.014	0.9813
15.6	60	7.148	1.0000	32.8	91	7.010	0.9807
16.1	61	7.143	0.9994	33.3	92	7.005	0.9801
16.7	62	7.139	0.9988	33.9	93	7.001	0.9794
17.2	63	7.135	0.9982	34.4	94	6.996	0.9788
17.8	64	7.130	0.9975	35.0	95	6.992	0.9782
18.3	65	7.126	0.9969	35.6	96	6.987	0.9775
18.9	66	7.121	0.9963	36.1	97	6.983	0.9769
19.4	67	7.117	0.9957	36.7	98	6.978	0.9763
20.0	68	7.113	0.9951	37.2	99	6.973	0.9756
20.6	69	7.108	0.9945	37.8	100	6.969	0.9750
21.2	70	7.104	0.9938				

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Figure 1-3 Density of Vapor at1 Atmosphere as a Function of Temperature

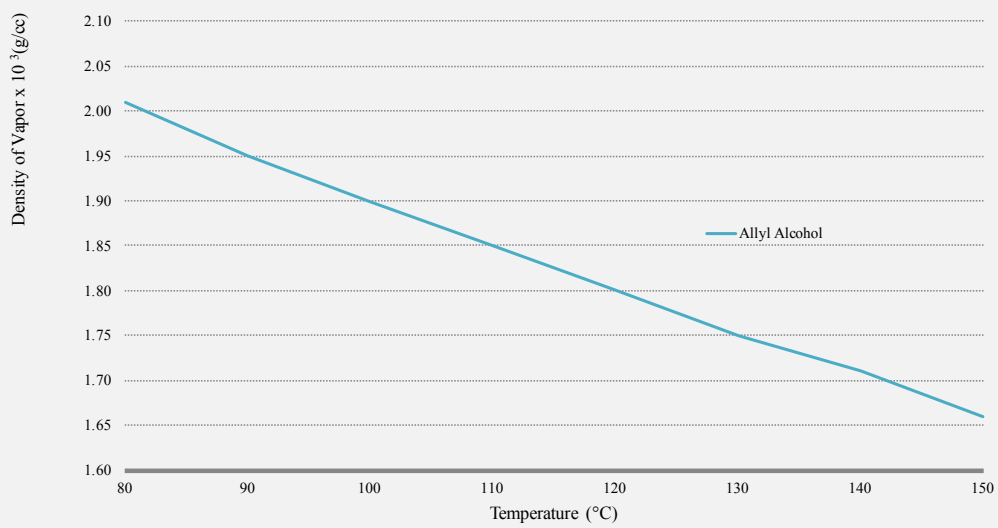

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Figure 1-4 Viscosity of Saturated Liquid as a Function of Temperature

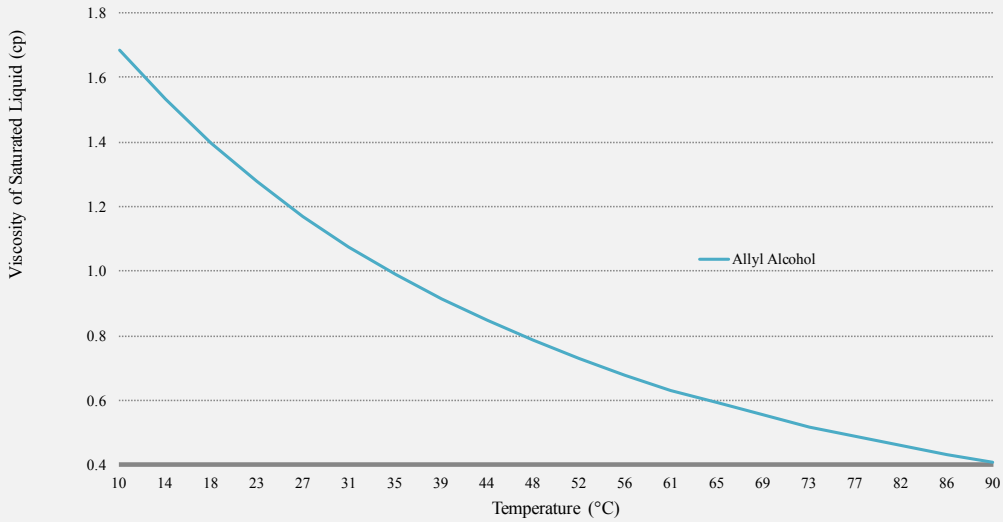

Figure 1-5 Viscosity of Vapor at 1 Atmosphere as a Function of Temperature

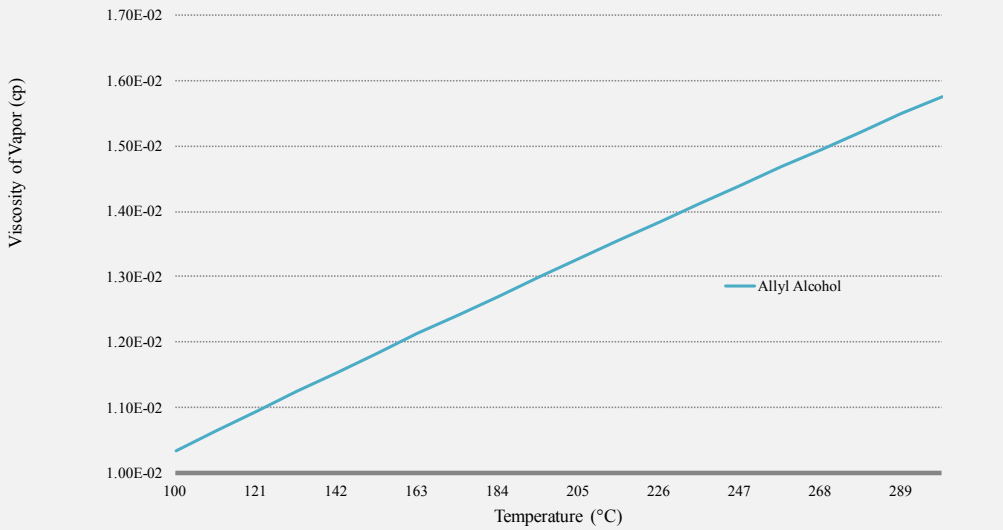

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Figure 1-6 Heat of Vaporization as a Function of Temperature

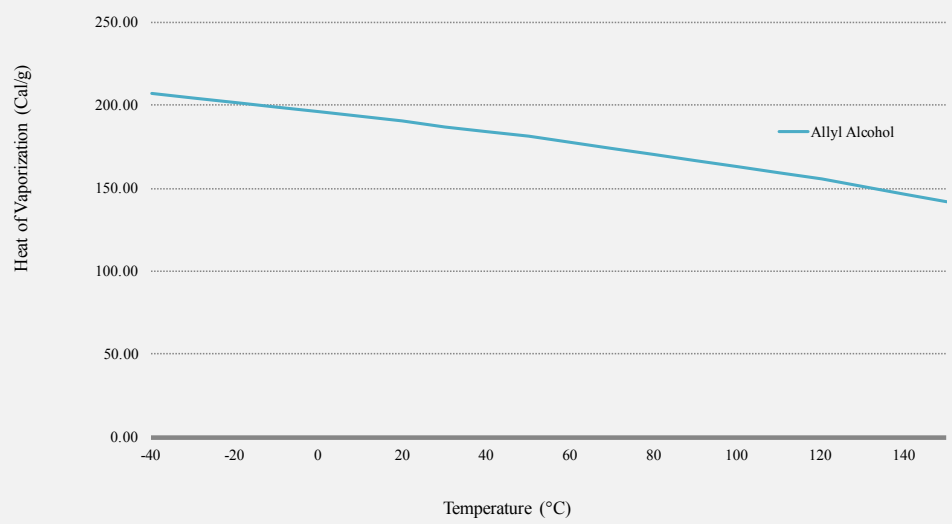

Figure 1-7 Heat Capacity of Saturated Liquid as a Function of Temperature

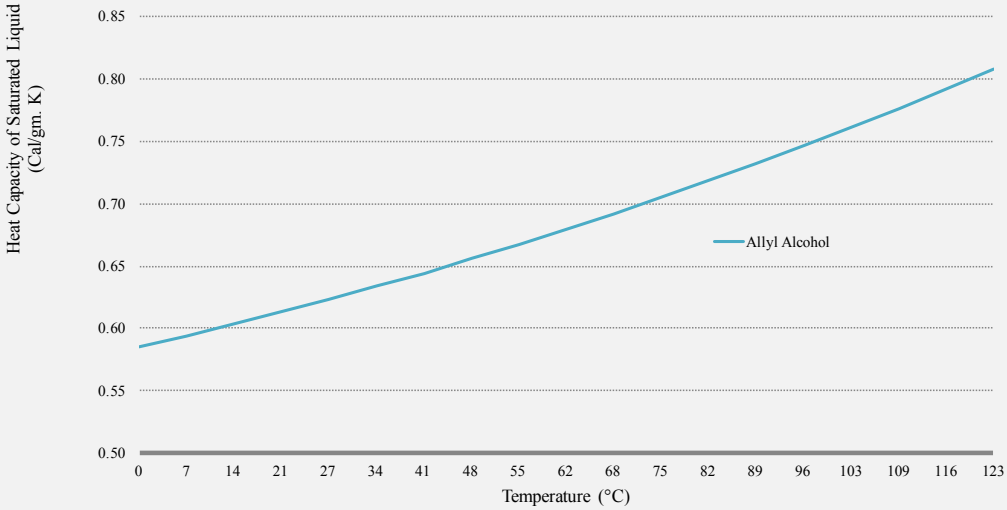

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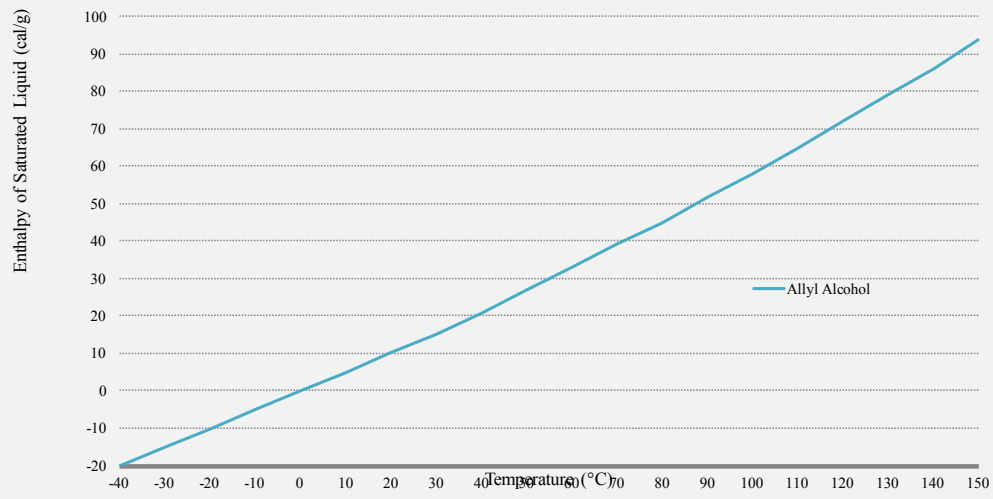
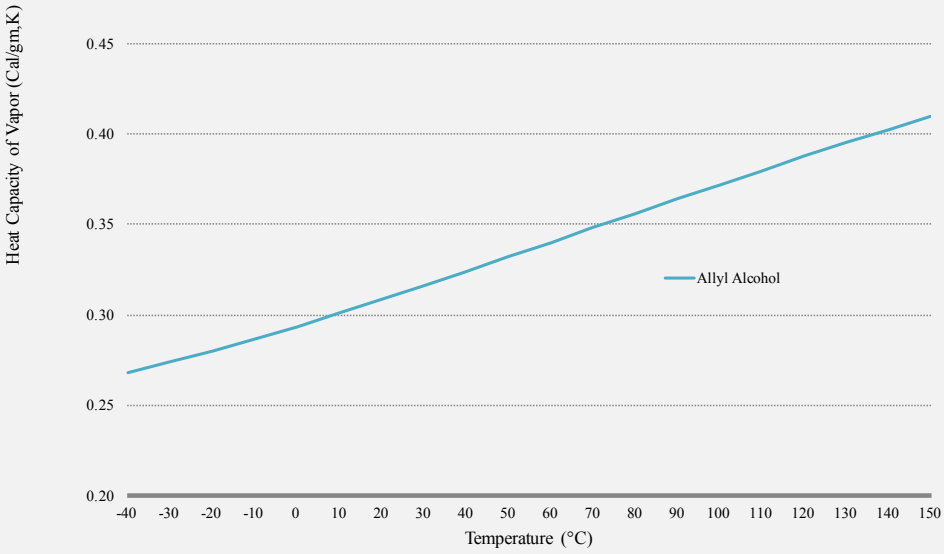
Figure 1-8 Enthalpy of Saturated Liquid as a Function of Temperature



Reference: Liquid Allyl Alcohol at 0°C

Figure 1-9 Heat Capacity of Vapor (Ideal Gas) as a Function of Temperature



1. General Information

Figure 1-10 Enthalpy of Saturated Vapor as a Function of Temperature

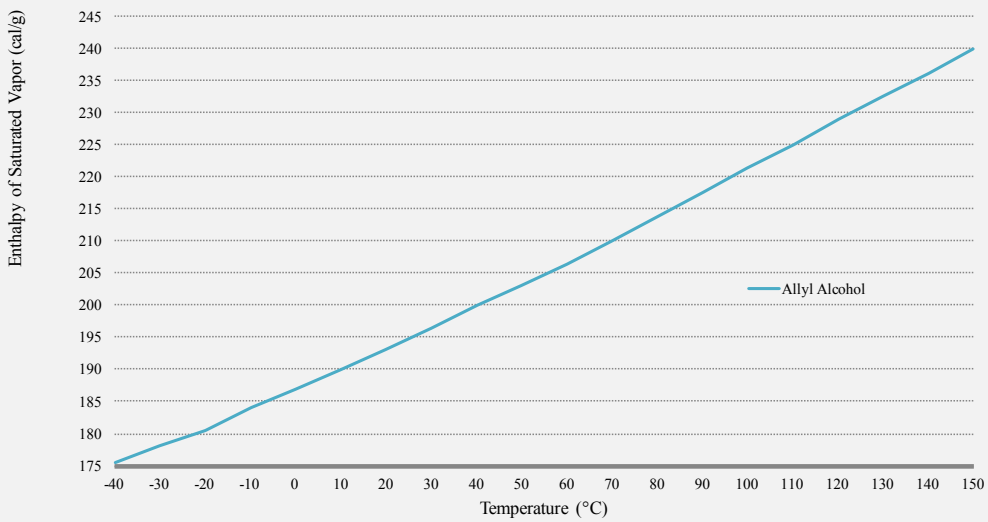


Figure 1-11 Surface Tension as a Function of Temperature

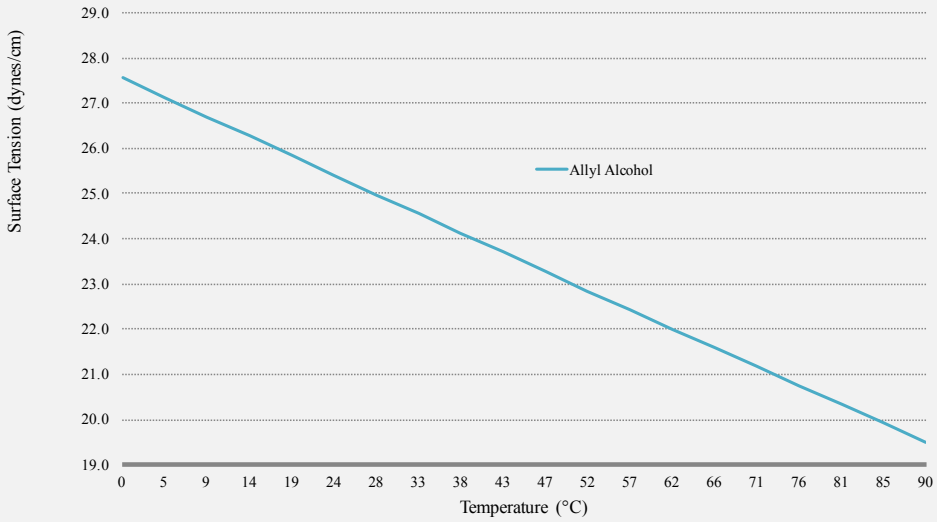


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Figure 1-12 Thermal Conductivity of Saturated Liquid as a Function of Temperature

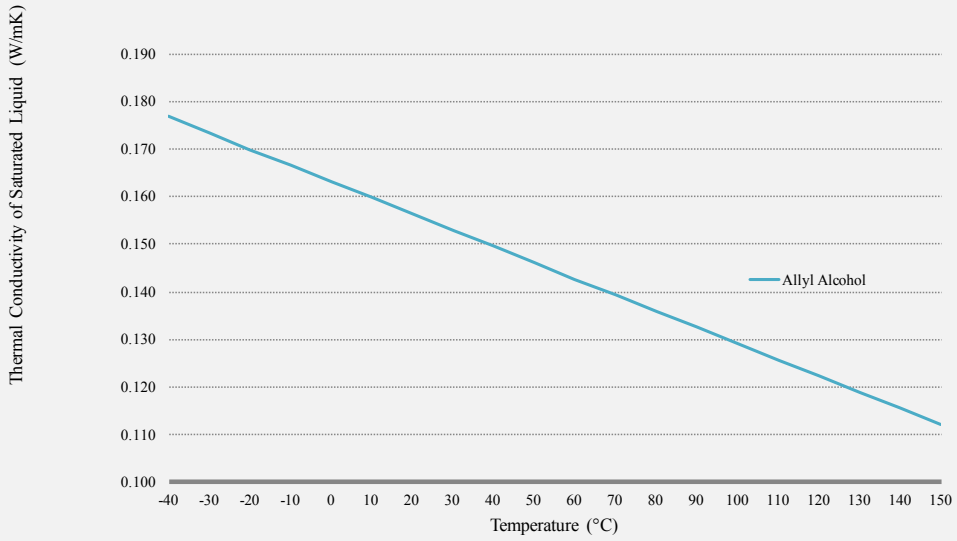
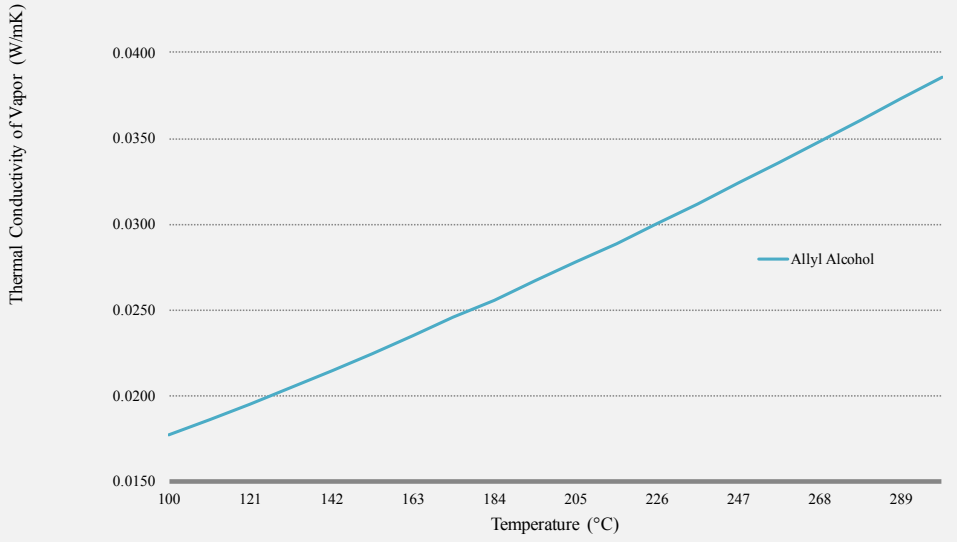


Figure 1-13 Thermal Conductivity of Vapor at 1 Atmosphere as a Function of Temperature



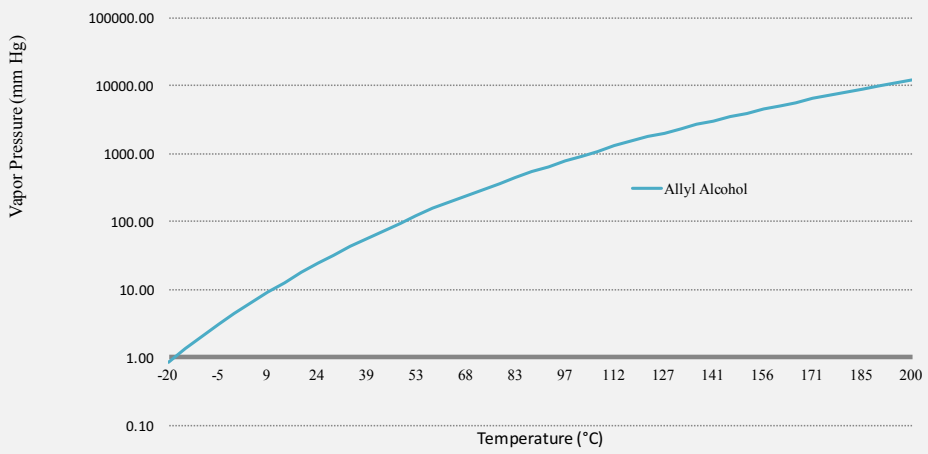
1. General Information

Table 1-3 Vapor Pressure of Allyl Alcohol as a Function of Temperature

Temperature		Vapor Pressure			Temperature		Vapor Pressure		
°C	°F	mmHg	psia	psig	°C	°F	mmHg	psia	psig
-20.00	-4.00	0.96	0.02		95.00	203.00	706.87	13.67	
-15.00	5.00	1.48	0.03		96.97	206.55	760.00	14.70	0.00
-10.00	14.00	2.22	0.04		100.00	212.00	848.43	16.41	1.71
-5.00	23.00	3.29	0.06		105.00	221.00	1012.55	19.58	4.88
0.00	32.00	4.79	0.09		110.00	230.00	1201.55	23.24	8.54
5.00	41.00	6.87	0.13		115.00	239.00	1418.96	27.44	12.74
10.00	50.00	9.72	0.19		120.00	248.00	1666.92	32.23	17.54
15.00	59.00	13.57	0.26		125.00	257.00	1948.75	37.68	22.99
20.00	68.00	18.69	0.36		130.00	266.00	2267.64	43.85	29.15
25.00	77.00	25.43	0.49		135.00	275.00	2626.93	50.80	36.10
30.00	86.00	34.21	0.66		140.00	284.00	3030.08	58.59	43.90
35.00	95.00	45.53	0.88		145.00	293.00	3480.63	67.30	52.61
40.00	104.00	59.96	1.16		150.00	302.00	3982.27	77.00	62.31
45.00	113.00	78.18	1.51		155.00	311.00	4538.72	87.76	73.07
50.00	122.00	100.99	1.95		160.00	320.00	5153.81	99.66	84.96
55.00	131.00	129.28	2.5		165.00	329.00	5831.40	112.76	98.06
60.00	140.00	164.10	3.17		170.00	338.00	6575.40	127.15	112.45
65.00	149.00	206.60	3.99		175.00	347.00	7389.73	142.89	128.20
70.00	158.00	258.09	4.99		180.00	356.00	8278.32	160.08	145.38
75.00	167.00	320.03	6.19		185.00	365.00	9245.09	178.77	164.07
80.00	176.00	394.03	7.62		190.00	374.00	10293.92	199.05	184.36
85.00	185.00	481.85	9.32		195.00	383.00	11428.66	220.99	206.30
90.00	194.00	585.43	11.32		200.00	392.00	12653.07	244.97	229.97

1. General Information

Figure 1-14 Vapor Pressure as a Function of Temperature



2. Occupational Health

2.1 Hazard Assessment

The primary route of exposure to allyl alcohol is through inhalation or dermal absorption.

Allyl alcohol is highly toxic by inhalation and is a severe irritant to the skin and eyes. Allyl alcohol is readily absorbed through the skin and, because it is metabolized to acrolein, can induce both liver and kidney damage. Exposure to vapor or mist of allyl alcohol can cause lachrymation (tearing), photophobia (light sensitization), blurring of vision and reversible corneal damage. Inhalation of allyl alcohol can induce pulmonary congestion.

Long-term studies in animals have shown that allyl alcohol causes marked liver and kidney damage. There are no data in the literature which define the carcinogenic potential of allyl alcohol.

2.1.1 Acute Effects of Overexposure

The oral and dermal lethal doses (LD50) are remarkably similar (99 vs 89 mg/kg) indicating that allyl alcohol can be readily absorbed through the skin in toxic amounts. The application of allyl alcohol to eyes causes erythema (reddening) of the conjunctiva and swelling and cloudiness of the cornea. Single doses of allyl alcohol by various routes of administration have caused marked elevation of liver enzymes and subsequent necrosis (death) of the cells in the periportal region of the liver.

It is reported that allyl alcohol can be absorbed through intact human skin in toxic and even lethal concentrations. Dermatitis of varying degrees can occur, in addition to first and second degree burns. Deep muscle pain at the contact site has been reported. Concentrations of 6.25 ppm can cause slight eye irritation, with severe irritation occurring at 25 ppm. According to the ACGIH Documentation of TLV's (5th Edition), corneal necrosis was reported to result in temporary blindness in a man exposed to levels of allyl alcohol which were irritating to the eyes and nose.

2.1.2 Repeated Exposures

Rats exposed to airborne concentrations of allyl alcohol of 40, 60, 100, or 150 ppm showed labored respiration, severe central nervous system depression and nasal discharge. At the 100 ppm exposure level, some animals died by the 46th exposure and at 150 ppm all animals had died by the tenth exposure. Clinical signs were absent in animals exposed to 20 ppm and below.

Allyl alcohol was administered orally in aqueous 0.5% methylcellulose to groups of 10 male and female Wistar rats at dose levels of 0, 1.5, 3, 6, 12, or 25 mg/kg bw. In the 6, 12, and 25 mg/kg groups, there was a significant increase in relative liver weights and significant increases in the incidence of squamous epithelial hyperplasia in the forestomach. Females of the 25 mg/kg group also showed high incidences of bile duct hyperplasia and liver periportal hypertrophy.

Occasional exposures of humans to unknown airborne concentrations of allyl alcohol over a number of years have not been reported to cause any adverse medical findings.

2.1.3 Reproductive and Developmental Toxicity

2.1.3.1 Reproductive effects

May affect reproductive organs and performance at exposures that also cause maternal toxicity. In a reproductive toxicity screening study, hyperplasia of luteal cells in the ovary, alterations in estrus cyclicity, thymic atrophy, and liver pathology were present in female rats after receiving 40 mg/kg bwt/day allyl alcohol for 2 weeks premating, during mating, throughout gestation and until postnatal day 3. A decrease in postnatal viability of the pups was also noted at this dose level. In repeated toxicity studies, alterations in estrus were present in female rats that also exhibited injury to their gastrointestinal tract and liver after receiving 25 mg/kg bwt/day allyl alcohol for 14 weeks. There were no effects on the estrous cycle in mice nor were adverse changes present in gonadal structure in mice or rats or sperm parameters in rats with dose levels of allyl alcohol at 25-50 mg/kg bwt/day for 14 weeks.

2.1.3.2 Developmental Toxicity

Allyl alcohol is not a teratogen but may be toxic to embryo/fetal development at exposures that also cause maternal toxicity. Developmental toxicity indicated by an increased incidence of total litter loss was noted in rat dams exposed to 35 or 50 mg/kg bwt/day allyl alcohol from gestation days 6 through 19. Total litter loss occurred only in the presence of severe maternal toxicity (loss of body weight, severe decreases in feed consumption, and evidence of significant liver toxicity). Despite the severe maternal toxicity observed, there were no test-article related increases in malformation rates or incidence of variations. In a developmental toxicity study in rabbits, at a 20 mg/kg bwt/day allyl alcohol dose from gestation days 7 through 28, mortality, abortion, decreased defecation, and reduced body weight gain/food consumption was noted in the dams, in addition to reduced fetal body weight; however, there were no malformations noted.

2. Occupational Health

2.1.4 Genetic Toxicology
Inconsistent genotoxicity findings are reported for allyl alcohol with predominately positive results from in vitro tests but negative results from in vivo tests. In vitro, allyl alcohol was both positive and negative for mutations in bacteria, was positive for mutations in mammalian cells, and was positive for chromosomal aberrations in human cells. In contrast, no increase in micronuclei or dominant lethal mutations occurred in rodents after in vivo treatment.

2.1.5 Carcinogenicity
There is no data in the literature that adequately evaluates whether allyl alcohol is a carcinogen.

2.2 Occupational Exposure Limits
Please consult your local Safety Data Sheet (SDS) for an overview of current occupational exposure limits.

2.2.1 Odor Threshold
Allyl alcohol is a clear, colorless to slightly straw-colored liquid with a strong, mustard-like odor. Its odor threshold is 0.8 ppm. Odor is not an adequate warning of potentially hazardous ambient air concentrations.

2.3 First Aid
When an emergency arises, approach the incident with caution. Understand emergency procedures, and become familiar with the location of rescue equipment and emergency contact numbers before the need arises.

Caution should be used to prevent responder exposure to allyl alcohol from victim.

Personnel providing assistance to a victim should be cautious not to contaminate themselves by touching the victim's clothing unless wearing appropriate protective apparel. If the victim is unable to do so, remove his clothing to minimize continued skin contact. The removal of clothing from the victim is important to minimize continued skin contact and to prevent continued off gassing of allyl alcohol during transport to an emergency care facility. Emergency transport services should be equipped to provide continual flushing of the skin or eyes especially when the victim experiences irritation or burning.

2.3.1 Eye Contact
Flush eyes immediately with copious amounts of cool water for at least 15 minutes, periodically lifting the lower and upper lids to enhance flushing. Individuals splashed with allyl alcohol may require assistance in locating emergency eyewash stations and flushing the eyes. Medical attention should be provided as soon as possible, and an ophthalmologist should be available for consultation.

2.3.2 Skin Contact
If allyl alcohol contacts the skin, immediately flush the contaminated skin with copious amounts of water. If allyl alcohol contacts clothing, remove clothing and flush affected area with water for at least 15 minutes. While under deluge shower, continue to remove clothing, watches, rings, or anything else that would prevent complete flushing of allyl alcohol. If skin irritation or reddening is noted, seek medical attention.

2.3.3 Inhalation
If overcome from inhalation of allyl alcohol, move victim from contaminated atmosphere into fresh air at once. Treat for shock if necessary. If victim has stopped breathing, administer cardiopulmonary resuscitation (CPR) immediately. First aid-trained individuals, or equivalent, should administer CPR. The victim should be monitored for respiratory distress. If cough or difficulty in breathing develops, administer 100% humidified supplementary oxygen with assisted ventilation, if required. Seek prompt medical attention.

2.3.4 Ingestion
If even a minor quantity is swallowed, give two glasses of lukewarm water and induce vomiting. Do not give anything by mouth or induce vomiting if patient is not completely conscious and alert. Obtain emergency medical attention.

2. Occupational Health

2.4 Medical Management

Victims who have been acutely exposed to allyl alcohol and have received the initial first aid procedures outlined above may require additional emergency medical treatment. Advanced life support should be provided by medical staff to all victims with evidence of respiratory injury or extensive skin burns. In case of ingestion, the stomach should be emptied by gastric lavage under qualified medical supervision. Lavage return should approximate fluid given. Administer activated charcoal cathartic, aqueous or mixed with saline cathartic or sorbitol. Typical charcoal dose: for an adult is 30 to 100 grams, and for a child is 15 to 30 grams. Observe patient for signs of gastrointestinal irritation.

Employers should be prepared to handle potential medical emergencies resulting from allyl alcohol exposure. Each facility should have at least one person trained and certified in first aid. If medical personnel are not present at the work site, a local physician and hospital emergency room should be contacted and informed of potential medical emergencies and their treatment.

Medical personnel should be informed of the proper precautions to take when confronted with an allyl alcohol emergency. Copies of the product Safety Data Sheet (SDS) or this Product Safety Bulletin should also be provided and reviewed with appropriate medical personnel.

2.4.1 Initial Medical Screening

Prospective employees who will work with or around allyl alcohol should be medically evaluated to determine pre-existing conditions that may be aggravated by exposure to allyl alcohol. The individual could find it stressful to wear personal protective equipment, which may include respiratory protection and chemical protective clothing (see Sections 3.3 and 3.4). Some workers are claustrophobic when placed in full facemask respiratory protection, full containment suits, or when entering confined spaces.

Workers required to wear respiratory protection should be evaluated and approved for work by a medical professional. The medical decision is based upon the practitioner's judgment, but commonly involves a targeted medical history and physical with particular reference to the cardiorespiratory system.

Allyl alcohol's irritant properties can potentially exacerbate symptoms in persons with impaired pulmonary function, particularly obstructive airway disease. Allyl alcohol can also cause skin burns. Persons with existing skin disorders may be more susceptible to dermal effects. Also, those with existing eye disease may be at increased risk of harm from exposure.

Allyl alcohol is readily metabolized to acrolein, which can induce both liver and kidney damage. therefore persons with impaired liver function should exercise caution with the chemical.. The possibility of hepatic periportal toxicity should also be considered. Allyl alcohol has caused extreme periportal effects in experimental animals. the potential of the key metabolite to induce kidney damage justifies special consideration of those with impaired renal function given the importance of the kidney in elimination of toxic substances from the body.

A specific protocol for initial medical examination should be developed by an occupational health physician before hiring individuals who may be exposed to allyl alcohol.

2.4.2 Periodic Screening

Workers that are potentially exposed to allyl alcohol should receive periodic medical evaluations that essentially duplicate the initial evaluation for comparative purposes. Regular medical screening is an effective tool for the identification and prevention of occupational disease.

3. Personal Safety and Health

3.1 Site Facilities

If a potential for contact with allyl alcohol exists in work areas where it is handled or stored, quick drenching facilities and equipment should be provided. This should include deluge showers and eyewash stations. These items should be installed, tested and maintained in accordance with established industry standards. Workers should be familiar with the location and operation of this safety equipment.

If contaminated clothing is laundered, appropriate facilities should be provided. Allyl alcohol will evaporate from clothing potentially increasing the risk of worker exposure. Site facilities should include closed containers for clothing storage and engineering controls to limit worker exposure. Personnel who will be handling contaminated clothing should be trained and fully aware of the methods available to protect themselves, including the use of personal protective equipment and methods to determine vapor concentrations.

Shower facilities should be available for use at the end of the shift by workers working with allyl alcohol. It is strongly recommended that a clean room arrangement is established in locker/shower facilities.

3.2 Hygiene Practices

Proper personal hygiene practices should be used when working with and around allyl alcohol. Workers should be familiar with good work practices to avoid direct contact with allyl alcohol. They should also be familiar with decontamination procedures for equipment. Allyl alcohol should not be handled or stored in areas where personnel take breaks, such as lunch rooms, or in areas that are not designed for chemical storage.

Hygiene practices that should be enforced for employees working with allyl alcohol include prohibiting the consumption and storage of food, use and storage of tobacco products, and application and storage of cosmetics. After handling allyl alcohol and prior to eating, smoking, drinking, applying cosmetics or using toilet facilities, personnel should thoroughly wash their hands and faces with lukewarm water and mild soap or detergent.

Protective clothing used during the handling of allyl alcohol, including gloves, aprons, protective suits and respirators, should be properly decontaminated using mild soap/detergent and water. Non impervious clothing should be sealed in containers to prevent vapors from escaping into the air until laundered or disposed. Clothing may be laundered, provided that personnel handling these materials are aware of the hazards of allyl alcohol. Articles such as wallets, belts and shoes constructed of leather, and other items that cannot be effectively decontaminated should be disposed of properly as contaminated waste (see Section 7.2).

3.3 Respiratory Protection

Good industrial hygiene practice requires that engineering controls be used to reduce workplace airborne concentrations of allyl alcohol to below the established Occupational Exposure Limits. However, if engineering controls are not technically feasible; are currently being installed; or fail to control exposure and need to be supplemented, respiratory protection may be provided for worker protection. Respirators may also be needed for nonroutine operations such as confined space entry and in emergency situations arising from spills/leaks and fire/explosions involving allyl alcohol.

If respirators are used, a complete respiratory protection program should be implemented which includes training, fit testing, inspection, medical surveillance, cleaning and maintenance. Respiratory protection programs should meet the requirements set forth in the national Respiratory Protection Standards

Approved respirators should be used when worker exposure exceeds established limits. Since allyl alcohol is very irritating to the eyes, full face respirators with an organic vapor cartridge are considered the minimum level of respiratory protection. Supplied air or self-contained breathing apparatus (SCBA) with a full-face mask operated in positive pressure mode must be used when the exposure can exceed 20 ppm (IDLH level).

For emergency escape purposes, a full-face respirator (gas mask) may be used. Table 3-1 provides for the selection of respiratory protection.

Respirators contaminated with allyl alcohol can be decontaminated using lukewarm water with mild soap or detergent. Allyl alcohol may permeate through and degrade the elastomeric materials of the respirators. Therefore, precautions must be taken to prevent direct contact with liquid allyl alcohol. Degraded respirators must be discarded.

3. Personal Safety and Health

Table 3-1 Allyl Alcohol Respiratory Protection Selection Guide

Condition	Minimum Respiratory Protection Required Above 0.5 ppm
20 ppm OR LESS	• A chemical-cartridge respirator with a full facepiece and organic-vapor cartridge(s). • A gas mask with a chin-style or a front- or back-mounted organic vapor canister. • Any self-contained breathing apparatus with a full facepiece. • A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive-pressure mode or with a full facepiece, helmet or hood operated in continuous-flow mode.
GREATER THAN 20 ppm*OR ENTRY AND ESCAPE FROM UNKNOWN CONCENTRATIONS	• A combination respirator that includes a Type C supplied-air respirator with a full facepiece operated in pressure demand or other positive-pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure demand or other positive-pressure mode.
FIRE FIGHTING	• Self-contained breathing apparatus with a full facepiece operated in pressure-demand mode.
ESCAPE	• Any gas mask providing protection against organic vapors. • Any escape self-contained breathing apparatus.

*Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of allyl alcohol; however, this equipment should be selected, used and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 150 ppm, an auxiliary self-contained breathing apparatus operated in positive-pressure mode should also be worn.

3. Personal Safety and Health

3.4 Chemical Protective Clothing

Personal protective clothing and equipment (PPE) should be provided to personnel during routine and nonroutine handling, spill cleanup, and firefighting involving allyl alcohol. Personal protective clothing is necessary to prevent exposure to vapor or liquid during both routine and nonroutine work activities. Select chemical protective clothing according to the chemical properties of allyl alcohol, the working conditions, and the potential for contact with liquid or vapor.

3.4.1 Eye Protection

Chemical safety goggles, cup-type plastic of gas-tight design, equipped with impact-resistant lenses, should be worn whenever the potential for exposure to vapor or liquid is present. A face shield (8-inch minimum) may be worn to provide added splash protection. These eye protective measures should meet applicable national specifications.

3.4.2 Foot Protection

Heavy rubber overboots should be provided and worn over leather shoes or boots to protect the leather from contamination. Leather items absorb allyl alcohol, thereby increasing the risk of dermal (skin) exposure, and cannot be effectively decontaminated. Rubber boots should be worn under pant legs to prevent allyl alcohol from entering the boot.

Where the potential for falling objects exists, steeltoed rubber boots or safety shoes with overboots should be worn. The steel-toed shoes/boots should meet the applicable national specifications. Boots that become torn during use should be replaced.

3.4.3 Skin Protection

Impervious protective clothing suitable for a particular work activity should be worn.

Allyl alcohol was tested against a variety of chemical protective clothing (CPC) materials. Protective clothing and gloves made with butyl rubber provide protection from contact with liquid for at least 8 hours (see Table 3-2). However, the quality and thickness of the CPC may vary between manufacturers. Therefore, manufacturer specific allyl alcohol permeation data should be obtained and evaluated before selection.

Protective clothing used in a contaminated environment should be properly decontaminated prior to handling by unprotected individuals and reuse. To decontaminate the protective clothing wash with a mild soap/detergent and water.

3. Personal Safety and Health

Table 3-2 Allyl Alcohol Permeation Test Data*
Concentration: 100%

Resistant Material	Overall Rating	Breakthrough Time (hours)	Permeation Rate (µg/cm2 min)
BUTYL RUBBER	G	E	NA
BUTYL RUBBER/NYLON	F	V	NA
BUTYL NEOPRENE	G	E	NA
CHLORINATED POLYETHELENE/NYLON	F	G	NA
NEOPRENE	G	F	V
CHLOROPRENE RUBBER/FABRIC	F	V	NA
CHLOROPRENE RUBBER/NYLON	NR	F	NA
CHLOROPRENE/FABRIC/CHLOROPRENE	F	G	NA
POLYETHYLENE/TYVEK®	NR	F	NA
PV ALCOHOL	F	P	G
POLYVINYL CHLORIDE, SHEET	NR	F	NA
POLYVINYL CHLORIDE, NYLON	NR	P	NA
SARANEX®	G	E	NA
TEFLON™ NOMEX®/TEFLON®	E	E	E
VITON®	G	E	NA
VITON®/CHLOROBUTYL	F	G	NA
VITON®/NEOPRENE	G	E	NA

*Test data reported as an average of breakthrough times and permeation rates. This information should be used as a guideline for material selection. Contact manufacturer for specific product information.

Overall Rating	Breakthrough Time (hrs.)	Permeation Rate (µg/cm2/min)	
E - EXCELLENT	E - > 8 hrs.		
V - VERY GOOD	V - 4 to 8 hrs.	E - < 0.9	F - < 900.0
G - GOOD	G - 2 to 4 hrs.	V - < 9.0	P - < 9000.0
F - FAIR	F - 0.25 to 2 hrs.	G - < 90.0	NA - NOT AVAILABLE
NR - NOT RECOMMENDED	P - < 0.25 hrs.		

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3. Personal Safety and Health

Breakthrough Time (hrs.)	Permeation Rate (µg/cm2/min) P*	F	G	V	E
P	1	1	2	2	2
F	1	2	3	3	3
G	2	3	3	4	4
V	2	3	4	4	5
E	3▽	3	4	5	5

Rating

1 - NOT RECOMMENDED
2 - FAIR
3 - GOOD
4 - VERY GOOD
5 - EXCELLENT

* Use if no data identified
▽Favors a long breakthrough time

3.5 Direct Reading Instruments

Allyl alcohol is readily detectable by a variety of direct reading instruments. The advantage of using direct reading instruments is that real-time analysis and instantaneous air concentrations can be determined. The value of a real-time analysis, in terms of prevention of injury and illness, is considerable.

Direct reading instruments that have been successfully used to measure allyl alcohol are combustible gas indicators, infrared spectrophotometers, flame ionization detectors and photoionization detectors. Appendix III contains a partial list of product vendors. Limits of detection vary between these instruments and should be evaluated to ensure proper use. The proper selection, calibration, use and interpretation of direct reading instruments requires the services of a professional industrial hygienist or other knowledgeable person.

3.6 Air Sampling and Analysis

When assessing worker exposure to allyl alcohol, an extended sampling period is desirable. The most common method of air sampling is collection on a sorbent media over an extended period of time. Air is drawn at a predetermined rate by a sampling pump into a charcoal tube.

The method may be substituted with the use of passive samplers, which use the diffusion characteristics of the material instead of an active sampling pump. These methods have been extensively developed and evaluated for use with allyl alcohol.

These methods for air sampling and analysis are the primary means to determine worker exposures over extended periods. When considering the use of these methods for determination of worker exposure, it is important that a monitoring system is developed by professional industrial hygienists. This program should include the sampling strategy, quality assurance, and statistical analysis of results.

4. Engineering

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

4.1 Bulk Storage

The construction of low pressure allyl alcohol storage tanks should be in accordance with American Petroleum Institute (API) 620 and 650 and National Fire Protection Association (NFPA) 30. Higher pressure storage vessels should comply with American Society of Mechanical Engineers (ASME) Code, Section VIII, Division 1. Carbon steel is acceptable but should be clean and rust free. Stainless steel should be used if trace iron contamination or slight discoloration are objectionable. The tank should be padded with nitrogen. Allyl alcohol should enter through the bottom of the tank. Incoming liquid should be prevented from free falling through the tank vapor space (see Section 8).

4.2 Piping

Piping and piping components should comply with the latest applicable national standards. The minimum grade acceptable is 304 stainless steel if iron contamination is a concern. Carbon steel is also acceptable. Welded or flanged connections are preferred; the use of threaded connections should be avoided. Flanged connections should be kept to a minimum.

4.3 Electrical Area Classification

All electrical equipment should conform to applicable national regulations

4.4 Pump Specifications

Pump Seals: Double mechanical seals are recommended to minimize fugitive emissions.

Centrifugal: API or ANSI stainless steel centrifugal pumps with mechanical seals are recommended for large capacity pumping. Magnetic drive or sealless “canned motor” stainless steel pumps are recommended where possible.

4.5 Instrumentation

Independent and redundant high level alarms and/or shutdowns should be provided to avoid overflow of allyl alcohol storage vessels. Batch reactors should have high temperature alarms and rate of rise controllers for automatic feed shut off and quench cooling control.

4.6 Relief Requirements

The requirements of API 2000 should be followed for low pressure vertical storage tanks. Pressure relieving systems for pressure vessels are defined in API 520 parts 1 and 2. Flame arresters, when required, should follow the requirements of API 2028 and 2210, Underwriters Laboratory (UL) 525 and NFPA 30.

4.7 Leak Detection Devices

Process, secondary containment areas and confined spaces should be monitored with instrumentation to detect low airborne concentrations of allyl alcohol.

Instruments that have been successfully used to measure allyl alcohol are combustible gas indicators, infrared spectrophotometers, flame ionization detectors and photoionization detectors (see Section 3.5).

4.8 Material Requirements

All equipment (including but not limited to piping, pressure vessels, storage tanks, pumps, gaskets, etc.) should follow recognized industry codes and standards and the requirements of local jurisdictions. These codes include but are not limited to:

- ASME Boiler and Pressure Vessel Code
- ASME B31.3 “Process Piping”
- API 650 “Welded Storage Tanks for Oil

4. Engineering

4.8.1 Equipment (Piping, Tanks, Vessels, etc.)

- Carbon Steel
- 304L and 316L Stainless Steels are also acceptable
- Cast Iron should be avoided due to its brittleness

4.8.2 Gasket

- Spiral Wound: 316L stainless steel windings, 100% graphite filled; for piping flanges, stainless steel inner ring and carbon steel outer ring should be used - Lamons WRI, Flexitallic CGI, or equivalent
- Flat Ring or Sheet Gaskets
- Metal Reinforced Graphite Laminate: 316/316L stainless steel insert with 98% graphite mechanically bonded on both sides - Lamons LG-TC, Flexitallic Flexicarb ST, Grafoil® GHE, or equivalent
- Corrugated Metal Gasket: 316/316L stainless steel corrugated metal core with 98% graphite on both sides - Lamons CMG or equivalent
- Kammprofile: 316L stainless steel core with graphite facings - Lamons LP series, Flexitallic Flexpro™ series, or equivalent

4.8.3 Elastomers (O-rings)

- Perfluoroelastomers (FPM) - Kalrez®1050 or equivalent
- Polytetrafluoroethylene (PTFE) - Teflon™ or equivalent

4.8.4 Pipe Thread Sealant

- PTFE based paste or tape, however, the use of threaded pipe connections is generally discouraged. Continuity should be checked across connections or other means must be provided to ensure proper bonding and grounding of piping components

4.8.5 Pumps

- Casings: see section 4.8.1 above
- Gaskets: see section 4.8.2 above
- Elastomers: see section 4.8.3 above
- Seals: Double mechanical seals (such as API 682 plan 52, 53, or 72) are recommended
- Faces: tungsten carbide on carbon
- Glands: 316/316L stainless steel

4.8.6 Valves

- Body and Bonnet: see section 4.8.1 above
- Bonnet Gaskets: see section 4.8.2 above or welded bonnet valves may be used
- Packing: Graphite based die formed rings or bellows sealed
- Isolation valves should be “fire safe” per API 607

4.8.7 Hoses

- Stainless steel corrugated core with stainless steel outer braid
- User must follow hose manufacturer’s recommendations regarding temperature/pressure ratings, minimum bending radius, support requirements, etc.

4.9 Vapor Containment System

Emissions from equipment should be vented to a continuous flare or, where flares are not available, vapor containment systems should be designed in accordance with API 2000, API 520, API 2028 and 2210, UL 525, and NFPA 30.

4.10 Chemical Compatibility

Incompatible with strong acids, bases, oxidizing agents, carbon tetrachloride, oleum, diallyl phosphite, potassium chloride, tri-bromomelamine and metal alkyls, such as triethyl aluminum and butyl lithium.

5. Fire Safety

5.1 Fire and Explosion Hazard

Allyl alcohol is a highly flammable liquid (H225) that is classified by the following U.S. organizations:

Hazard Classifications

Organization	Classification	
NFPA 30	Class 1B, flammable liquid	
NEC-NFPA 70	Class 1, Group C, flammable liquid	
NFPA 704	Health	4
	Fire	3
	Reactivity	1

Vapors of allyl alcohol at concentrations between 2.5% and 18% are flammable and can ignite if an ignition source is present. Allyl alcohol vapor is twice as heavy as air and may travel a considerable distance to a source of ignition and flash back. All precautions necessary for the safe handling and storage of a volatile flammable liquid or vapor should be strictly observed when handling allyl alcohol. Handling of allyl alcohol should be done under nitrogen at all times.

Storage areas should be designed to prevent exposure of allyl alcohol containers to fire (see Section 8.1). Section 9 provides recommendations for the safe unloading and transfer of allyl alcohol which are necessary to minimize the fire and explosion hazard while performing these operations.

If this material is involved in a fire, prevent unauthorized individuals from entering the area and evacuate the area downwind from the fire. Fires should be fought from a safe distance upwind. Thermal decomposition products, such as carbon dioxide, carbon monoxide and perhaps other toxic gases and vapors, may be generated.

Heat may build pressure and cause rupture of closed containers. A water fog may be used to cool the containers. Water may be ineffective as an extinguishing agent. Prevent liquid from entering water sources and sewers by building dikes as necessary to contain flow.

5.2 Fire Prevention

Sources of ignition, including heat, sparks, flames and static electricity, should be avoided when working with allyl alcohol. Compliance with this basic rule requires continual management. Meeting this rule typically should include the following combination of work practices and mechanical controls:

- A strong “no smoking” policy in areas where allyl alcohol is used
- The use of non-sparking tools while working with or near allyl alcohol-containing equipment
- Grounding of metallic containers/vessels in which the material is stored
- Bonding and grounding of metallic receiving containers
- Stringent welding, cutting and burning permit systems
- Implementation of inside and outside storage methods that comply with legal requirements and good industry practice.

5.2.1 Static Electricity

As with other flammable liquids, the transfer of allyl alcohol can create static electricity charges, which can act as an ignition source for flammable vapors. The charge can develop when the liquid flows or is poured through air. To reduce or eliminate this, bonding and grounding is required by building and fire codes, and industry practice (NFPA 70, NFPA 77, NFPA 30).

Bonding provides a low resistance path to current flow between two surfaces which are physically separated or become separated. Maximum resistance to ground of 1 megaohm is acceptable (NFPA 77), but generally much lower values are possible.

Grounding connects the containment vessels, pipes, etc. to a grounding electrode (ground) in the earth by means of conductors welded/attached to both the equipment and the ground. A 10 ohm maximum is the recommended value for the resistance of the cable and ground.

5. Fire Safety

5.3 Fire Suppression

A variety of suppression methods are available for extinguishing fires involving allyl alcohol. As with any fire suppression method, the facility's specific needs should be discussed in detail with the vendor before selection of material. Other considerations include volumes of allyl alcohol used and stored, method and location of storage, current fire suppression systems, and the advice of facility safety, production and engineering personnel.

Evaporation of allyl alcohol can be suppressed by applying a blanket of alcohol foam. Fire and vapor suppression foams have been developed specifically for alcohol fires and releases. They provide a membrane coating which forms a protective layer.

Portable fire extinguishers should be placed in the vicinity where allyl alcohol is handled or stored and in areas where the potential for spills or leaks exists. Class B dry chemical or foam extinguishers should be used when fighting small allyl alcohol fires. Guidelines for the correct selection, use, distribution, inspection, maintenance, and recharging of portable fire extinguishers should be referred to when designing a work area (NFPA 10).

5.4 Fire Fighting

If a facility relies on community fire companies for fire response, information regarding allyl alcohol operations and storage should be provided. Information should include facility layouts indicating the storage locations and quantities of allyl alcohol. Drills should be conducted periodically with the fire company and facility information updated on a regular basis.

If a facility chooses the option of an internal fire brigade for structural firefighting, then compliance with the OSHA Fire Brigade Standard is required. These requirements as defined in 29 CFR 1910.156 include the organization of a fire brigade, personal firefighting equipment and training requirements.

Allyl alcohol thermally decomposes to carbon dioxide and possibly carbon monoxide. Skin absorption properties, not common to organic solvents, should be emphasized as well as its capacity to cause severe irritation. It is critical that all fire fighters are protected against absorption of allyl alcohol vapor or liquid through the skin.

Fire fighters should use full protective clothing and equipment, including National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) approved self-contained breathing apparatus (SCBA) with full-face mask operated in the pressure-demand mode. Water spray can be used to disperse vapors to protect the fire fighters who may be attempting to stop a leak. All personnel not directly involved with controlling the fire should be removed to a safe location. If the material is spilled on the ground, attempts should be made to contain it. Fire water runoff containing allyl alcohol should be minimized and contained due to the potential aquatic hazard of this material.

If a fire is controllable or allyl alcohol containers are not exposed to direct flame, an evacuation zone with a minimum radius of 1800 feet may be needed. If the fire becomes uncontrollable or allyl alcohol containers are exposed to direct flame, an evacuation zone with a minimum radius of 5000 feet may be required.

In some instances, depending on specific facility hazards, it may be prudent to allow an allyl alcohol fire to burn itself out. A qualified fire fighting expert should make this decision.

After a fire has been extinguished, residual allyl alcohol contamination may occur. This may require a cleanup of the liquid. Individuals who engage in such a cleanup should be thoroughly trained in proper techniques and have received training in accordance with the OSHA Hazardous Waste Operations and Emergency Response (HazWOpER) standard, 29 CFR 1910.120 (see Section 7).

6. Hazard Communication

6.1 Hazard Communication

Under hazard communication and national and local worker right-to-know laws, workers should be informed of the potential hazards of chemicals in the workplace. Such laws require that employers who use hazardous chemicals in their workplace, including allyl alcohol, develop written programs and train workers on the potential hazards and protective measures.

6.1.1 Worker Training

As a user of allyl alcohol, an employer should provide information and training to workers on its hazards, the methods for detecting releases and methods of protection from exposure. This information should be included in your Hazard Communication Training Program. To assist you in this effort, the following summary information is provided.

6.1.1.1 Hazards

Allyl alcohol is a toxic and flammable liquid. The vapors are heavier than air and may travel long distances along the ground. These vapors are flammable and will burn or explode.

Exposure to allyl alcohol can occur through any route of exposure but most commonly occurs through inhalation, or skin or eye contact. If inhaled, short-term exposure to allyl alcohol in high concentrations will cause pulmonary edema (fluid in the lungs) and chemical pneumonia.

Skin contact with allyl alcohol can result in irritation or chemical burns, depending on the concentration of the liquid and the duration of skin contact. Allyl alcohol is readily absorbed through the skin in toxic and even lethal concentration.

Eye contact with liquid allyl alcohol may result in chemical burns. High vapor concentrations may cause eye irritation.

For a complete discussion of the health effects of allyl alcohol see Section 2.

6.1.1.2 Methods of Detection

To determine allyl alcohol concentrations in air, measurements can be made using air sampling equipment. A variety of instruments are available to provide instantaneous or continuous monitoring of allyl alcohol concentrations in air.

Direct reading instruments including combustible gas indicators, infrared spectrophotometer, flame and photoionization detectors, and colorometric detector tubes (see Section 3.5) can be used to monitor for allyl alcohol. When assessing worker exposure to allyl alcohol, personal breathing zone samples should be collected to determine compliance with the established exposure limits (see Section 3.6).

6.1.1.3 Methods of Protection

Hazard Communication Training should include information on methods of protection that can be used by workers handling allyl alcohol. This should include the engineering and administrative controls employed, as well as the personal protective clothing and equipment (PPE) to be worn (see Sections 3.3 and 3.4).

6.1.2 Labeling

All incoming containers of this product are accompanied by a product label providing health and safety information. The product label is a primary source of information for safe handling of this material. Lyondell product labels contain the material identification, principal hazards, and Lyondell's name, address and telephone number.

6.1.3 Safety Data Sheets

The Lyondell Safety Data Sheet (SDS) is provided to customers with the first order of the new year and with the first order after any change or revision to the SDS. SDS are the primary means of providing information regarding the safe storage, handling and use of Lyondell products. While the product SDS is an invaluable source of health and safety information, it may not supply information specific to the actual uses of the product.

Lyondell SDS are available in several languages and formats on our website www.lyb.com. While the additional downstream sales of this product, or materials containing this product, are the responsibility of the distributor, Lyondell will support your hazard communication efforts.

6. Hazard Communication

6.2 SARA Title III (U.S. only)

The Emergency Planning and Community Right to Know Act of 1986, also referred to as the Superfund Amendment and Reauthorization Act or SARA Title III, requires facilities which use or store allyl alcohol to notify their state emergency response commissions and work with local authorities to develop emergency response plans. Users of allyl alcohol should read the SARA Title III regulations and familiarize themselves with its requirements.

Since allyl alcohol is a potentially hazardous chemical, facilities should submit a copy of their MSDS or their chemical inventory list to their local emergency planning committee (LEPC). If a facility uses or stores more than the threshold planning quantity (TPQ) of 1,000 pounds of allyl alcohol in a year, the facility should submit an annual Tier I or Tier II Report to state and local agencies. This inventory listing should include all mixtures of allyl alcohol in excess of 1.0% concentration.

6.3 State Regulations

State or local regulations, while patterned after the federal legislation, may have different or more stringent requirements. Specific state regulations should be reviewed in order to assess the applicability of these regulations to the use of allyl alcohol.

7. Environmental

Biodegradation is expected to be the predominant fate of allyl alcohol in water as it is readily biodegradable. If released in the water, allyl alcohol is not expected to volatilize, photo-oxidize or directly photolyze.

Aqueous waste streams containing allyl alcohol can be treated in acclimated and well operated biological treatment systems except where prohibited under land disposal restrictions. The maximum concentration of allyl alcohol that can be treated in biological systems should be demonstrated in bench scale studies prior to introduction of the material into operating facilities. Sufficient equalization capacity is required to minimize variations in the quantity of allyl alcohol in the treatment system influent.

Allyl alcohol may contaminate the soil from accidental spills and uncontrolled process runoff. If released into the ground, the major fates of allyl alcohol are expected to be migration to groundwater and biodegradation. Volatilization and direct photolysis are not expected to be significant in moist soil. Allyl alcohol has a calculated log Kow value of 0.17 at 25°C, which indicates that allyl alcohol will not tend to bioaccumulate in plants, aquatic life, or animals.

Allyl alcohol is very toxic to freshwater fish. Allyl alcohol should not be discharged into any public water system.

7.1 Spills and Leaks

Facilities involved in the storage and/or handling of allyl alcohol should be designed to contain and/or control spills from process areas and loading/unloading operations. Soil and groundwater contamination from an accidental spill of allyl alcohol can be minimized by installation of curbs, sumps and impervious containment areas.

To minimize soil and groundwater contamination in the event of an allyl alcohol spill, the containment areas should be designed and constructed of impermeable materials such as concrete, synthetic liners or compacted clay. Cracks in the concrete secondary containment areas should be sealed with compatible epoxy sealants. The sealant selected should be evaluated in allyl alcohol service to ensure compatibility, as allyl alcohol will degrade certain epoxy resins.

Pumps, piping and equipment, designed to operate within potential spill areas, should be compatible with allyl alcohol (see Section 4) and free of potential ignition sources.

If possible, all pumps and ancillary equipment should be located outside the primary containment area and should be provided with curbing to collect drips, leaks and minor spills. Drain valves can be included in the design; however, during normal operations these valves should be in a closed position.

In the event of an allyl alcohol release into the environment local or national regulations should be consulted to ensure compliance with reportable quantities..

Allyl alcohol spills should not be discharged into the public sewer system or public waterways. For spill control, use sorbent pads and blanket with firefighting foam. Restrict water use for cleanup.

Any accidental discharge of allyl alcohol or process waste containing allyl alcohol into the municipal sewer system should be reported immediately to local authorities.

In the event of a spill of allyl alcohol, all nonessential personnel should be evacuated. All ignition sources should be extinguished. After donning the appropriate personal protective clothing and equipment (see Section 3), the spill can be covered with an alcohol foam (see Section 5.3) to suppress vapor emission and minimize potential fire hazard. The spill may then be vacuumed or absorbed and collected in appropriate spill cleanup containers for disposal.

7. Environmental

7.2 Waste Disposal

Allyl alcohol is a flammable liquid and is hazardous when discharged into the environment. In areas where allyl alcohol may be released or handled, access should be limited to required personnel only. Waste disposal should be conducted in accordance with local regulations.

Low concentrations of allyl alcohol in aqueous waste streams may be disposed in a well-operated and acclimated biological treatment system. Aqueous waste streams with higher concentrations of allyl alcohol, contaminated or off-specification product, and nonaqueous process wastes and residues may be incinerated. The incineration systems utilized for disposal of allyl alcohol should be properly designed and have the required permits. Process waste streams should be characterized to determine the proper regulatory classification.

If allyl alcohol process waste is treated biologically at a POTW, the local authority should be consulted to determine its requirements. If allyl alcohol is treated in an onsite biological wastewater treatment system, sufficient equalization should be provided to reduce “shock” loads on the system. Operation of the treatment system should comply with national water regulations.

Soil contaminated with allyl alcohol product should be excavated and disposed of in compliance with all requirements of hazardous waste regulations.

Discarded, off-specification, commercial chemical product may be considered a hazardous waste.
The materials should be disposed of in accordance with the local regulations. Waste, off -specification allyl alcohol product, containers that have not been cleaned, and spill clean-up materials may be subject to land disposal restrictions.

7.3 Container Disposal

Any shipping container or drum which has been used to ship allyl alcohol and has not been satisfactorily cleaned should be considered a potential fire/explosion risk and should not be cut, burned, soldered or welded. These materials may also be considered a listed hazardous waste and should be cleaned or disposed of in accordance with applicable regulations.

8. Product Storage

Among the considerations in the design and construction of storage facilities for allyl alcohol are its flammability, toxicity, potential effects to the environment, and risks to worker health. The specific design requirements for facilities receiving and storing allyl alcohol depend upon several factors, including types of containers used, mode of delivery to the facility, processing methods, amounts stored and handled, quantities of other nearby flammable or combustible materials handled, character of the adjacent community, and risks posed by adjacent facilities. The proper design and construction of storage and handling facilities require consultation with competent professional engineers.

Additional requirements may be imposed by the U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA). EPA's Risk Management Plan (RMP) for Accidental Releases, 40 Code of Federal Regulations (CFR) 68.130 (see Appendix VI for citations) applies to facilities that process or store regulated substances that exceed the threshold quantities as established by the EPA . The RMP threshold quantity for allyl alcohol is 15,000 pounds or more. OSHA's standard for Process Safety Management of Highly Hazardous Chemicals, 29 CFR 1910.119 (see Appendix VI for citations) applies to processes that involve flammable liquids, including allyl alcohol, in one location, in quantities of 10,000 pounds or more.

Facilities must review the RMP regulations and the PSM standard prior to designing or modifying existing facilities. Though Lyondell does not assume the responsibility of deeming management plans as appropriate or effective, Lyondell will require that facilities provide evidence of compliance with these regulations, including, but not limited to, providing copies of the management plans to Lyondell prior to delivery of bulk quantities. Additionally, U.S. Department of Transportation (DOT) regulations, as codified at 49 CFR 172.800, will require facilities to establish or update a written transportation security plan to account for the transportation, storage, and handling of any quantity of allyl alcohol.

8.1 Storage Tanks

Considerations on site selection and tank spacing include proximity to other flammable material storage facilities, nearby ignition sources, firefighting accessibility, and potential consequences of a release beyond the plant boundaries. Installations should comply with applicable national standards such as NFPA 30 and NFPA 70 in the US.

Construct allyl alcohol tanks as low pressure vessels in accordance with NFPA 30 and American Petroleum Institute (API) Standard 620 or 650, Recommended Rules for Design and Construction of Large, Low-Pressure Storage Tanks. See Figure 8-1 for typical storage tank configuration.

Outside storage tanks should be diked to contain potential spills. A reliable water/foam supply should be available, in adequate pressure and volume, to meet the fire demands of the particular situation. The degree to which allyl alcohol-containing equipment is protected may be based on a number of criteria which include: storage and usage volumes, temperatures, pressures, material handling procedures, proximity to vulnerable structures and personnel, and availability of outside support (see Section 5.4).

Tanks should be situated within containment systems which are capable of both the detection and control of releases. Consult API 2350 for proper design considerations for overfill prevention. Tanks should be vented according to API 2000.

Bulk storage tanks should be vented to a vapor collection and containment system, eliminating discharges to the atmosphere during loading, unloading and breathing due to atmospheric temperature changes. A flare system is preferred for vapor collection and destruction. For non-contained discharges, a flame arrester should be used.

8.2 Unloading Stations

Unloading areas should be designed and operated to meet current standards for fire protection, worker safety and environmental protection. These standards require that instrumentation at off-loading stations warns operators of the potential for overfilling the storage tank and also that a totally independent device shuts off flow whenever overfill is imminent. Neither device is to be used as a regular operating tool for tank level determination. As part of the off-loading procedure, the shutoff device should be regularly tested.

Lyondell recommends that loading racks should be located at least 150 feet from all equipment and tanks. Electrical wiring and devices should comply with the requirements of NFPA 70. Piping should comply with NFPA 30 and the latest version of American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI) B31 Chemical Plant and Petroleum Refinery Piping. Piping systems for tank trucks and tank cars should be connected to a common earth ground and bonded to the discharge system. Continuity to ground should be checked prior to unloading.

8. Product Storage

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

The sump or catch-basin should have fire seals and should be equipped with instruments that will reliably detect liquid levels and the presence of allyl alcohol vapor. Rain water and spills trapped inside the containment area are to be disposed of through the sump or catch-basin. Discharge valves from the collection area should be disposed of only by a trained operator after determining the liquid's composition. Lighting adequate for night-time unloading operations should be provided, unless all unloading will be done during daylight.

A suitable method of unloading bulk tankers should be provided. Acceptable methods include pumping from the top through a dip pipe or pressurization with nitrogen. If nitrogen pressurization is used, the installation should be designed to avoid overpressurization of the vessel. Furthermore, a means of collection and environmentally acceptable treatment of the displaced vapor from the storage tank should be provided (e.g., flaring or scrubbing). Vapor containment systems should be designed to remove or recover vapor generated from loading or unloading operations (see Section 4).

8.3 Workplace Location

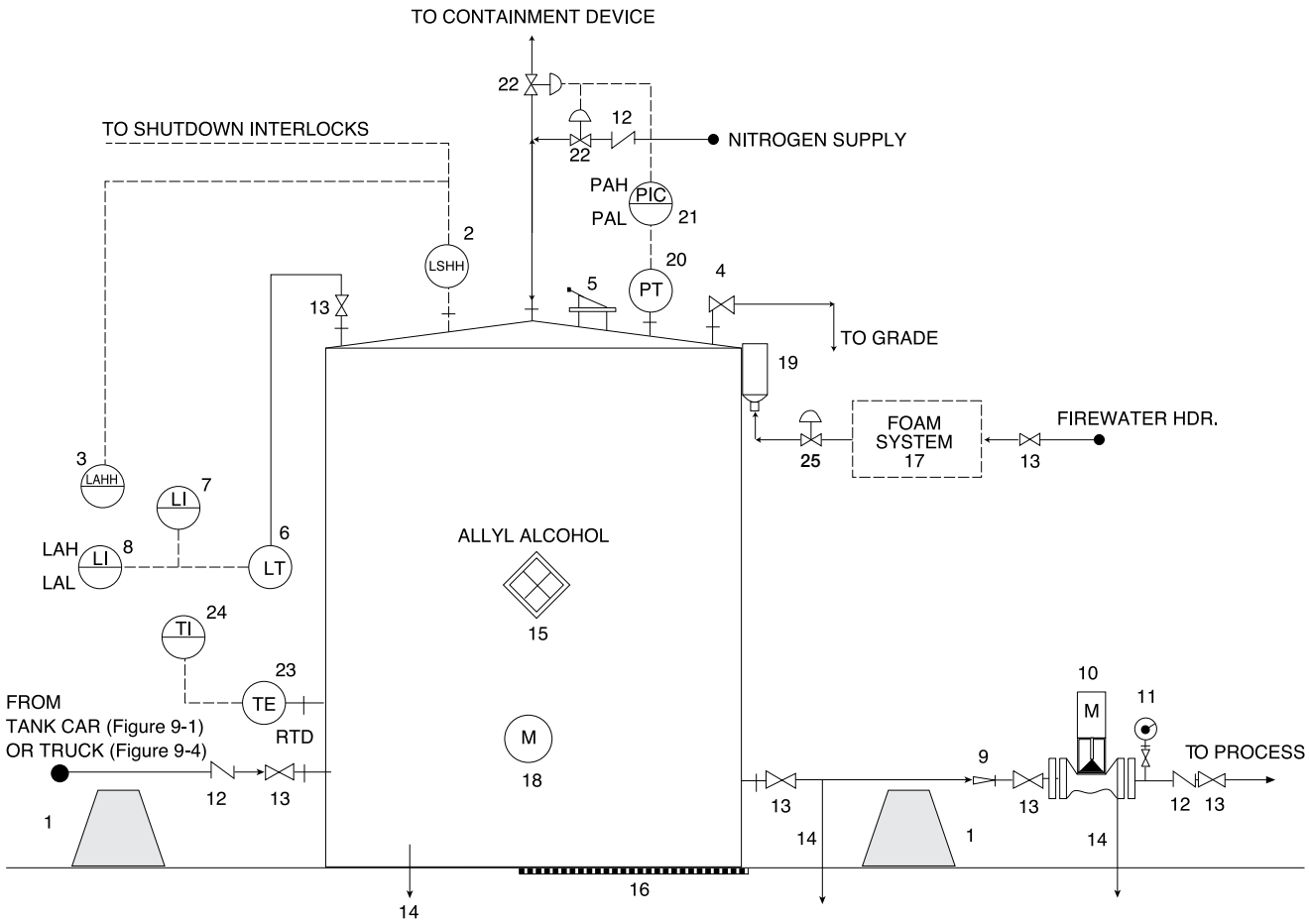
When planning for the handling, storage and use of allyl alcohol, the workplace location is of primary importance. When properly located, worker and community exposure can be reduced and controlled. Break rooms and locker/shower facilities should be separated from areas handling allyl alcohol.

Break rooms and locker facilities should have isolated air handling systems (HVAC). Workers should be encouraged to remove contaminated work clothes before entering break rooms. Workers that handle allyl alcohol on a routine basis should be advised to shower and change into fresh clothes at the end of their shift.

Community exposure to fugitive emissions or possible spill or release should be evaluated prior to site selection. The impact of the site on existing facilities should also be taken into consideration. Additional factors to consider are the location's proximity to access roads, surface waters and other drinking water sources, and emergency services, such as medical, fire department and mutual aid facilities.

8. Product Storage

Figure 8-1 Typical Storage Tank Configuration



1. Containment Dike
2. Level Switch High/High
3. Remote Level Alarm High/High
4. Vacuum/Pressure Relief Device
5. Emergency Relief Device
6. Level Transmitter
7. Level Indicator
8. Level Indication (Remote-W/ Level Alarm High and Low)
9. Strainer
10. Pump
11. Pressure Gauge w/Diagphragm Seal
12. Check Valve
13. Block Valve
14. Approved Ground
15. N.F.P.A Identification Code
16. Approved Leak Detection (If Required)
17. Foam System
18. Manway
19. Foam Deflector
20. Pressure Transmitter
21. Pressure Controller w/Pressure Alarm High and Low
22. Pressure Control Valve
23. Temperature Element
24. Temperature Indication (remote)
25. Remote Accuated Valve

9. Transfer Operations

Allyl alcohol should be transferred and handled according to written operating procedures developed for the specific facility. This section includes guidelines used by Lyondell in its handling of allyl alcohol.

Operating procedures should address the hazards associated with this material (see Section 6), the selection of personal protective clothing and equipment (see Section 3), and fire-prevention methods (see Section 5). Only workers trained in proper operating procedures should handle allyl alcohol.

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

9.1 Seal Procedure

Lyondell seals all tank cars, tank trucks and ISO containers with cable seals. Please verify the seal numbers on the bulk vessel with the seal numbers provided in the accompanying paperwork. If the seals are missing, evidence of tampering is present, or the seal numbers do not match, please contact Lyondell.

When preparing the bulk vessel for return, please seal originally sealed openings that were broken with cable seals and record the seal numbers on the return paperwork.

9.2 Work Preparation

When unloading vessels or containers, workers should have the following equipment and supplies available:

- Functional local eyewash stations and safety showers
- Non-sparking tools
- Unloading block valve
- Stainless steel double-braided accordion-type hose
- Grounding connectors
- Nitrogen supply with pressure regulator and check valve.

The consignee should determine that tank ullage (sufficient capacity) is available to accept the shipment. Ensure that all high level warning devices are activated and functioning. Verify that the material is allyl alcohol by confirming that the identification number is UN 1098 and by review of the shipping manifest.

In certain circumstances and conditions a “second” person should verify proper valve positioning to confirm that the piping is routed to the correct receiving tank.This may be advisable in multi-tank bulk storage tank farms that have complicated piping runs and contain other incompatible strong acids, bases or oxidizers (see Section 4.10).

Visually inspect containers for structural damage or tampering in transit. Wet spots may be an indication of leaks. Look for evidence of discharge from pressure relief valves.

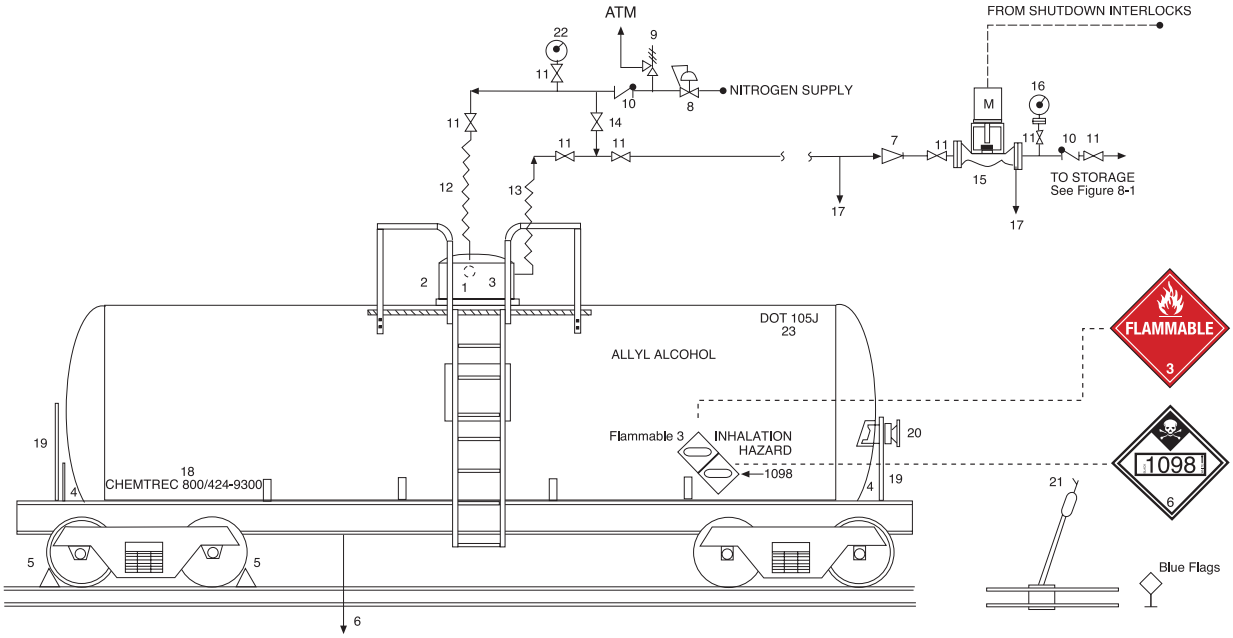
9.3 Tank Cars

Lyondell ships allyl alcohol in DOT 105J tank cars (see Figure 9-1). These tank cars are top unloaded by pressure or pumping. Refer to 49 CFR 174 for DOT unloading regulations.

The following procedures are comparable to those used by Lyondell for unloading tank cars and can be used as a basis for site-specific procedures. A suggested unloading checklist is provided in Figure 9-2.

9. Transfer Operations

Figure 9-1 Typical Tank Car Configuration



1. SAFETY VALVE
2. MANWAY (see Figure 9-4)
3. TOP UNLOADING ARRANGEMENT
4. PLACARD (Figures 11-3 & 11-4) (ALL 4 SIDES)
5. WHEEL CHOCKS
6. APPROVED GROUND CLAMP
7. STRAINER
8. PRESSURE CONTROL VALVE
9. PRESSURE SAFETY VALVE (N_2)
10. CHECK VALVE
11. BLOCK VALVE
12. FLEX. HOSE ASSEMBLY W/2" NPT CONN.
13. DRY DISCONNECT & FLEX. HOSE ASSEMBLY W/2" NPT CONNECTIONS
14. NITROGEN HIGH POINT PURGE W/BLOCK VALVE
15. PUMP
16. PRESSURE GAUGE W/DIAPHRAGM SEAL
17. APPROVED GROUND
18. CHEMTREC EMERGENCY NUMBER 800/424-9300
19. HANDRAIL
20. HAND BRAKE WHEEL
21. DERAILER
22. PRESSURE GAUGE
23. DOT CLASSIFICATION NO.

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

9. Transfer Operations

9.3.1 Unloading Procedures

The unloading procedures for tank cars are as follows:

1. Gather all necessary equipment. For tank car unloading, also include:
   - Wheel chocks
   - DOT-approved “STOP – Tank Car Connected” or
   - “STOP – Men at Work” (Must be metal or
   - Comparable, at least 12-inches high by 15-inches
   - Wide. “STOP” must be at least 3.9-inches and
   - Other words must be at least 2-inches high. Letters
   - Must be white on blue background.
   - Derailer
2. Position the tank car correctly with respect to the unloading station, then set its brake and chock one wheel on both sides.
3. Place DOT-approved blue, rectangular “STOP” signs at both ends of the car between rails. Place an additional sign at the rail siding switch.
4. Place a derailer on the rail siding between the car and the siding switch.
5. Connect ground cable to car and check for continuity.
6. Remove the housing cover pin and lift pressure dome cover. This will expose all valves and fittings which are required for unloading and sampling (see Figure 9-3).
7. Inspect for leakage around valves and fittings in the pressure dome area by pouring soapy water on the connections only and checking for bubbles. If leaks are detected, tighten fittings and recheck.
8. If a sample from the tank car is required to confirm its contents, the following procedure may be used: Sample contents of tank car through the sample line which is located in the pressure dome area. Fill the sample bottle leaving approximately 20% vapor space to allow for expansion. If closed sampling system is not employed, proper personal protective equipment should be used.
9. Determine the receiving tank ullage (available space) and the liquid level in the tank car before transfer.
10. Attach nitrogen or vapor return line to the vapor valve.
11. Attach flexible hose to the liquid unloading (eduction) valve.
12. Open vapor valve. If product will be unloaded under nitrogen pressure, open vapor valve and use a regulator to adjust the nitrogen pressure to equalize that of the tank car. This will force liquid allyl alcohol into unloading hose. Nitrogen should be supplied in nominal pressures to equalize the tank and ensure the pressure supply is compatible with unloading system.
13. Open the liquid unloading valve and allow allyl alcohol to fill the pump by opening the liquid line block valves. These valves must be opened slowly to avoid activating the excess flow valve. Start pump and begin pumping allyl alcohol to the storage tank. A positive pressure should be maintained on the tank car to keep the pump from pulling a vacuum on the car. Monitor this closely.
14. Open the liquid unloading valve. If product is being pumped off, the liquid unloading line must be opened slowly to avoid activating the excess flow valve. Start pump and begin pumping allyl alcohol to the storage tank. A positive pressure should be maintained on the tank car to keep the pump from pulling a vacuum on the car.
15. Check that receiving tank’s level is rising at the expected rate for the transfer system.
16. Monitor the transfer. When the tank car is empty, immediately shut off pump.
17. Clear the transfer line. Close the unloading line valve to the storage tank and the storage tank vent. Close the tank car vapor valve and the tank car liquid unloading valve. A positive pressure of 2-6 psig of nitrogen should be applied to the tank car for the return trip. Vent transfer line of pressure. Disconnect transfer, nitrogen and storage tank vent lines.
18. Test for leakage by pouring soapy water over the valves. If no bubbles are detected, close and secure dome cover. If bubbles are detected, retighten all valves and retest. If leaks are still detected, contact Lyondell Customer Service before shipping.

9. Transfer Operations

Figure 9-2 Tank Car Unloading Checklist

Allyl Alcohol
Tank Car Unloading Checklist

Tank Car Number: _____ Date: _____

Operator: _____ Time: _____

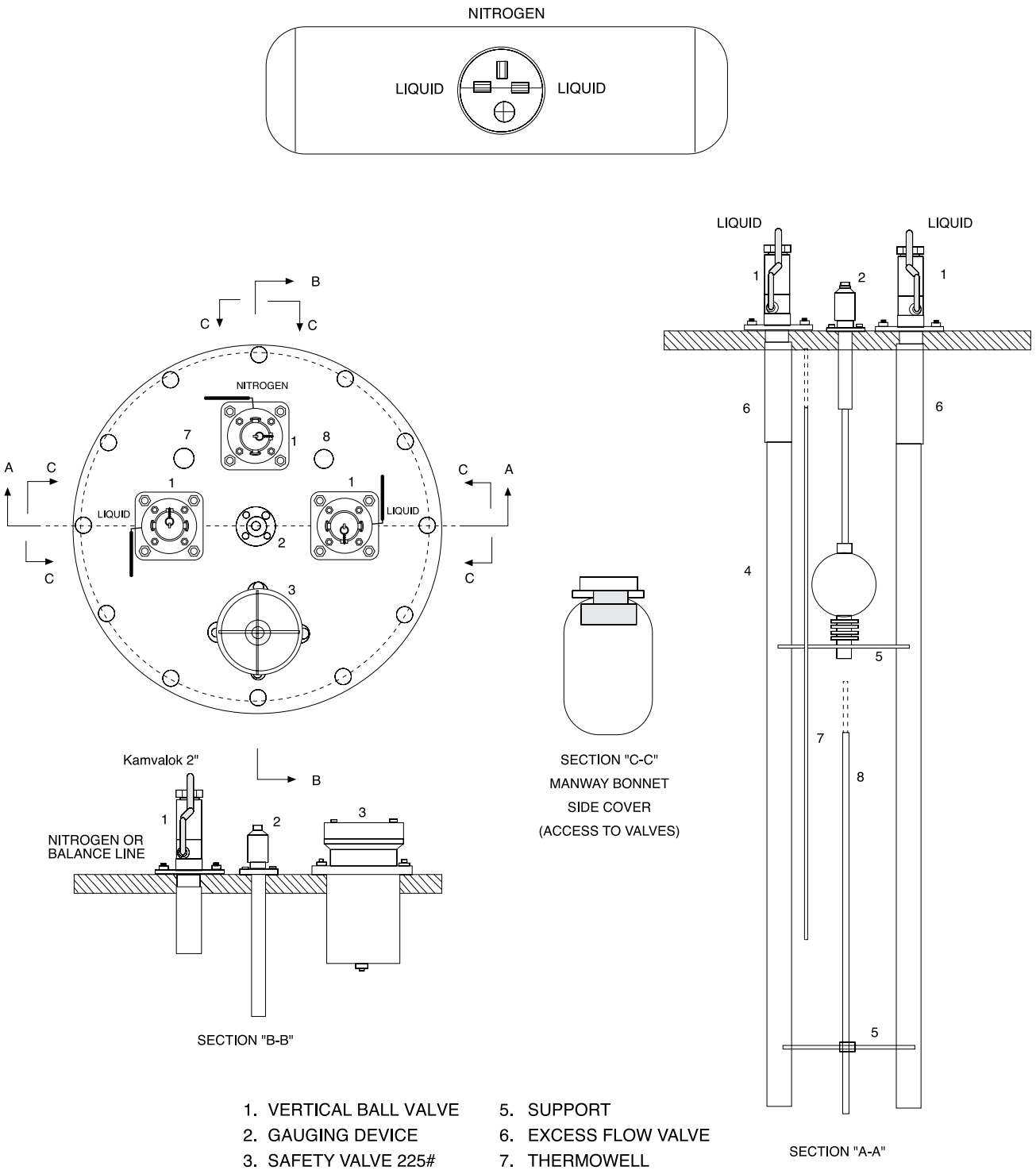
Prior to Unloading Tank Car	**YES**	**NO**
Wheels chocked and hand brakes engaged		
Blue flag and derailer device in place		
Metal caution signs located in front of and behind tank car		
Eyebath and safety shower flushed and ready		
Ground cable connected to car and checked for continuity		
Pressure dome inspected for leakage around valves and fittings		
Bill-of-lading and seal numbers checked		
Certificate of Analysis and placards checked		
Storage tank capacity and tank car liquid level determined before transfer		
Load and back-vent lines connected, purged and checked for leaks		
Proper piping alignment made and checked		
Open transfer lines and monitor liquid level		
Qualified operator in attendance during transfer		
Qualified operator wearing all required PPE		
After Unloading Tank Truck	**YES**	**NO**
When tank car is empty, shut down the pump		
Transfer line blown clear of allyl alcohol		
Unloading line valve closed to the storage tank and the storage tank vent		
Tank car vapor valve and liquid unloading valve closed		
Transfer line vented of pressure		
Tank car pressured (slightly) with nitrogen for return trip (2-6 PSI)		
Transfer, nitrogen and storage tank lines disconnected		
Inspected for leakage around valves and fittings and dome cover secured		
Ground cable disconnected		
Check tank car placards and reseal		
Blue flag and derailer device removed		
Wheel chocks removed		

In the event of an emergency – 1-800-245-4532

Advise Lyondell of any mechanical problems – 1-888-777-0232

9. Transfer Operations

Figure 9-3 Typical Tank Car Dome Configuration



1. VERTICAL BALL VALVE
2. GAUGING DEVICE
3. SAFETY VALVE 225#
4. EDUCTION PIPE
5. SUPPORT
6. EXCESS FLOW VALVE
7. THERMOWELL
8. SAMPLE LINE

9. Transfer Operations

9.3.2 Release of Empty Car

The following steps complete the process of unloading tank cars:

1. Disconnect the ground cable.
2. Remove the wheel chocks, derailer, blue flag, and caution signs. Leave the car brakes engaged for railroad crew to release.
3. Check placards for return trip. Ensure car has been resealed with the seals provided.
4. If there were any mechanical problems with the tank car, advise Lyondell Customer Service.

9. Transfer Operations

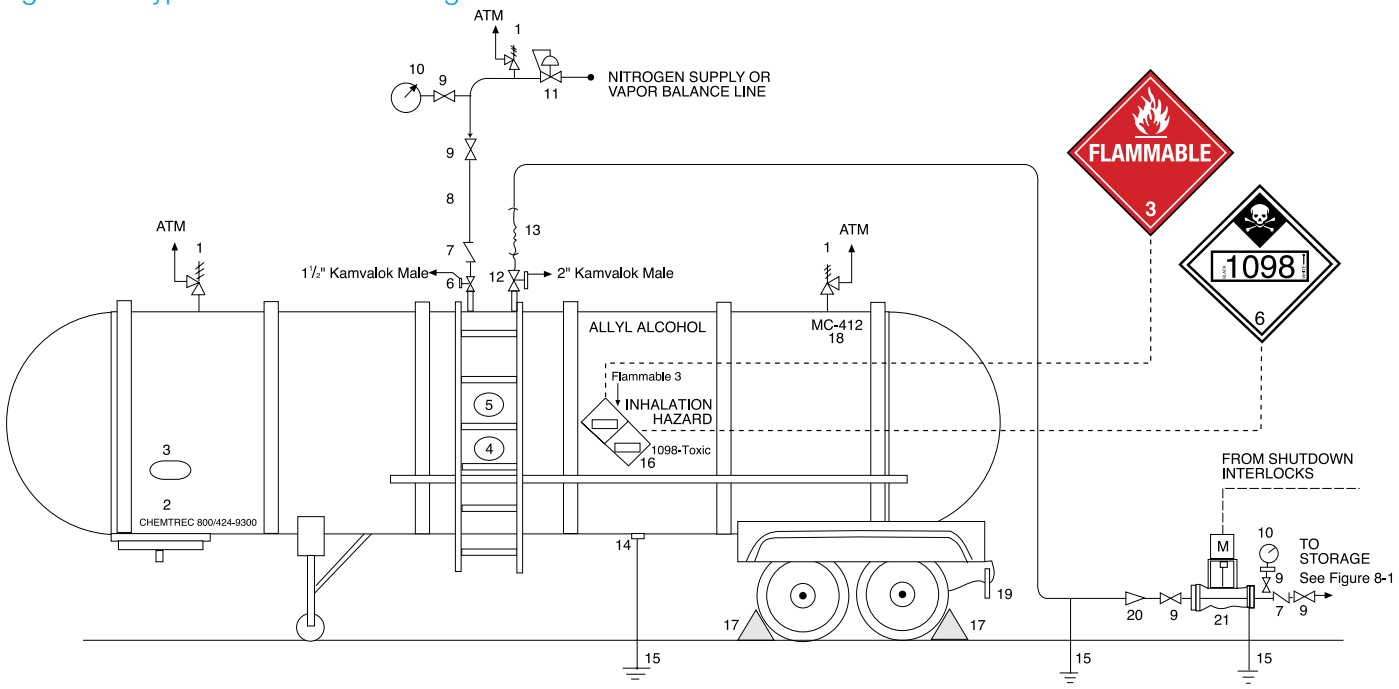
9.4 Tank Trucks

Lyondell ships allyl alcohol in DOT-412 stainless steel tank trucks with approximate capacity of 6,000 gallons. These tank trucks are top unloaded by pressure or pumping through a valve located at the rear of the truck (see Figure 9-4). Refer to 49 CFR 177 Subpart B for information on unloading regulations.

The following procedures are comparable to those used by Lyondell for unloading tank trucks and can be used as a basis for developing site specific procedures for unloading allyl alcohol.

A suggested unloading checklist is provided in Figure 9-5.

Figure 9-4 Typical Tank Truck Configuration



1. PRESSURE RELIEF VALVE
2. CHEMTREC EMERGENCY NUMBER 800/424-9300
3. CERTIFICATION DATE
4. THERMOMETER AND PRESSURE GAUGE
5. ROTARY GAUGE (LIQUID LEVEL)
6. 1½" KAMVALOK MALE
7. VALVE
8. FLEX. HOSE ASSEMBLY
9. BLOCK VALVE
10. PRESSURE GAUGE
11. PRESSURE CONTROL VALVE
12. 2" KAMVALOK MALE
13. FLEX. HOSE ASSEMBLY
14. APPROVED GROUND CLAMP
15. GROUND WIRE
16. PLACARD (Figures 11-3 & 11-4) (ALL 4 SIDES)
17. WHEEL CHOCKS
18. DOT CLASSIFICATION NO.
19. REAR END PROTECTION
20. STRAINER
21. PUMP

9. Transfer Operations

Figure 9-5 Tank Truck Unloading Checklist

Allyl Alcohol
Tank Truck Unloading Checklist

Tank Truck Number: _____ Date: _____

Operator: _____ Time: _____

Prior to Unloading Tank Truck	**YES**	**NO**
Wheels chocked and hand brakes engaged		
Ground cable connected to truck and checked for continuity		
Bill-of-lading and seal numbers checked		
Eyebath and safety shower flushed and ready		
Placard placed on windshield		
Inspected for leakage around valves and fittings		
Certificate of Analysis and placards checked		
Storage tank capacity and tank truck liquid level determined before transfer		
Load and back-vent lines connected, purged and checked for leaks		
Proper piping alignment made and checked		
Open transter lines and monitor liquid level		
Qualified operator in attendance during transfer		
Qualified operator wearing all required PPE		

After Unloading Tank Truck	**YES**	**NO**
When tank truck is empty, shut down the pump		
Transfer line blown clear of allyl alcohol		
Unloading line valve closed to the storage tank and the storage tank vent		
Tank truck vapor valve and liquid unloading valve closed		
Transfer line vented of pressure		
Tank truck pressured (slightly) with nitrogen for return trip (2-6 PSI)		
Transfer, nitrogen and storage tank lines disconnected		
Inspected for leakage around valves and fittings		
Ground cable disconnected		
Check tank truck placards and reseal		
Placard removed from windshield		
Wheel chocks removed		

In the event of an emergency – 1-800-245-4532

Advise Lyondell of any mechanical problems – 1-888-777-0232

9. Transfer Operations

9.4.1 Unloading Procedures

The unloading procedures for tank trucks are as follows:

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

9. Transfer Operations

9.4.2 Release of Empty Truck

The following steps complete the process of unloading tank trucks:

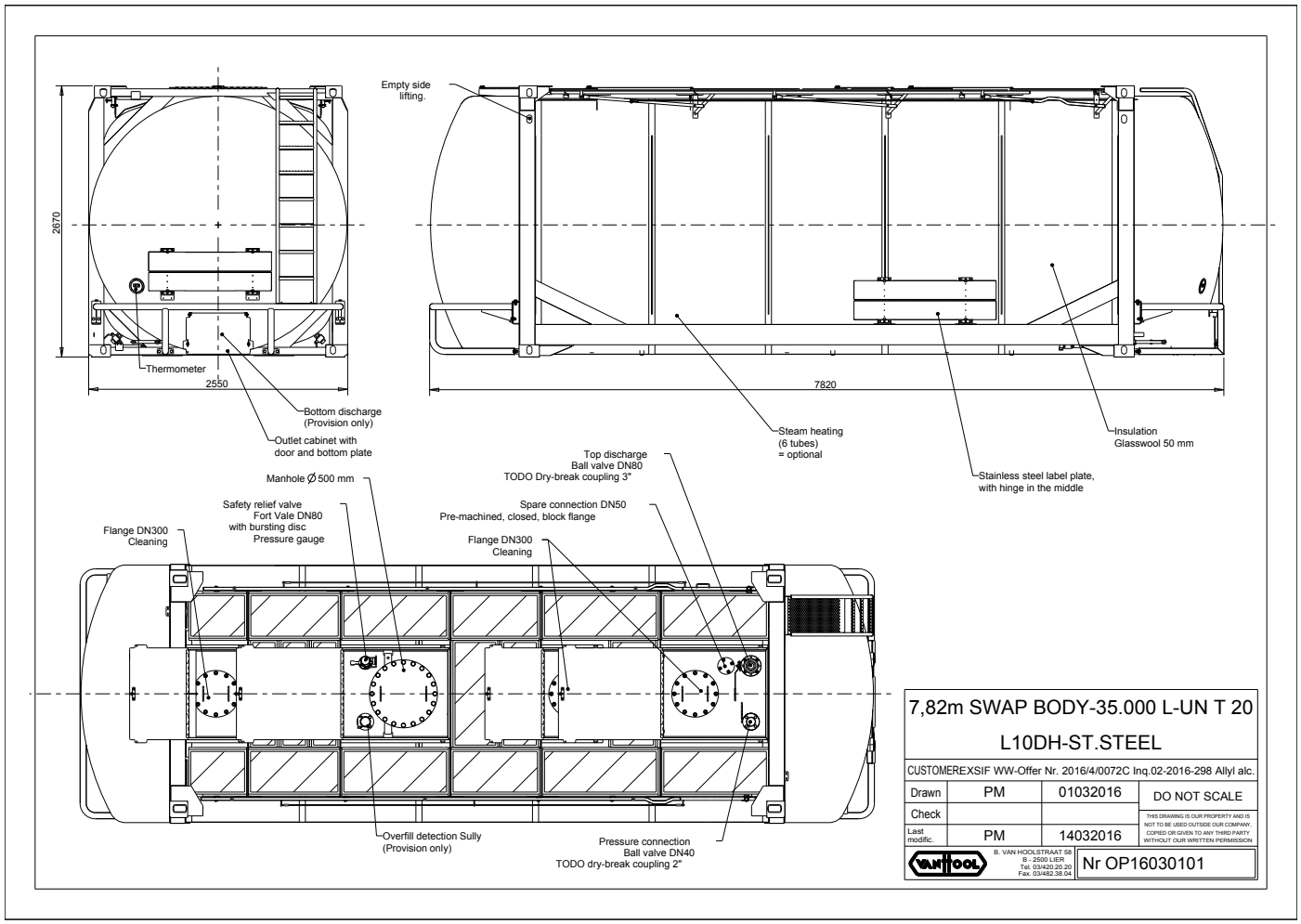
1. Disconnect the ground cable. Remove the wheel chocks and traffic-control devices.
2. Ensure that tank truck placards for the return trip meet DOT requirements. Ensure truck has been resealed.
3. Release the vehicle to the driver.
4. If there were any mechanical problems with the tank truck, advise Lyondell Customer Service.

9.5 ISO Container (Europe only)

Lyondell ships allyl alcohol in ISO containers meeting L10CH / T-20 specifications with baffle plates. These contain up to 30000 liters and are shipped at atmospheric pressure. The container is prepared for top-unloading with the unloading valve located at the rear top-end of the container (see Figure 9-6). Container needs to be equipped with a scully level probe. Bottom connections are not allowed by regulation (ADR).

International Organization for Standardization (ISO) tank work preparation and unloading procedures are essentially the same as those for unloading tank trucks.

Figure 9-6 Typical ISO Container Configuration



9. Transfer Operations

9.6 Dry Disconnect Fittings and Hoses

Lyondell recommends the use of dry-disconnect fittings for the transfer of allyl alcohol from all transportation equipment. These dripless fittings are designed to minimize worker exposure and environmental release during transfer operations. Allyl alcohol tank trucks and rail cars (US) and ISO containers (Europe) are equipped with dry-disconnect fittings. Lyondell recommends customers use a corresponding dry-disconnect fitting on a stainless steel braided hose to transfer allyl alcohol.

Customers are urged to implement preventative maintenance programs for both the fittings and hoses. Lyondell replaces allyl alcohol dry-disconnect fittings and hoses on annual basis in the US. In Europe, regulations specify that ISO container dry-disconnect fittings, at a minimum, be replaced every 2-1/2 years. Customers should determine appropriate maintenance schedules based on their practices. Fittings and hoses should always be inspected prior to each use.

10. Tank Cleaning & Equipment Repair

10.1 Work Preparation

The proper preparation for tank cleaning and equipment repair is necessary to prevent exposure to hazardous chemicals. Preparation should include a clear definition of the tasks to be performed, and an identification of hazardous materials and related hazardous conditions. A hazardous work permit system should be used to identify the job related hazards and plan for the safe completion of this work. Worker protection should include the use of engineering controls and the selection of personal protective equipment (PPE) (see Section 3).

Tanks and equipment that contained allyl alcohol vapor or liquid should be cleared of residual material before starting cleaning and/or repair. Liquids should be removed from a low point. Residual liquid and vapor should be flushed with water or another suitable material, and vapor should be purged with nitrogen. The tank vapor space should be tested for allyl alcohol prior to opening the tank to atmosphere.

Only workers properly trained should be involved in the cleaning and repair of tanks and equipment that have previously held allyl alcohol.

Eyewash and safety showers should be located near the work operation. Appropriate fire extinguishing equipment should be present (see Section 5.3).

10.2 Control of Hazardous Energy

The control of hazardous energy (lock out/tag out) procedures are employed to protect workers and the environment when working on process equipment.

Written procedures should be developed to prevent accidental contact with hazardous chemicals and pressurized and energized equipment, and to prevent the accidental startup of the equipment. These procedures should be in compliance with the Occupational Safety and Health Administration (OSHA) Standard 29 Code of Federal Regulations (CFR) 1910.147.

10.3 Confined Space Entry

Consult applicable national regulations for entry into confined spaces. For confined spaces that typically contain allyl alcohol, a lower flammability limit of 2.5 vol.% (8,000 ppm) should be used to determine permit requirements. Appropriate respiratory protection for allyl alcohol vapor exposures (see Section 3.3) may also be required.

10.4 Equipment Cleanout

If a new tank is to be put into service, it is critical that it be clean of all rust, dirt, grease and water. Soap or detergents and water should be used to remove grease and oils. The cleaned surface should be rinsed with water until a neutral pH is obtained.

Iron oxide can cause discoloration of allyl alcohol. To eliminate loose rust (iron oxide) and scale from inside a tank, a high pressure fresh water blast is effective.

Acidic or basic cleaning or pickling systems should be avoided because their residues can cause vigorous reaction of allyl alcohol. After this step, the tank walls should be dried and the bottom cleaned of all solids and water. The tank should then be purged with nitrogen until testing indicates a flammability reading of less than 25% of the allyl alcohol lower explosive limit of 2.5%. This concentration will provide a measure of protection in case any air pockets remain during purging. After out-of service equipment has been padded with nitrogen gas, the manhole should be marked as follows: “DANGER DO NOT ENTER—PADDED WITH N2.”

10.5 Maintenance and Inspection

Preventive maintenance and inspection by trained workers are recommended for allyl alcohol storage equipment, particularly when its integrity is critical to protecting the environment.

The inspection program should also include daily inspection of equipment and storage areas, and monitoring of ventilation systems.

Preventive maintenance schedules should be developed for critical equipment such as firefighting equipment, combustible gas detectors, pumps, safety relief valves, gaskets and emission control equipment.

11. Transportation Regulatory Requirements

The Distribution Safety Program of Lyondell has been implemented in accordance with the company's Operational Excellence Standards.

Not every authorized U.S. Department of Transportation (DOT), International Maritime Organization (IMO), International Civil Aviation Organization (ICAO) or International Air Transport Association (IATA) packaging is addressed in this chapter. Lyondell has selected transport routes and modes, in concert with packaging configurations, to develop and implement risk reduction alternatives.

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

11.1 Classification

Allyl alcohol is listed in the Hazardous Materials Table (49 CFR 172.101); therefore, it is designated as a hazardous material for transportation purposes.

Allyl alcohol is assigned a primary hazard classification of Toxic Material (division 6.1) with a packaging group (PG) designation of I. The designation PG I implies that the degree of danger present is great. It is classified as a Toxic Inhalation Hazard, Zone B and has a secondary hazard of flammability (class 3). It has a reportable quantity of 100 pounds (see Table I of the Appendix A to 49 CFR 172.101). The identification number is UN 1098.

The DOT shipping requirement is UN 1098, Allyl alcohol, 6.1 (3), PG I, Hazard Zone B , RQ, Poison—Inhalation Hazard, (49 CFR 172 Subpart C). Allyl alcohol is identified as poisonous by inhalation under Special Provision 2 of the Hazardous Materials Table. "Poison-Inhalation Hazard" is placed on the shipping papers in accordance with 49 CFR 172 Subpart C.

Transport on passenger carrying aircraft and railcar and on cargo aircraft is forbidden.

11.2 Marking, Labeling and Placarding

General and specific requirements concerning marking, labeling, placarding and preparation of shipping papers are found in 49 CFR 172 and depend on the transport mode, packaging configuration and quantity of HM being transported. Markings are placed on opposing sides on non-bulk packings and on each side and each end for a greater capacity (bulk) packaging.

Marking, labeling and placarding requirements are detailed in 49 CFR 172, Subparts D, E, and F respectively. Subparts E and F have pictorials of labels and placards. Poison and flammable liquid labels (see Figures 11-1 and 11-2), and modified poison and flammable placards (see Figures 11-3 and 11-4) are required. Each bulk packaging that is required to be placarded when it contains a hazardous material must remain placarded when it is emptied, unless it meets the special requirements of Subpart F.

11.3 Packaging

Packaging exemptions are not permitted. Special provisions have been added to the HM Table. 49 CFR Part 173 Subpart E provides a full listing of authorized combination packages.

Outage in bulk packaging must be at least five percent of total capacity of the tank or compartment at the reference temperature of 41°C (105°F) for insulated tanks (49 CFR 173) .

11.3.1 Tank Trucks

According to the requirements of 49 CFR 172 and 173, allyl alcohol is to be shipped in insulated stainless steel or steel equivalent DOT 412 cargo tank trucks. These tanks have an approximate capacity of 6,000 gallons.

"Special Provisions," as designated in 49 CFR 172 Subpart B, specifically limit or modify bulk containers for allyl alcohol. A partial listing of these special provisions is provided for informational purposes. Tank trucks must conform to the following specifications:

- Special Provision for construction (see B32).
- Bottom outlets are prohibited (see B9).
- Insulation so that the overall thermal conductance at 15.5°C (60°F) is not not more the an 1.5333 kJ/hr/m2 (0.075 Btu/hr/ft2)) temperature differential.
- Insulation must not promote corrosion to steel when wet.
- Tank trucks must be marked with the warning "Inhalation Hazard" on two opposing sides, near the "Poison" and "Flammable" placards (see Figure 9-5).

11. Transportation Regulatory Requirements

11.3.2 Tank Cars

Tank cars used to transport allyl alcohol are cylindrical and constructed of AAR Specification TC128-78 grade B normalized steel. While there are various types of cars authorized, with its increased safety features, Lyondell uses a Specification DOT 105J insulated and pressurized tank car.

A Canadian shipment or package of allyl alcohol may be transported by tank car within the United States if it is in compliance with the requirements of DOT 49 CFR 171 or the regulations of Transport Canada and the Transportation of Dangerous Goods Act, Part IV. A transborder consignment of allyl alcohol from the United States to Canada may also be made under the same provisions.

Tank cars must conform to the following specifications:

- Tank cars must be placarded “Toxic” and “Flammable” (see Figure 9-1). Shipping papers are to be annotated “Placarded Poison, Flammable”.
- Tank cars must be marked with the identification number 1098 on each side and each end.
- The car must also be marked on two opposing sides with the warning “Inhalation Hazard” near the “Poison” and “Flammable” placards.

Tank cars will be unloaded in accordance with 49 CFR 174 Subpart C (see Section 9.2).

While other tank cars are authorized in 49 CFR 173 Subpart F, Lyondell uses DOT Specification 105 tank cars. Placarding will be in accordance with 49 CFR 172 Subpart F. The white“Poison” placard will contain the hazard class number “6” in the lower corner. The flammable placard will not contain the “Flammable” text or Hazard Class number “3” per this Subpart.

Also the UN number 1098 will be placed in the center of the “Poison” placard on a white rectangular background outlined in black (see Figure 11-3).

As described in paragraph 11.2, emptied packagings remain placarded with the same placard used when the package contained the hazardous material.

Allyl alcohol, a flammable liquid, may not be transported by rail unless it is originally consigned or subsequently reconsigned to a party having private track on which it is to be delivered and unloaded. This is required by 49 CFR 174 Subpart G. A definition of a private track can be found in 49 CFR 171.

11. Transportation Regulatory Requirements

Figure 11-1 — 11-4 Placarding

Figure 11-1

Figure 11-2

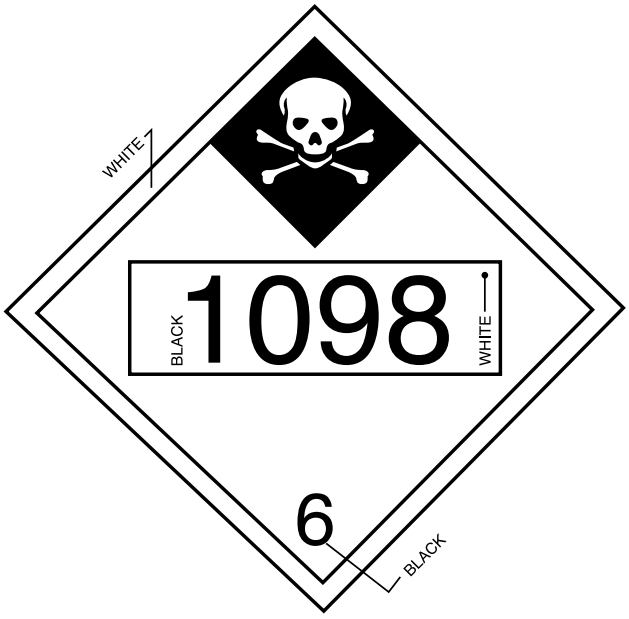


Figure 11-3

Figure 11-4

11. Transportation Regulatory Requirements

11.3.3 ISO Containers (Europe only)

International Organization for Standardization (ISO) tanks are a specific class of Intermodal (IM) tanks designed and constructed to permit their use interchangeably in two or more modes of transport. They are portable tanks.

In Europe Lyondell is using T-20/L10CH type tanks. Labelling requirements within Europe are shown in Figure 11-5.

Specification requirements for T-20/L10CH stainless steel portable tanks, which are authorized to carry allyl alcohol, are delineated in the ADR regulations conform to the following specifications:

- T-20/L10DH tanks are constructed of stainless steel with a shell and head thickness of at least 8 mm..
- Bottom outlets are prohibited.
- Insulation so that the overall thermal conductance at 15.5°C (60°F) is not more than 1.5333 kJ/hr/m2
- (0.075 Btu/hr/ft2) temperature differential. Insulation must not promote corrosion to steel when wet.

The T-20 /L10DH tank is transported only on a drop chassis trailer with a resulting lower center of gravity.

Periodic inspections of the chassis should be made.

Intermodal ISO containers must be labeled according the ADR with the “Poison,” “Flammable,” and marine polluant label plus the Kemler code UN 1098 / 336 (see Figure 11.5).

11.3.4 Marine Transportation

The transport of allyl alcohol is on deck of vessels. The United States DOT specification and UN Standard packaging is constructed of materials that will not react dangerously with or be decomposed by the allyl alcohol (see Section 1.5).

The requirements for shipment of poisonous and flammable liquids such as allyl alcohol over water are defined in 49 CFR 176.Lyondell transports allyl alcohol in ISO containers on container ships or barges.

Vessel/barge owners should comply with 46 CFR 153, Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (BCH Code), and Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. These are Coast Guard and IMO regulations governing vessel/barge operation and construction. An independent inspector is employed for quality and quantity measurements to ensure that the allyl alcohol is loaded in uncontaminated tanks.

11.3.5 Air Transportation

Allyl alcohol air transportation in either cargo only or passenger aircraft in any amounts, quantities or volumes is forbidden. There are no authorized exceptions.

11.4 Transportation Emergencies

Lyondell markets its products in a manner which is considerate of the health and safety of customers, transporters and the general public. However, even with the best of preparations, emergencies can occur.

All Lyondell Safety Data Sheets (SDS) contain a 24 hour telephone number for CHEMical TRansportation Emergency Center (CHEMTREC). The CHEMTREC numbers are (800) 424-9300 and (202) 483-7616.

11.4.1 CANUTEC

If an emergency accident/incident occurs in Canada, you may elect to call CANadian Transport Emergency Centre (CANUTEC) collect at (613) 996-6666. CANUTEC is the national bilingual advisory service provided by Transport Canada to assist emergency response personnel in handling dangerous goods emergencies.

11.4.2 SETIQ

If an emergency accident/incident occurs in Mexico, you may elect to call SETIQ (in the Mexican Republic) 01-800-00-214-00; (Calls originating in Mexico City or in the Metropolitan Area) 5559-1588; (Calls originating elsewhere) 0-11-52-5-559-1588.

11.4.3 Reporting Requirements

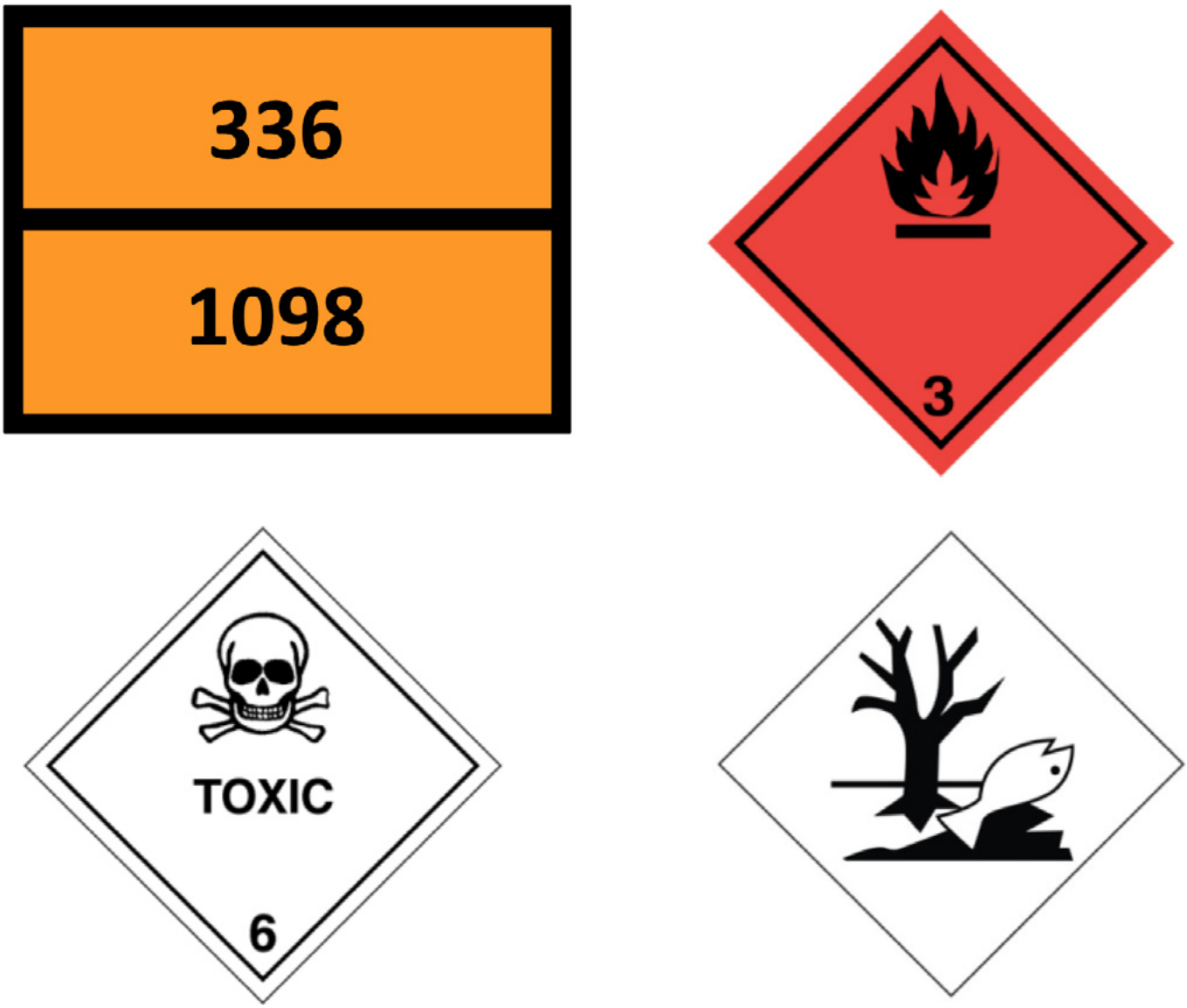
The response and reporting requirements which may be necessary in the event of a transportation incident involving allyl alcohol are detailed in 49 CFR 171. These requirements, which vary with the severity of the incident, require immediate notification to DOT and the filing of a detailed hazardous materials incident report by the carrier.

11.4.4 Transport of Allyl Alcohol Residue

If a discharge of allyl alcohol occurs during transport, an official of the federal, state or local government may require immediate removal to prevent further consequences, according to 49 CFR. This may be accomplished without preparation of a manifest, and the EPA does not require the freight carrier to have an EPA identification number. If a hazardous waste transporter is used, they must have an EPA identification number (40 CFR).

11. Transportation Regulatory Requirements

Figure 11-5 Intermodal ISO Container Labelling (Europe only)



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