H-8

Aid for OSHA compliance:

Safety Chart for Common Solvents

ONE OF THE POTENTIALLY MOST HAZARDOUS classes of chemicals in common use is the industrial solvent group. Definitions of these hazards are found in many reference books, but such source material is not easily available to most plant engineers not directly involved in the chemical industries. However, the Occupational Safety and Health Act standards (Section 1910.93) require that anyone using these chemicals must be protected from exposure above certain levels or beyond certain periods of time, and, therefore, knowledge of the subject is mandatory.

The accompanying safety chart lists the characteristics of the most common industrial solvents and their

Common Solvent Name	Boiling Point °C	Flash Point °C	Explosive Limits %		Approx. Evaporation Rate	Threshold Limit Value (TLV) ppm		Major Health Hazard
			Lower	Upper		Time Weighted Average	Short Term Exposure Limit	
Acetone	134	0(C.C.)	2.6	12.8	1000	2.00	1000	2400	Skin irritant; headaches
n-Amyl Acetate	298	77(C.C.)	1.1	–	750	4.50	100	525	Narcotic effect; irritant
n-Amyl Alcohol	280	100(C.C.)	1.2	–	700	3.04	–	–	Eye and respiratory irritant
Benzene (Benzol)	176	12(C.C.)	1.4	8.0	1000	2.77	25 (skin)	80 (skin)	Toxic by inhalation and skin absorption
n-Butyl Acetate	259	92(T.O.C.)	1.7	15.0	740	0.88	150	710	Irritating to eyes and respiratory tract; narcotic
sec - Butyl Acetate	234	66(C.C.)	1.7	–	–	4.00	200	950	Irritating to eyes and respiratory tract
Butyl Alcohol	244	114(T.O.C.)	1.7	18.0	650	2.55	100	300	Irritating to eyes, nose and throat; causes headache and dizziness
Carbon Tetrachloride	170	none	–	–	–	–	10 (skin)	65 (skin)	Narcotic; can cause organ damage
Chloroform	142	none	–	–	–	4.12	25	120	Anesthetic; causes eye irritation
Cyclohexanone	312	147(C.C.)	1.1	–	847	3.38	50	200	Eye and throat irritation mild narcotic
Diacetone Alcohol	334	151(O.C.)	–	–	1190	4.00	50	240	Irritating to eyes and mucous membranes; mild narcotic
Diethyl Carbonate	258	99(O.C.)	–	–	–	4.07	–	–	Irritant
Diethylene Glycol Monoethyl Ether	395	205(O.C.)	–	–	–	4.62	–	–	Irritant
Diisobutyl Ketone	331	120(C.C.)	–	–	–	4.90	25	150	Narcotic and anesthetic effects
Dipentene	346	108	–	–	–	4.66	–	–	Irritant
Ethyl Acetate	171	40(T.O.C.)	2.7	11.5	900	3.04	400	1400	Irritating to eyes and respiratory passages; mild narcotic
Ethyl Alcohol (Ethanol)	173	61(C.O.C.)	3.3	19.0	750	1.59	1000	1900	Irritant; narcotic
Ethylene Dichloride	182	70(O.C.)	6.2	15.9	840	3.35	50	200	Strong irritant
Ethylene Glycol Monobutyl Ether	340	141(C.C.)	–	–	472	4.07	50	240	Irritant
Ethylene Glycol Monoetnyl Ether	275	106(C.C.)	2.6	15.7	460	3.10	200 (skin)	740 (skin)	Irritant; somewhat toxic
Ethylene Glycol Monoethyl Ether Acetate	313	120(C.O.C.)	1.7	–	715	4.72	25 (skin)	120 (skin)	Irritant
Ethylene Glycol Monomethyl Ether	256	125(O.C.)	–	–	551	2.62	25 (skin)	80 (skin)	Can cause blood abnormality
Ethylene Glycol Monomethyl Ether Acetate	289	132(C.C.)	–	–	–	4.07	25	121	Irritant
Ethyl Lactate	309	115(C.C.)	1.55	–	752	4.07	–	–	Irritant

hazards. To use this chart most effectively, one should understand the following definitions:

Common chemical name of each solvent: Each solvent is listed by the most common chemical name or names. If your plant uses a solvent which is not listed here, it is possible that it is a trade named product for one which is listed. Check the label to determine if any one of these chemical names appears. If none is given, ask the manufacturer to provide the chemical name for the solvent.

Boiling point in degrees Fahrenheit: Theoretically, this is the lowest temperature at which the vapor pressure exceeds the ambient pressure. Of course, this is also the temperature at which the solvents become

Common Solvent Name	Boiling Point °F	Flash Point °F	Explosive Limits % in Air		Weight per Gallon	Vapor Density	Threshold Limit Value ppm	Maximum Allowable Concentration ppm	Health Hazard
Furfuryl Alcohol	340	167(O.C.)	1.8	16.3	915	3.37	5	20	Somewhat toxic
Heptane	209	25(C.C.)	1.2	6.7	452	3.45	500	2000	Irritating to respiratory tract; mild narcotic
Hexahydrophenol (Cyclohexanol)	322	154(C.C.)	–	–	–	3.45	50	200	Irritant
Hexane	156	<–10	1.2	6.9	500	2.97	500	1800	Irritant
Isobutyl Alcohol	226	100(C.O.C.)	1.7	–	800	2.55	100	300	Strong irritant
Isopropyl Alcohol	180	70(C.O.C.)	2.5	5.2	852	2.07	400	980	Irritant; mild narcotic
Kerosene	347-617	100-165(C.C.)	1.16	6.0	490	4.50	–	–	Irritant; headaches; moderate narcotic effect
Methyl Acetate	136	14	4.1	13.0	935	2.55	200	610	Narcotic and irritant
Methyl Alcohol (Methanol)	149	65(C.O.C.)	6.0	36.5	878	1.11	200	260	Strong narcotic and and mild irritant
hyl n-Amyl Ketone	303	120(O.C.)	–	–	–	–	100	465	Irritant and moderate narcotic
Methylene Chloride	104	none	15.5 in O_2	66.4 in O_2	1224	2.93	500	1740	Dangerous to eyes, narcotic
Methyl Ethyl Ketone (Butanone)	175	22(T.O.C.)	1.8	11.5	960	2.41	200	590	Irritant and narcotic
Methyl Isobutyl Ketone (Hexone)	244	73	1.3 @ 122°F	8.0 @ 212°F	858	3.45	100	410	Irritating to eyes and mucous membrane; moderate narcotic
Mineral Spirits	302-374	104(C.C.)	1.1	6.0	473	3.90	100	400	Irritant
Nitroethane	237	106(T.O.C.)	–	–	778	2.58	100	310	Irritant
Nitromethane	214	95(C.C.)	7.3	–	785	2.11	100	250	Irritant
1-Nitropropane	270	120(T.O.C.)	–	–	789	3.06	25	90	Moderately toxic
Perchloroethylene	250	none	–	–	–	5.83	100	670	Toxic by inhalation or swallowing
Pine Oil	392-428	172(C.C.)	–	–	–	–	–	–	Cause of very slight allergy
n-Propyl Alcohol	207	59(C.C.)	2.5	13.5	812	2.07	200	500	Irritant
Propylene Oxide	93	–35(T.O.C.)	2.1	21.5	–	2.00	100	240	Moderate irritant
Stoddard Solvent	428-572	100-110	1.1	6.0	450	–	200	1150	Mild irritant
Tetrahydrofuran (THF)	150	1(T.C.C.)	2.3	11.8	–	2.50	200	590	Irritating to eyes and mucous membrane; moderate narcotic
Toluol (Toluen)	231	40(T.C.C.)	1.27	7.0	1026	3.14	100	370	Moderate narcotic; can cause organ damage
Trichloroethane -1-1-1	165	none	–	–	–	–	350	1900	Moderate narcotic and irritant
Trichloroethylene	189	none	–	–	770	4.53	100	535	Narcotic and addictive
T rine	309-338	95(C.C.)	0.8	–	488	4.84	100	500	Mild cause of allergy; toxic
VM&P Naphtha	212-284	20(C.C.)	0.9	6.0	450	–	100	400	Causes intoxication
Xylol (Xylene)	280	77	1.1	7.0	924	3.66	100	435	Moderate irritant

BULLETIN 55A

Ethylene Dichloride

Chemicals

PPG INDUSTRIES

High-purity ethylene dichloride (EDC) is produced by PPG Industries' Chemicals Group at Lake Charles, Louisiana. PPG is one of the world's largest producers of ethylene dichloride and ships to customers in tank cars, tank trucks, barges and ocean-going ships. A terminal in Chicago, Illinois, also makes tank car and tank truck shipments.

USES

Almost three-quarters of the ethylene dichloride produced in the U.S. is used as an intermediate for making vinyl chloride. Other important intermediate uses for EDC include making 1,1,1-trichloroethane, trichlorethylene, perchlorethylene, ethylene amines and polysulfide elastomers.

Ethylene dichloride is also used as a scavenging agent in tetraethyllead fuel additive compounds to prevent lead salts and lead oxide from depositing on engine cylinder walls.

Ethlyene dichloride is an excellent solvent for greases, oils, fats and waxes. Due to the toxicity and flammability of EDC, other chlorinated solvents have displaced it in many applications. However, EDC has certain advantages and is still used for various solvent applications in chemical processing.

GOVERNMENT SPECIFICATIONS

PPG technical-grade ethylene dichloride meets the chemical and physical requirements of Military Specification MIL-E-10662, Ethylene Chloride, Technical, including the requirement that 95% minimum distills between 82.5°C and 84.5°C at 760 mm Hg.

HEALTH HAZARDS

Ethylene dichloride can be taken into the body by ingestion, inhalation or skin absorption. By any of these means it can be highly toxic. Acute poisoning may cause headache, dizziness, feelings of drunkenness, loss of consciousness, internal bleeding and death. Repeated exposures can bring on nausea, vomiting, stomach pain, irritated mucous membranes, loss of appetite, liver and kidney failure and possible death. Numerous cases of ethylene dichloride poisoning, both fatal and nonfatal, have been documented by the National Institute for Occupational Safety and Health.

TYPICAL PROPERTIES

Chemical Names: Ethylene dichloride; ethylene chloride; 1,2-dichloroethane.

Chemical Formula: CH_2ClCH_2Cl

Molecular Weight: 98.97

Description: Ethylene dichloride is clear and colorless, but darkens slowly upon exposure to sunlight. It has an odor like chloroform. The liquid is mobile, volatile and flammable, and its vapor is toxic and flammable.

Boiling Point, °C	83
°F	181
Freezing Point, °C	−35.9
°F	−32.6
Flash Point, Tag open cup, °C	18
°F	65
Explosive Limits, volume % in air	6.2 to 15.9
Autoignition Temperature, °C	413
°F	775
Viscosity at 25°C, cps	0.78
Density at 20°C, pounds/gallon	10.5
Refractive Index at 20°C, n_D	1.444
Vapor Pressure at 20°C, mm Hg	62.0
Vapor Density, air = 1	3.42
Solubility at 25°C, g EDC/100 g water	0.84
at 20°C, g water/100 g EDC	0.16

Solubility: Ethylene dichloride is soluble in most organic solvents.

Reactivity: At moderate temperatures, ethylene dichloride is stable and resistant to oxidation. When moisture-free at ordinary temperatures, it does not corrode metals. But in contact with water at elevated temperatures, ethylene dichloride will corrode iron and certain other common metals.

Specification and typical analysis:

	Specification	*Typical Analysis*
Purity, minimum %	99.7	99.99
Color, maximum APHA	10	8
Appearance	clear, free of suspended matter	clear, free of suspended matter
Acidity, as HCl, maximum ppm	10	<1
Alkalinity, as NaOH, maximum ppm	10	—
Water, maximum ppm	200	50
Free Chlorine	none	0
Nonvolatile Residue, maximum ppm	100	1
Total Chlorinated Hydrocarbons, low-boiling, maximum ppm	500	75
Total Chlorinated Hydrocarbons, high-boiling, maximum ppm	500	100
Total Oxygenated Compounds, maximum ppm	300	0
C_3 and Higher Compounds, maximum ppm	300	10
Total Soluble Iron, maximum ppm	0.5	0.5
Specific Gravity, 60°/60°F	1.261-1.264	1.262

When ethylene dichloride is ingested, the predominant characteristic is blood disorder, including clotting problems. With skin absorption or inhalation, the first effects are headache, weakness, eye irritation and nausea. Ethylene dichloride has been found in human milk and in the exhaled breath of nursing mothers who were exposed to the chemical.

Ethylene dichloride in contact with eyes or skin can result in local pain and irritation. Dermatitis may result from removal of natural skin oils and moisture, although permanent eye or skin injury has not been known to occur. If EDC is held close to the skin, as by contaminated clothing, severe irritation and moderate edema and necrosis may result.

Chronic Exposure

There are reports of two mild cases of human exposure for periods of two to five months which showed symptoms of central nervous system depression and gastrointestinal upset with nausea and vomiting. These persons recovered when removed from exposure. The liver and kidneys may be damaged by prolonged or repeated inhalation of the vapor.

Recent animal studies conducted by the National Cancer Institute (NCI) have shown that ethylene dichloride can cause cancer in rats and mice by oral administration. However, in other studies of rats and mice exposed to EDC by inhalation, the results—although preliminary—did *not* confirm the NCI findings.

The National Institute for Occupational Safety and Health (NIOSH) has recommended that the current OSHA permissible exposure limit be reduced from 50 ppm to 5 ppm (8-hour TWA) with a ceiling of 15 ppm. Although no evidence now exists showing that ethylene dichloride can cause cancer in human beings, PPG strongly suggests that EDC users review their health programs and operations and institute operating and housekeeping practices designed to limit employee exposure as much below currently established exposure limits as practical.

HANDLING AND STORAGE

Ethylene dichloride is a flammable liquid. It introduces a fire hazard wherever it is handled, stored or used. At high temperatures, such as occur in open flames, it decomposes to give off toxic and corrosive gases. Mixed with air at ordinary temperatures, ethylene dichloride is explosive within the limits of 6.2 to 15.9% by volume. Fire and explosion hazards can be minimized by adequate ventilation, the proper t[illegible] and arrangement of equipment, a[illegible] reasonable precautions and care in handling.

Information on the "Safe Handling and Use of Ethylene Dichloride" appears in Chemical Safety Data Sheet SD-18 published by the Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009. The MCA also publishes Manual Sheet TC-4 on "Unloading Flammable Liquids from Tank Cars."

PACKAGING AND SHIPPING

PPG Industries delivers ethylene dichloride by tank car, barge, tank truck, drums and ship from the Lake Charles, Louisiana, plant. Tank car and tank truck shipments can also be made from a terminal in Chicago, Illinois.

Tank car capacities include 8,000, 10,000 and 20,000 gallons. Tank truck capacity is generally 4,000 gallons.

SAMPLES AND SERVICE

Samples of ethylene dichloride are available in various sizes to meet customer requirements.

The technical service staff of PPG Industries' Chemicals Group is available for consulting on handling, storage and use.

PPG INDUSTRIES

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BULLETIN 115A

Vinyl Chloride

Chemicals

PPG INDUSTRIES

At its plants in Lake Charles, Louisiana, and Guayanilla, Puerto Rico, PPG produces vinyl chloride monomer by the oxyhydrochlorination of ethylene. PPG holds more than 400 domestic and foreign patents on this process.

Uninhibited VCM is quite stable and can be routinely shipped, handled and stored provided proper procedures, outlined below, are followed. To prevent polymerization in transit or storage, it is essential that the monomer be protected at all times from contact with air, oxygen, moisture, catalytic impurities and light.

PPG normally supplies VCM uninhibited. The use of uninhibited VCM eliminates the need for subsequent processing to remove the inhibitor.

More information appears in the PPG manual, "Vinyl Chloride Monomer Handling and Properties," form A-994-115C.

GRADES

PPG Industries produces only polymer-grade vinyl chloride monomer.

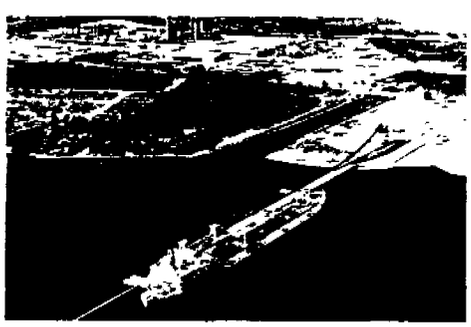
USES

Most vinyl chloride is polymerized to polyvinyl chloride (PVC) or copolymerized with other monomers such as PPG's vinylidene chloride. Vinyl chloride monomer should not be used as an aerosol propellant.

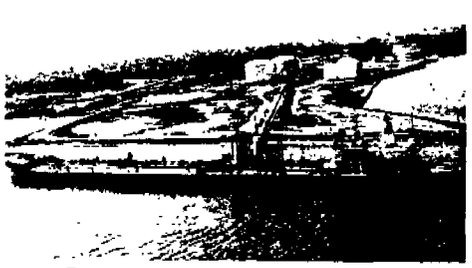
TOXICITY

The Occupational Safety and Health Standard on exposure to vinyl chloride published October 4, 1974, says: "Based on the demonstrated evidence of vinyl chloride monomer's carcinogenicity in three animal species (rats, mice and hamsters), and the substantial probability that vinyl chloride monomer had been the causal agent in the cases of liver angiosarcoma found in workers both here and abroad, OSHA . . . published a comprehensive proposal . . . to protect employees from hazards of exposure to vinyl chloride monomer."

Stated in this OSHA standard is the following "Permissible exposure limit:



At the PPG plant in Guayanilla, Puerto Rico, the company's modern 34,000-ton chemical tanker, S.S. Puerto Rican, receives a load of vinyl chloride monomer.

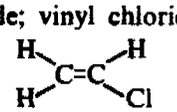


At the Paulsboro, New Jersey terminal, the S.S. Puerto Rican's load of vinyl chloride monomer is transferred to the refrigerated storage tanks in the background.

PROPERTIES

Chemical Names: Vinyl chloride; vinyl chloride monomer; chloroethylene; chloroethene

Chemical Formula: CH_2CHCl;



Molecular Weight: 62.5

Description: At ordinary temperatures and pressures, vinyl chloride is a colorless gas with a mild, sweet odor. But as supplied in tank cars and trucks under pressure, it is a liquid. Vinyl chloride is highly volatile and its vapor is extremely flammable.

Boiling Point, °C	−13.8	Autoignition Temperature, °C	472
°F	+7.0	°F	882
Freezing Point, °C	−153.7	Liquid Density at 60°F	0.9192
°F	−245	Vapor Density, air =1	2.15
Flash Point, open cup, °C	−78	Vapor Pressure, psia at 0°C	25.1
°F	−108.4	20°C	49.2
		40°C	87.6
Explosive Limits, volume % in air at 25°C (77°F)	3.6 to 33	Solubility, water in monomer, at 25°C (77°F), weight %	0.11

Solubility: Vinyl chloride is relatively insoluble in water but soluble in most organic solvents.

Reactivity: Vinyl chloride polymerizes exothermically in the presence of light, air, oxygen or catalysts. Heat alone will not initiate polymerization. Vinyl chloride is thermally stable to quite high temperatures. Although peroxide formation due to air exposure is a slow reaction, certain peroxide products are shock-sensitive. Vinyl chloride is noncorrosive to metals when dry at normal temperatures, but water and elevated temperatures accelerate corrosion. The double bond behaves as in other unsaturated compounds. The chlorine atom is relatively inactive and is more stable than in saturated or allylic compounds.

Specification and typical analysis:

	Specification	*Typical Analysis*
Appearance	clear, free of suspended matter	clear, free of suspended matter
Color	colorless, water-white	colorless, water-white
Acidity, as HCl, ppm	2 maximum	< 0.1
Iron, as Fe, ppm (filtered sample)	0.3 maximum	0.1
Nonvolatile residue, ppm	50 maximum	5
Water, ppm	100 maximum	50
Peroxide, as H_2O_2, ppm	0.06 maximum	0.01
Acetaldehyde, ppm	0.4 maximum	<1
Acetylene, ppm	2 maximum*	<1

*This maximum is an industry standard; however, the PPG product contains no detectable amount of acetylene.

(1) No employee may be exposed to vinyl chloride at concentrations greater than 1 ppm (part per million by volume) averaged over any 8-hour period, and

(2) No employee may be exposed to vinyl chloride at concentrations greater than 5 ppm averaged over any period not exceeding 15 minutes.

(3) No employee may be exposed to vinyl chloride by direct contact with liquid vinyl chloride."

In cases where these limits of exposure are exceeded, feasible engineering and work practice controls shall immediately be used to reduce exposures to or below the permissible exposure limit. Wherever feasible engineering and work practice controls are not sufficient, they shall nonetheless be used to reduce exposures to the lowest practicable level and shall be supplemented by the mandatory use of respiratory protection.

Respirators shall be selected from among those jointly approved by NIOSH and by MESA, under the provisions of 30CFR Part 11.

Besides the suspected carcinogenicity, vinyl chloride monomer vapor can produce immediate symptoms in persons exposed to high concentrations.

The odor of vinyl chloride monomer is sweetish and the sense of smell cannot be relied upon as a warning. High vapor concentrations may cause lung irritation, can cause dizziness and anesthesia, and may do other bodily damage in ways not yet ascertained. In all cases of overexposure, immediately remove the affected individual to fresh air and obtain medical attention.

Liquid vinyl chlorjde monomer may cause frostbite because it evaporates so fast. If a polymerization inhibitor is included, it may cause local skin burns. However, most vinyl chloride monomer shipped today is not inhibited.

Workers should wear eye protection and protective clothing to prevent skin contact with the liquid. If vinyl chloride gets on clothing or shoes, they should be removed immediately. If vinyl chloride contacts the skin, wash immediately with soap and water. If vinyl chloride contacts the eyes, the eyes should be washed immediately and thoroughly with water for at least 15 minutes. Get medical attention.

HANDLING AND STORAGE

Detailed information appears in the PPG manual, "Vinyl Chloride Monomer Handling and Properties, form A-994-115C.

Fire hazard

Vinyl chloride vapor is extremely flammable. Its explosive limits are between 3.6 and 33% by volume in air. Sufficient ventilation and the elimination of ignition sources are mandatory in areas where vapor concentrations may reach a flammable level. When a tank car is unloaded, both the car tank and the unloading pump must be electrically grounded.

The major products of combustion include toxic and corrosive hydrogen chloride as well as carbon monoxide and carbon dioxide. Under certain conditions, traces of phosgene may be produced.

Emission restrictions

The EPA Standard for Vinyl Chloride was published in the Federal Register on October 21, 1976 (see Code of Federal Regulations, 40CFR61, National Emission Standards for Hazardous Air Pollutants). This regulation applies both to polymer and monomer plants.

Unloading tank cars

If tank car valves are defective or leaking, **do not unload.** Telephone the PPG Chemicals plant at Lake Charles, Louisiana, 318-882-1200. Information on unloading tank cars and trucks appears in the PPG manual, "Vinyl Chloride Monomer Handling and Properties," form A-994-115C.

Warning: Air should never be permitted to enter vinyl chloride tank cars or other containers during or after unloading. Close and seal all openings. Leave at least 10 psig of vinyl chloride vapor pressure in empty tank car being returned.

PACKAGING AND SHIPPING

PPG Industries delivers vinyl chloride by ship, barge, tank car and tank truck. There are three shipping points: Lake Charles, Louisiana; Guayanilla, Puerto Rico; and Paulsboro, New Jersey.

PPG maintains a fleet of tank cars for vinyl chloride service only. All cars are equipped for top unloading. Tank car capacity is 180,000-pounds net weight. Tank trucks hold up to 40,000 pounds. Ships and barges hold up to several million pounds.

SAMPLES AND SERVICE

The technical service staff of PPG Industries' Chemical Division is available for consulting on handling, storage and use.

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BULLETIN 50A

Ethyl Chloride

Chemicals

PPG INDUSTRIES

CONFIDENTIAL:
Subject to Protective Order
of 14th Judicial District Court

Ethyl chloride of high purity, typically 99.97%, is produced by PPG Industries Chemical Division at Lake Charles, Louisiana. It is a technical-grade product for use by industry and is shipped by barge and tank car. The process by which PPG achieves this high-purity ethyl chloride is the hydrochlorination of ethylene.

At temperatures above 12.4°C (54°F) ethyl chloride is a gas, but it is easily compressed to the liquid state for shipping and handling.

USES

About 80% of the ethyl chloride produced in the United States is currently consumed for making tetraethyl lead antiknock gasoline additives. Other uses that consume considerable tonnage include the manufacture of ethylcellulose and styrene.

● Tetraethyl lead is made by reacting ethyl chloride with lead-sodium alloy. Houston Chemical Company, a division of PPG Industries, produces this antiknock ingredient. The high purity of PPG ethyl chloride makes processing easier and increases the yield of tetraethyl lead.

Ethylcellulose is made by reacting ethyl chloride with soda cellulose. Ethylcellulose resin is used in paper coatings, printing inks, films, adhesives and molded plastics. It forms tough lacquers and thermoplastic materials.

Styrene is made from ethylbenzene, which is mostly produced by the Friedel-Crafts ethylation of benzene with ethyl chloride.

Chemical intermediate. The ability of ethyl chloride to supply an ethyl group makes it useful for the synthesis of dyestuffs, fine chemicals and other materials. For example, ethyl chloride can be reacted with silicon to yield silanes with ethyl groups, which can then be converted to ethyl polysiloxane (silicone) compounds.

TYPICAL PROPERTIES

Chemical Names:	Ethyl chloride; chloroethane.
Chemical Formula:	C_2H_5Cl
Molecular Weight:	64.52
Description:	Ethyl chloride is a colorless mobile liquid at 1 atmosphere below 12.4°C (54°F). Above the boiling point, it is a colorless gas. Ethyl chloride has an ethereal odor and is highly volatile and flammable.

Freezing Point, °C	−138.3
°F	−217
Flash Point, Tag open cup, °C	−43
°F	−45
Explosive Limits, volume % in air	3.16 to 15
Autoignition Temperature, °C	519
°F	966
Specific Heat at 0°C, cal/ (g) (°C) or Btu/ (lb) (°F)	0.37
Heat of Vaporization at Boiling Point	
cal/g	92.5
Btu/lb	165.6
Viscosity at 10°C, cps	0.279
Density at 20°C, pounds/gallon	7.461

Refractive Index of Vapor, n_D^{25}	1.001
Vapor Pressure, mm Hg	
0°C (32°F)	464
10°C (50°F)	692
20°C (68°F)	1011
Specific Gravity of Vapor (air=1)	2.23
Solubility at 0°C,	
g ethyl chloride/100 g water	0.447
g water/100 g ethyl chloride	0.07

Solubility:
Ethyl chloride is soluble in most organic solvents.

Reactivity:
At ordinary temperatures the oxidation and hydrolysis of ethyl chloride take place slowly. In the absence of air and water, it can be used with most common metals up to 200°C (392°F). Ethyl chloride burns with a green-edged flame, producing hydrogen chloride, carbon dioxide and water. It is thermally stable to 400°C (752°F); thermal splitting yields ethylene and hydrogen chloride. The reactivity of ethyl chloride as an intermediate is often based on the affinity of alkali metal atoms for its chlorine atom.

Specification and Typical Analysis:

	Specification	Typical Analysis
Purity, wt %	99.5 minimum	99.97
Color, APHA	20 maximum	<5
Appearance	clear, free of suspended matter	clear, free of suspended matter
Acidity as HCl, wt %	0.002 maximum	<0.0001
Water, wt %	0.02 maximum	0.0010
Nonvolatile Residue, wt %	0.01 maximum	<0.0001
Total Impurities, wt %	0.5 maximum	0.03
Distillation Range, °C	12 to 13	12.2 to 12.4
Specific Gravity, 0°C/4°C	0.922 to 0.925	0.922

However, most polysiloxanes are made with methyl or phenyl rather than ethyl groups.

Solvent. As a chlorinated hydrocarbon, ethyl chloride can dissolve fats, oils, waxes and resins. It is especially potent for phosphorus and sulfur. Combined with methyl alcohol and benzene, ethyl chloride can dissolve nitrocellulose; combined with methyl acetate, it can dissolve triethylcellulose. Ethyl chloride acts as a processing solvent in the polymerization of olefins with catalysts such as aluminum chloride and titanium tetrachloride.

Anesthetic. The rapid cooling effect of ethyl chloride as it vaporizes makes it useful as a local anesthetic. Its narcotic action as a chlorinated hydrocarbon accounts for the capability of ethyl chloride as a general anesthetic. PPG Industries does not supply U.S.P.-grade ethyl chloride.

HEALTH HAZARDS

The threshold limit value (TLV) established in 1970* by the American Conference of Governmental Hygienists is 1000 parts per million. Vapor concentrations in work areas should not exceed this TLV as a time-weighted, average atmospheric concentration for an 8-hour day.

Because of its narcotic action, ethyl chloride has been used as an inhalation anesthetic. Vapor concentrations as low as 1% by volume can produce narcotic and anesthetic effects. Concentrations of 4% or over may produce deep or even fatal anesthesia. Inhaled ethyl chloride is rapidly absorbed, but is also rapidly eliminated.

Since the liquid evaporates rapidly, ethyl chloride could conceivably produce frostbite in contact with the skin. To some extent it is absorbed through the skin. The probability of hazard through skin absorption is remote. Ethyl chloride is slightly irritating to the skin and mucous membranes.

When ethyl chloride is decomposed by heat or ignition, hydrogen chloride gas, highly irritating to the nose and throat, is given off.

More information appears in a Hygienic Guide Series Sheet, "Ethyl Chloride," published by the American Industrial Hygiene Association, 25711 Southfield Road, Southfield, Michigan 48075, also in Chemical Safety Data Sheet SD-50 published by the Manufacturing Chemists Association, 1825 Connecticut Avenue, N. W., Washington, D. C. 20009.

Threshold limit values are reviewed yearly and are revised periodically.

HANDLING AND STORAGE

Ethyl chloride is a highly volatile, flammable liquid. Mixed with air at ordinary temperatures, ethyl chloride vapors are explosive by ignition within the limits of 3.16 to 15% by volume. Fire and explosion hazards can be minimized by adequate ventilation, the proper types and arrangement of equipment, and reasonable precautions and care in handling.

Above its boiling point of 12.4° C (54° F) ethyl chloride creates a pressure when confined. It is shipped and handled in pressurized containers. Small containers should not be exposed to the sun's direct rays or to heat sources.

Stainless steel is the preferred construction material for storage vessels, but ordinary steel may be used so long as a tank does not contain water as a separate phase. Prolonged contact between ethyl chloride and copper should be avoided.

Information on the "Safe Handling and Use of Ethyl Chloride" appears in Chemical Safety Data Sheet SD-50 mentioned above.

PACKAGING AND SHIPPING

PPG Industries delivers ethyl chloride by tank car and barge as the liquid under pressure.

SAMPLES AND SERVICE

Samples are shipped in small, pressurized metal containers of various sizes.

The technical service staff of PPG Industries Chemical Division is available for consulting on handling, storage and use.

A-1027 2.5M 471

Printed in U.S.A.

BULLETIN 120A

Vinylidene Chloride

Chemicals

PPG INDUSTRIES

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of 14th Judicial District Court
No. 91-1145

Vinylidene chloride monomer (VDC) is a versatile product used with other monomers to make a wide variety of copolymer resins and latices.

Properly inhibited and protected from exposure to air, oxygen, water and light, VDC is stable in shipment and storage at ambient temperatures. Correct handling practices, outlined below must be followed at all times.

VDC supplied by PPG Industries' Chemicals Group from its Lake Charles, Louisiana, plant is inhibited with hydroquinone monomethyl ether (HQMME or MEHQ) to prevent polymerization during shipment and storage. It is shipped under a nitrogen blanket to avoid contact with air and to prevent the formation of a peroxide that can act as a polymerization initiator.

For most applications, the MEHQ inhibitor in PPG vinylidene chloride need not be removed. If uninhibited monomer is required, however, the MEHQ can be removed by distillation or alkali extraction.

GRADES

The standard grade of VDC manufactured by PPG is inhibited with hydroquinone monomethyl ether at approximately 200 parts per million.

USES

Vinylidene chloride monomer has been used for many years, primarily as a copolymer with such monomers as vinyl chloride, vinyl acetate, acrylonitrile, and acrylic acid esters. The copolymer resins and latices are formed into films, fibers, coatings and linings.

VDC imparts to finished products qualities of flame retardance, chemical resistance, and impermeability to water vapor and gases.

Data on reactivity ratios of VDC copolymerizations with 36 monomers are presented in a booklet, "Vinylidene Chloride Handling, Properties and Reactivity Ratios," Form A-967-120R, available on request from PPG Industries' Chemicals Group.

HEALTH HAZARDS

Acute overexposure to vinylidene chloride vapor by inhalation can lead to anesthesia, irrational behavior, drunk-

PROPERTIES

Chemical Names: Vinylidene chloride; vinylidene chloride monomer; 1,1-dichloroethylene

Chemical Formula: CH_2CCl_2;

Molecular Weight 96.94. Contains 73.14% chlorine.

Description: At ordinary handling temperatures, below its boiling point of 88.9°F (31.6°C), vinylidene chloride is a liquid. It is clear and colorless and has a sweet odor. Vinylidene chloride is highly volatile and its vapor is toxic and extremely flammable.

Boiling Point, °C	+31.6	Critical Temperature, °C	222
°F	+88.9	°F	432
Freezing Point, °C	−122.5	Absolute Viscosity at 20°C, cps	0.330
°F	−188.5	Specific Gravity, 20°/20°C	1.213
Explosive Limits, volume % in air	7 to 16	Density at 20°C, pounds/gallon	10.1
Flash Point, Tag closed cup, °C	−30	Refractive Index, n_D at 20°C	1.4247
°F	−5	Vapor Pressure, mm Hg, at 20°C	49
Autoignition Temperature, °C	570.0	Solubility, water in monomer at 20°C, weight %	0.03
°F	1058		
Critical Pressure, atmospheres	51.3		

Solubility: Vinylidene chloride is practically insoluble in water (0.04 weight % at 20°C) but soluble in most organic solvents.

Reactivity: Uninhibited, or inhibitor-depleted, vinylidene chloride may polymerize very slowly even in the absence of oxygen. To further retard polymerization, the uninhibited monomer should be maintained in darkness below 14°F (−10°C).

Uninhibited, or inhibitor-depleted, vinylidene chloride reacts readily with oxygen or air to form a peroxide at temperatures as low as −40°F or C.

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Specification and typical analysis:

	Specification	*Typical Analysis*
Appearance	clear, free of suspended matter	clear, free of suspended matter
Color, APHA	25 maximum	5
Vinylidene Chloride, weight % (excluding inhibitor)	99.6 maximum	99.9
Acetylene, as C_2H_2, ppm	25 maximum	<1
Other Chlorinated Hydrocarbons, no one to exceed this weight %	0.25 maximum	0.1
Acidity, as HCl, ppm	10 maximum	<1
Peroxide, as H_2O_2, ppm	10 maximum	<1
Water, ppm	50 maximum	30
Inhibitor, HQMME*, ppm	180 to 220	200

*Hydroquinone monomethyl ether is sometimes referred to as MEHQ (monomethyl ether of hydroquinone).

enness, and — if continued — to unconsciousness and, ultimately, death. Vinylidene chloride is highly volatile and its vapor is heavier than air. Since its odor threshold lies between 500 and 1000 ppm, the odor of vinylidene chloride is not an adequate warning to prevent overexposure. In all cases of overexposure, medical attention should be obtained.

Vinylidene chloride is irritating to eyes and skin. The inhibitor, if not washed off promptly, can cause severe local irritation or burns.

Chronic exposure to low concentrations of vinylidene chloride can result in injury to the liver and kidneys. Also, in recent preliminary animal studies, it has been reported that vinylidene chloride vapor in concentrations higher than the present American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) of 10 ppm may be carcinogenic to some species of experimental laboratory animals via inhalation. Although these findings are preliminary and incomplete, PPG suggests that air concentrations of vinylidene chloride in the work area be maintained below 10 ppm at all times. PPG also recommends that the 8-hour time-weighted average (TWA) be maintained as far below 10 ppm as practical.

HANDLING AND STORAGE

If tank car valves are defective or leaky, *do not unload.* Telephone the PPG Industries Emergency Response Center at (304) 843-1300 in Natrium, West Virginia. This telephone is manned to answer 24 hours a day.

Nitrogen used in vinylidene chloride service should have a maximum oxygen content of 10 ppm. In a bulk storage tank, oxygen content should be kept below 100 ppm by volume.

Information on unloading tank cars and drums, handling spills and leaks, construction materials, storage tanks and transfer lines is presented in a booklet on "Vinylidene Chloride," Form A-967-120R, available on request from PPG Industries' Chemicals Group.

Fire hazard

Vinylidene chloride vapor is extremely flammable and burns vigorously at concentrations between 7 and 16% by volume in air. Proper ventilation and the elimination of ignition sources are mandatory in areas where vapor concentrations may reach a flammable level due to spills or leaks.

Explosion hazard

The peroxide compound that forms when uninhibited vinylidene chloride has been exposed to atmospheric oxygen is potentially dangerous. This peroxide can also form if the inhibitor content has been depleted. Depletion can result from any of several causes including distillation or exposure to oxygen due to improper storage. The potential presence of peroxide can frequently be detected by sharp, acrid odors or by the precipitation of a white flocculent polymer.

Dried polymer residues may contain adsorbed peroxide which can be exploded by a slight mechanical shock or by heat. These residues should be handled with extreme caution. Adding water that is at room temperature to polymer residues containing peroxide renders them inactive. However, the hazard may return if the water evaporates. The peroxide can be destroyed by several washes with a 5% by volume solution of methanol in perchlorethylene. Any peroxide present as a precipitate in monomer can be destroyed by mixing with one part perchlorethylene-methanol solution and four parts vinylidene chloride monomer. Separation and handling of precipitated polymer, and its potentially dangerous adsorbed peroxide, must be done with extreme caution. Contact either the PPG plant at Lake Charles or Technical Service in Pittsburgh for additional information. Equipment not used continually should be filled with water when shut down.

PACKAGING AND SHIPPING

PPG Industries ships vinylidene chloride (inhibited) in tank cars of 11,000-gallon (111,000-pound) and 20,000-gallon (190,000-pound) capacity and in 55-gallon (500-pound) drums from Lake Charles, Louisiana.

SAMPLES AND SERVICE

Samples of vinylidene chloride are available on request in 1-pint and 5-gallon containers. The technical service staff of PPG Industries' Chemicals Group is available for consulting on safe handling, storage and use.

[redacted]

SL 049067

TRICHLOROETHYLENE INFORMATION BULLETIN

PPG has recently learned that a "Memorandum Of Alert" has been issued by the National Cancer Institute (NCI) stating that trichloroethylene was orally administered into the stomach of mice and these mice subsequently developed liver and other organ tumors. NCI, however, cautioned that "The information transmitted represents only a statement of concern and that no definite conclusions as to the carcinogenicity of the substance may be reached until all of the data from the histopathology examinations have been received and evaluated."

In interpreting these preliminary results, PPG feels that the animal species tested and the route of administration should be explained. The oral administration used required a stomach tube to be inserted in the animal and through this tube, trichloroethylene dissolved in corn oil was introduced into the stomach and the tube removed. This procedure was repeated daily, five days per week for 18 months. The dosage of trichloroethylene administered to the mice would be equivalent to a person drinking a six ounce glass of trichloroethylene (without corn oil) daily for the major portion of his life.

The Occupational Safety And Health Standard for trichloroethylene is 100 parts per million (PPM) 8-hour time weighted average, 200 PPM acceptable ceiling concentration, and 300 PPM acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift not to exceed five minutes in any two hours. Since any possible worker exposure would most likely be through inhalation, it is apparent that exposure to the OSHA Standard levels would not allow absorption of the levels of trichloroethylene reported in the NCI studies. While PPG's exposure and monitoring data indicate levels well below OSHA Standards, PPG is, nevertheless, examining existing exposure monitoring and reduction programs for trichloroethylene.

Through the MCA, PPG has initiated a meeting on May 12 with the other domestic and foreign producers of trichloroethylene to review existing information and to plan additional research programs related to the industrial environment.

PPG is concerned about the NCI alert but is trying to place interpretation of the preliminary findings in reasonable perspective. We feel this information should be immediately brought to the attention of our employees, customers, and distributors.

You will be kept informed of future information obtained.

A. T. Raetzsch

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polyvinyl chloride product. From a public health standpoint, such bans are completely unnecessary and would serve only as meaningless gestures.

Question: Did the PVC industry withhold important information on the health effects of vinyl chloride from the public?

Answer: The PVC industry throughout the world has consistently acted in a responsible manner with regard to the development and dissemination of information on vinyl chloride. The industry has sponsor d the majority of the medical research on vinyl chloride conducted to date, and essentially all of it conducted before 1974, when the first tentative link between vinyl chloride exposure and angiosarcoma in humans was discovered by an industry doctor and publicly announced by his company. In fact, were it not for the actions taken by the PVC industry from 1970 onward, we might still know next to nothing about the health effects of vinyl chloride.

Question: *Does vinyl chloride increase the risk of still births and miscarriages among the wives of heavily exposed industry workers?*

Answer: While one recent research project at a single plant in Pennsylvania reported that *such a risk may exist, serious* scientific questions have been raised concerning the manner in which the study was conducted. It is clear that a more thorough scientific investigation of this subject will be required before any definitive conclusions can be reached. In addition, since the research was conducted, vinyl chloride exposure levels throughout the industry have been reduced a hundredfold or more. Even if a problem did exist, it has already been eliminated.

Question: Does vinyl chloride cause birth defects in communities with PVC facilities?

Answer: Because of a report from Ohio of excess birth defects in three widely separated communities with PVC facilities, the Center for Disease Control (CDC) of the U.S. Department of Health, Education and Welfare conducted its own two-part study—one part in Pennsylvania and the second in Ohio. CDC concluded, on the basis of these investigations and a thorough analysis of the existing research data, that the evidence to date did "not establish any association between (birth defect) cases and vinyl chloride exposure."

For Further Information Contact:

The Society of the Plastics Industry, Inc.

355 Lexington Avenue

New York, New York 10017

(212) 573-9400

PVC AND HEALTH QUESTIONS AND ANSWERS

The Society of the Plastics Industry, Inc.

PVC AND HEALTH
QUESTIONS AND ANSWERS

Since early 1974, vinyl chloride, the gaseous industrial chemical from which polyvinyl chloride (PVC) plastic is made, has been the subject of widespread misunderstanding regarding questions of occupational and public health. While a variety of erroneous and misleading impressions concerning vinyl chloride and PVC have been created in the public mind, the known facts, supported by extensive medical and technical research, are that:

1. The development of angiosarcoma of the liver, a rare form of cancer, from vinyl chloride exposure has been confined exclusively to the occupational setting.
2. Angiosarcoma may develop only after the inhalation of substantial amounts of vinyl chloride over an extended period of time.
3. There is no evidence of hazard to the general public either from exposure to the minute amounts of vinyl chloride that may be found in the air around PVC plants, or from the use of finished polyvinyl chloride products.

Following are some questions commonly asked about vinyl chloride and health. Answers are based on known scientific evidence and industry experience.

Question: What is PVC and how is it used?

Answer: Polyvinyl chloride or PVC is the second most widely used plastic resin in the United States. It is produced from vinyl chloride gas by a process called polymerization. The resin is, in turn, fabricated into a wide variety of consumer and industrial products, including floor tile, curtains, shoes, electrical insulation, telephone equipment, medical-surgical devices, phonograph records, food packaging, upholstery, umbrellas and raincoats, luggage and sporting goods. Approximately 2.2 million American jobs are directly or indirectly dependent on the PVC industry.

Question: How serious an occupational hazard is vinyl chloride?

Answer: Over the past 15 years, fewer than 20 deaths from angiosarcoma have occurred among U.S. workers heavily exposed to vinyl chloride gas. The workers' jobs principally involved cleaning residue of PVC resin from the reactors in which it was produced. While it can be expected that some additional deaths will occur in the future as a result of these heavy past exposures, with the strict control measures instituted over the last two years, there is every reason to believe that vinyl chloride related disease has already been eliminated as an occupational problem.

Question: Is vinyl chloride a major air pollutant?

Answer: No. Measurements taken by the Federal Environmental Protection Agency (EPA) determined that, even in the past, the average exposure of individuals living in proximity to vinyl chloride gas and PVC resin plants was many times lower than that now considered to be safe for occupational exposure. As a purely precautionary step, new EPA regulations will further significantly reduce even this minimal exposure. In addition, the EPA has concluded that the potential public exposure from PVC fabricating plants is so minimal as to require no regulations whatever.

Question: Does vinyl chloride cause disease in the general public?

Answer: No. A government survey of all angiosarcoma deaths in the United States between 1964 and 1974 found no excess of deaths from this disease among people living within five miles of vinyl chloride gas and PVC resin plants. The report concluded: "This survey has produced no evidence that living around vinyl chloride plants is a risk factor in the occurrence of liver angiosarcoma." In addition, there is no evidence whatsoever that any person has contracted this disease from the use of finished PVC products, or from ingesting food or beverages packaged in PVC containers.

Question: Is it safe to consume food or beverages packaged in PVC?

Answer: Yes. As a result of strenuous industry efforts over the past few years, the residual vinyl chloride content has been reduced to "non-detectable" levels in packaging products made from food-grade PVC resins. Therefore, there is no reasonable possibility of vinyl chloride migration into foods, drugs, cosmetics or other products contained in such packages.

Question: Should the manufacture and use of PVC products be banned?

Answer: Vinyl chloride concentrations in the workplace, in community air, and in finished PVC products are being rigidly controlled, and there is therefore no reason to ban the manufacture or use of any

Unloading and storage technique for vinyl chloride monomer

The system described here is critical to the safe handling of this widely discussed carcinogen.

Asu Mukerji, Catalytic Inc.

☐ Numerous tests and consequent governmental regulations have established vinyl chloride monomer (VCM) as a dangerous carcinogen.* Manufacturers of VCM have accordingly modified plants to protect workers from contact with the chemical.

In the changeover, one step has become critical to the overall process for converting toxic VCM to safe polyvinyl chloride (PVC)—the loading step, where VCM from tank cars and tank trucks is loaded into a customer's storage tanks for processing to PVC. Since the polymerization plants are relatively smaller than VCM plants, and are dispersed near to their markets, the critical loading stations are many.

Moreover, vapors from an empty VCM storage tank must be collected and contained as they are displaced by a new supply of liquid, because of stringent specifications as to permissible concentrations of VCM in the atmosphere.

Still further, VCM is an explosion hazard, corresponding to Class 1, Group D, Div. 1, of the National Electrical Manufacturers Assn. code, NEMA 7, and variations in ambient temperatures at various locations complicate the outdoor unloading/loading problem.

Vapor/liquid exchange

The key to solving these problems consists of a vapor-liquid-exchange process, which has been incorporated into the design of a number of successfully operating unloading stations (Fig. 1). With this process, a compressor draws vapor from the plant's storage tank, and feeds the compressed vapor into a tank car, forcing VCM from the tank car up through a dip tube and into the transfer piping system.

Alternately, a slipstream of liquid VCM from the storage tank is vaporized by steam to similarly increase tank-car pressure. The vaporizer generally comes into play either when the compressor is down for maintenance or when ambient temperatures are too low (below 60°F) for the compressor alone to handle the unloading.

Using the compressor, VCM transfer continues until the level in the tank car falls below the dip pipe, at which point the tank car is full of displaced vapors plus residue liquid. This liquid can be transferred by connecting the compressor's suction to the tank car, and its discharge to the storage tank. A four-way valve in the suction and discharge lines effects this changeover without exposing the operator to VCM.

With the normal compressor flow thus reversed, residual liquid in the tank car vaporizes from the reduction in pressure, while the compressed vapors are condensed in the storage tank by bubbling them through the large mass of liquid, which removes the heat of compression. In this manner, the tank car is normally evacuated down to the pressure required for reloading.

Depending on the heat transfer into the tank car, residual liquid vaporizes within 20 to 30 minutes, during which time the pressure will not be radically reduced. After the liquid has been vaporized, the time for evacuating the remaining vapors may be calculated with the formula:

$$M = (V/DE) \ln (P_1/P_2)$$

where: M = evaporation time, min.
V = tank-car volume, ft.^{3}
D = compressor piston displacement, ft^3/min.
P_1 = tank-car pressure at start of cycle, psia
P_2 = tank-car pressure at end of cycle, psia
E = average volumetric efficiency of compressor

The economics of the evacuation operation can be evaluated according to the value of VCM.

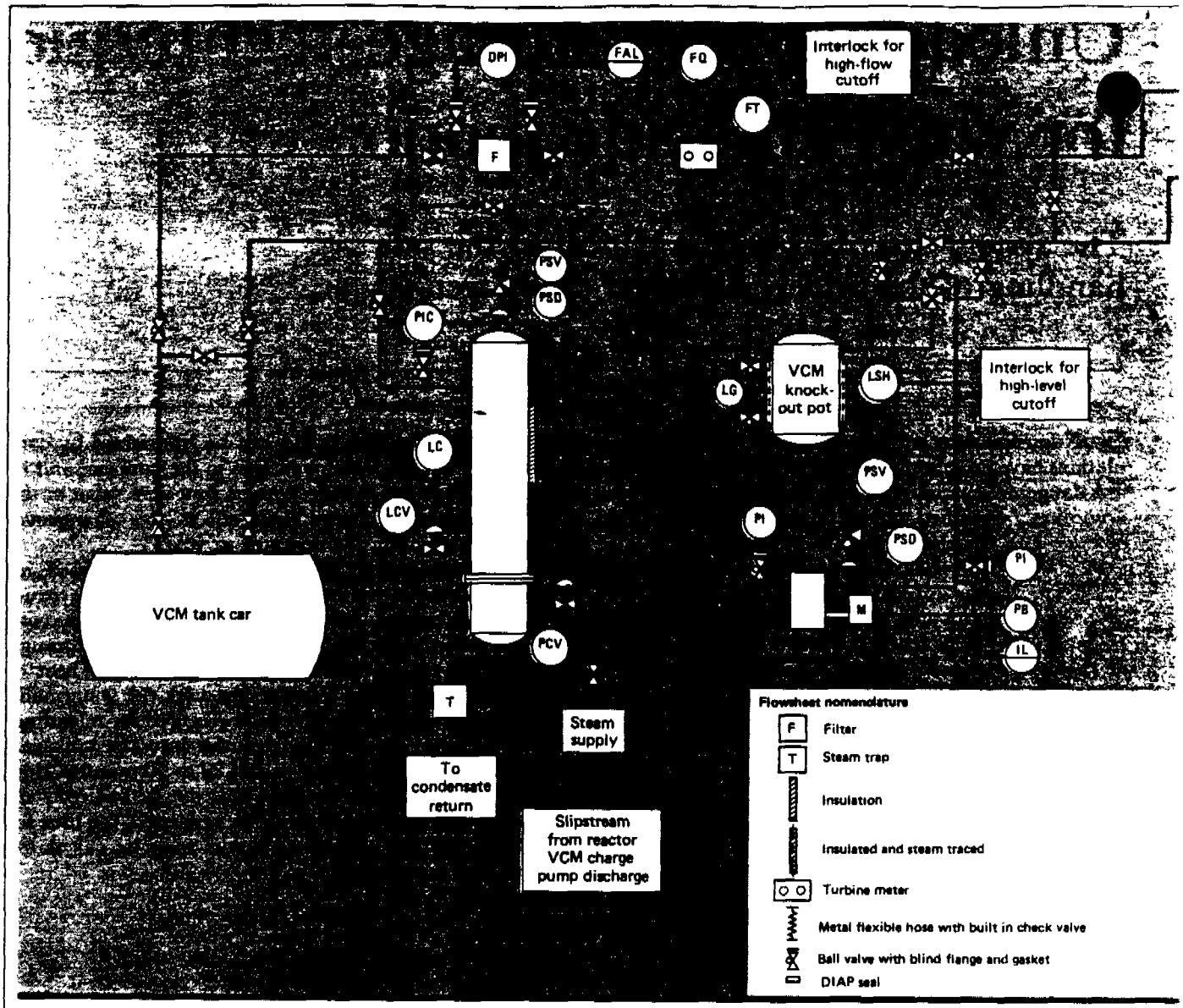
After the tank car has been completely evacuated, the compressor is used to evacuate the disconnected hose, which only then should be taken off for storage.

The storage tank is emptied of VCM for maintenance by filling it with water as displaced vapors are vented to a monomer gas collecting system, and then letting in air through the atmospheric vent as the water is drained into the diked storage area for runoff to storm sewers.

Unloading system

The unloading system consists of transfer piping, compressor, vaporizer, storage tanks, and instrumentation for safety and control. Flexible metal hoses connect the tank car to the rigid transfer piping. Each transfer connection on the tank car contains an isolation valve and a built-in excess-flow valve to prevent leakage in

*Chem. Eng.: May 13, 1974, p. 55; July 8, 1974, p. 28; Sept. 2, 1974, p. 23; Sept. 30, 1974, p. 23; Sept. 30, 1974, p. 42; Feb. 17, 1975, p. 35; Mar. 17, 1975, p. 23; June 9, 1975, p. 36; Oct. 13, 1975, p. 67; Jan. 5, 1976, p. 74.



VCM unloading system

the event of a ruptured hose. Similarly, the rigid piping contains check valves to prevent backflow from the storage tank in case of rupture.

VCM inventory is measured by means of a turbine meter and a flow totalizer in the transfer piping. A filter upstream of the meter protects it from dirt, as well as extending the online time of the monomer-reactor charging filter (see Fig. 1).

Design criteria

The steps in designing a VCM unloading system generally take the following sequence:

1. Establish the piping configuration for compressor, vaporizer, storage tank and tank car.
2. Determine the optimum transfer-line size for the desired flowrate.
3. Size and select the compressor.
4. Develop the detailed instrumentation.

The piping configuration is made in accordance with the flowscheme (Fig. 1) and a physical layout for the unloading station. Pressure drops in the transfer lines must include static elevation and line losses between the compressor discharge and the tank car, and between the compressor suction and the storage tank. Also, pressure drops across the turbine meter, and a dirty filter, must be allowed for.

Since the entire unloading area will be outdoors and may be in northern climates, the compressor and vaporizer design must allow for seasonal temperatures such as 110, 60, and 10°F, corresponding to monomer vapor pressures of 95, 43 and 11 psia, respectively.

A common practice is to size the compressor for spring conditions, relying on the vaporizer to augment transfer during the winter. In this case, the compressor will unload during summer at a much faster rate, which can be calculated by trial and error, assuming a flowrate and working backward through the compressor-sizing calculations.

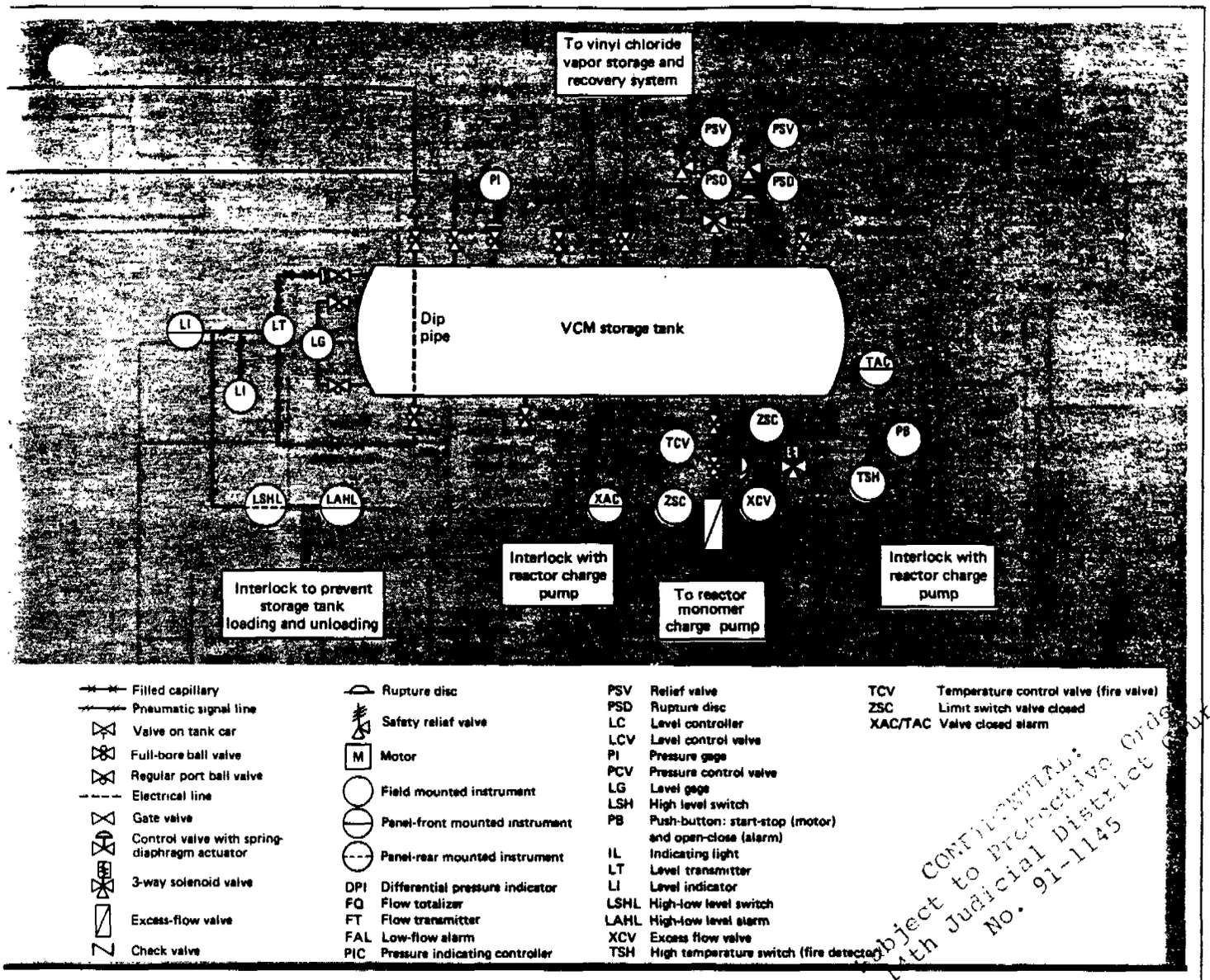


Fig. 1

These calculations determine the required compressor displacement, as a function of its volumetric efficiency, the vapor molecular weight, vapor density and specific heat, the discharge and suction temperatures and pressures, the unloading rate, and the heat lost by the tank car to its surroundings (see box, p. 160).

The vaporizer is essentially a vapor/liquid separator with a steam-heated chamber. Liquid VCM flow to this vessel is about one thirtieth of the liquid transferred from the tank. Vaporizer design is based on winter conditions, the worst case for unloading VCM. Operating pressure is the sum of the storage tank pressure and the pressure losses in the transfer line.

Liquid entrainment in the vapor can be minimized by introducing a wire-mesh screen to coalesce the liquid droplets, and by providing sufficient disengaging height above the liquid surface.

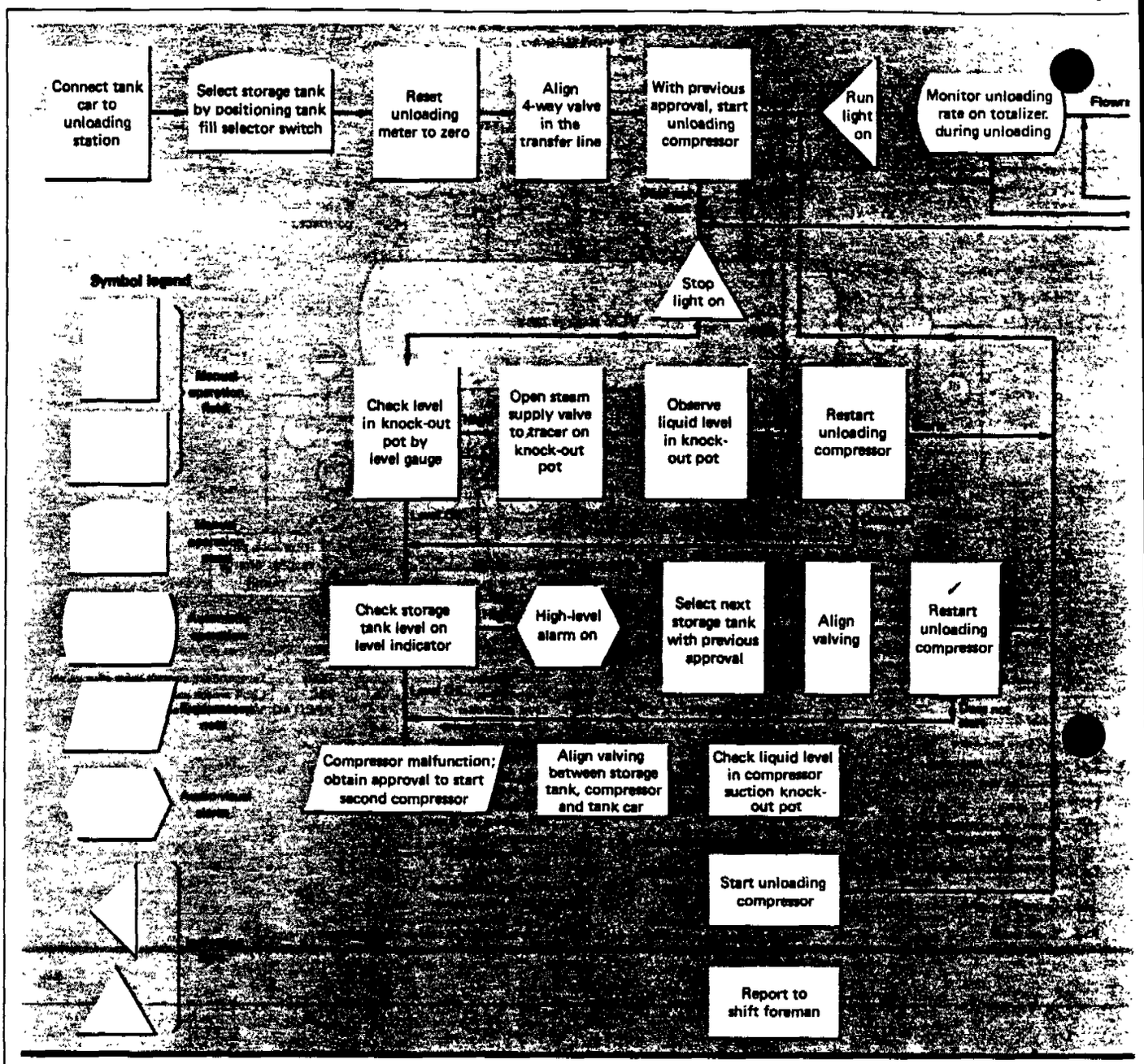
The required mass flowrate of VCM vapor to the tank can be taken from compressor calculations for winter conditions. This figure, along with the liquid and vapor densities of VCM at operating pressure and temperatures, gives the volumetric vapor flowrate to the tank car, and the liquid flowrate to the vaporizer. The remaining vaporizer design calculations deal with steam requirements and heat-transfer surfaces.

Instrumentation

All locally mounted electronic instruments must meet the Class 1, Group D, Div. 1 requirements of NEMA 7. Electronic, intrinsically safe, explosion-proof instruments are available from most vendors, for on-the-spot calibrating and troubleshooting, if required.

Also, electronic instruments should be capable of withstanding seasonal temperature extremes. Otherwise, heaters or coolers must be used. Pneumatic local instruments should be weatherproof and dust-tight.

The totalizer, used with the turbine meter in the transfer line, displays the instantaneous VCM flowrate in



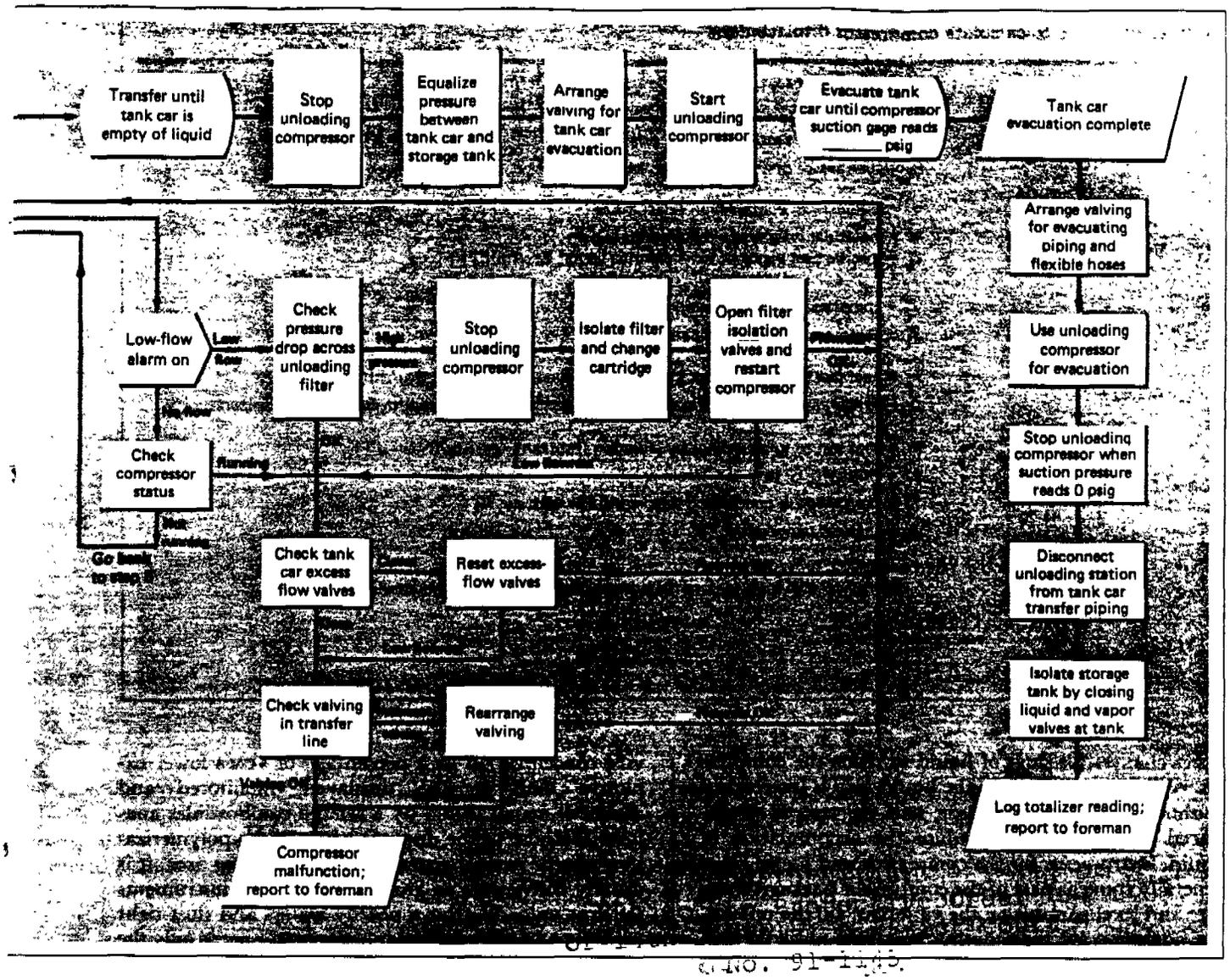
Operating diagram for unloading vinyl chloride tank car **Fig. 2**

gpm, and accumulates the actual VCM removed on both a resettable batch counter and a continuous counter, in order to be able to display VCM unloaded from several tank cars after a period of time. The batch counter reading is logged after unloading each tank car, and reset before unloading the next.

To compute a material balance, a reactor batch charge, and a reaction conversion, the operator must know the total weight of VCM unloaded into the storage tanks. Since the density of unloaded VCM varies with ambient temperature, a temperature-compensated flow measurement is required.

The turbine meter affords an accuracy of ±0.15 to ±0.25% of the instantaneous flow. For such accuracy, the meter vendors must have density and viscosity data for seasonal conditions. Also, the transfer line must provide straight runs of 15 pipe diameters upstream and 5 pipe diameters downstream of the meter.

The totalizer should have built-in low-flow and high-flow switches. The low-flow gives indication when (1) the filter ahead of the meter is plugged, or (2) the manual valves in the transfer line are blocked, or (3) the compressor is malfunctioning. The high-flow protects the turbine meter from overspeeding due to vapor flow, by stopping the compressor. Vapor flow occurs when the liquid level in the unloading tank car drops below the dip pipe. Overspeeding the turbine reduces the life of its bearings and may damage the rotor. Even after the compressor stops, vapor flow will continue until the tank car and storage tank have achieved the same



pressure, which can introduce significant error in the totalized reading.

This vapor flow can be avoided by placing an automatic on-off valve, actuated by a density-difference or pressure switch, at the tank-car end of the transfer line.

The level indication on a storage tank permits scheduling that tank for reloading and production, whether the tank has enough material to charge a reactor batch or whether a tank car's contents can be unloaded into it. Magnetic and capacitance-type level meters provide a reading unaffected by the varying VCM density. Readings that depend on liquid pressure, on the other hand, will vary with ambient temperature.

A high-level switch interlocked with the storage-tank unloading pumps prevents cavitation by maintaining enough liquid head at the pump suction.

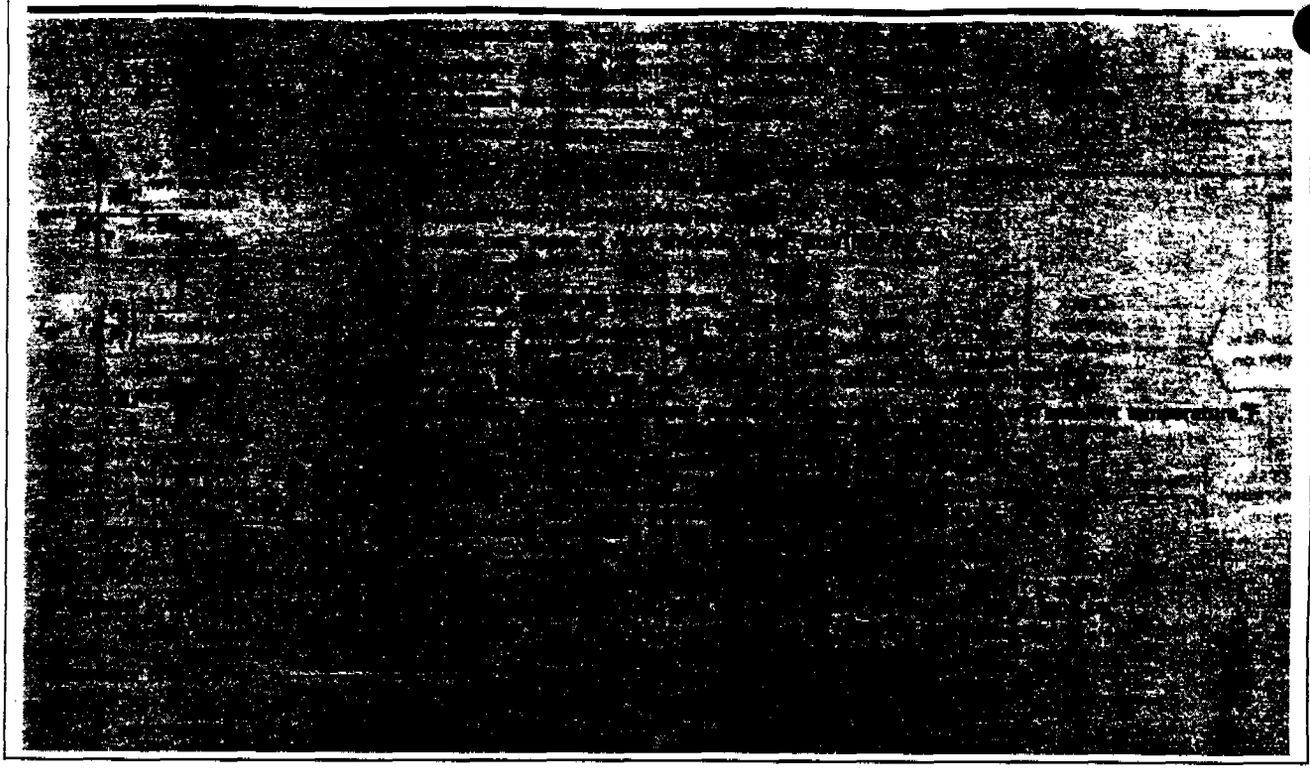
In the event of fire, an automatic fire-valve on the storage tank's discharge line isolates the tank. Normally, a fire-safe full-port ball valve with pneumatic actuator serves for this purpose. The fire detector can be a bimetallic switch set at 170°F near the fire valve. A relief-valve/rupture-disc combination protects the storage tank from overpressure due to fire or overfilling. A redundant relief system on each tank prevents accidental shutdown.

A self-actuated excess-flow valve downstream of the fire valve isolates the storage tank in case of line rupture, or failure of the reactor charge-valve, or an instrument malfunction in the VCM-reactor charging system. Fire and excess-flow valves are close-coupled to the storage tank and interlocked with the storage-tank unloading pump to prevent evacuation of pump suction lines with these valves closed, and thereby prevent overheating the pump.

For multiple storage-tanks using several unloading compressors and unloading pumps, the installation requires multiposition selector-switches to facilitate automatic interlocking of the selected tank instruments with the pump and compressor in use. Instrumentation for the compressor includes gages to display discharge pressure, and a relief-valve/rupture-disk combination to protect positive-displacement compressors. It is not good practice to pipe the discharge of this valve to the compressor suction, because of possible overheating due to continuous recirculation and recompression.

A liquid trap on the compressor suction side mini-

Expressions used to calculate c mpressor displacement



mizes chances for slugs of liquid to reach the compressor. A high-level switch in the liquid trap is interlocked to shut down the compressor, and the trap is steam-traced and insulated to reduce the accumulation of liquid. Instruments for the compressor and liquid traps generally come as part of the compressor package. Pressure and level controls on the vaporizer aid the unloading operation by maintaining heat and material balances, respectively. Pressure is maintained through the heat input to the vaporizer, and the level is held constant by liquid VCM flow.

Since the vaporizer operating pressure is higher than the storage-tank pressure, the storage-tank unloading pumps must supply a slip-stream of chloride to the vaporizer. Possible cavitation damage to the level-control valve can be eliminated by means of a valve with a high recovery coefficient or anticavitation trim.

A relief-valve/rupture-disk combination protects the vaporizer from overpressure due to fire, or steam-valve or level-valve failure. The steam valve is interlocked with the high-flow cutoff switch of the unloading system protecting the turbine meter.

Safety

Area monitors are located at breathing level in the work areas to detect VCM emissions. Since vinyl chloride vapor is heavier than air, it has a tendency to move downward, so detectors for combustible gases should be located at an elevation of $2\frac{1}{2}$ ft, near the sources of possible VCM vapor leaks.

VCM concentration, measured in ppm by a chromatograph, is displayed, and an alarm sounds when this concentration exceeds 75% of maximum permissible. VCM concentration as a percentage of VCM's lower explosive limit is also displayed, monitored and alarmed—as measured by a remote combustibles analyzer. Because of the distance between the polymerization-reactor control room and the unloading area, it is usually convenient to group controls and instruments for VCM unloading on a nearby water- and dust-tight control panel. The control room operator needs only the critical data for overall coordination—such as storage tank level; and the status of the unloading compressor, the fire and excess-flow valves, and the unloading pump. A remote pushbutton can be interlocked with all the fire valves on storage tanks, in order to close those valves in an emergency.

Relief valves protect the transfer piping from thermal expansion wherever liquid can be blocked between valves. The blinded vent on the storage tank is equipped with a flame arrester to prevent flash-back into the tank.

The author

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