GAS DATA BOOK

Sixth Edition

Matheson®

MATHESON GAS DATA BOOK

Library of Congress
Catalog Card No. 80-83159

VINYL CHLORIDE

(Synonyms: Chlor ethen ; Chloroethylene)
(Formula: CH_2:CHCl or C_2H_3Cl)

PHYSICAL PROPERTIES (1)

Molar Mass	
Molecular Weight	0.062 499 kg
One Mole of C_2H_3Cl	0.062 499 kg
Specific Volume @ 21.1 °C, 101.325 kPa	387.0 dm^3/kg; 6.2 ft^3/lb
Vapor Pressure @ 21.1 °C	336 kPa; 3.36 bar; 48.7 psia; 3.31 atm
Boiling Point @ 101.325 kPa	259.35 °K; −13.8 °C; 7.2 °F
Freezing Point	119.45 °K; −153.7 °C; −244.7 °F
Absolute Density, Gas @ 101.325 kPa @ 25 °C	2.620 kg/m^3
Relative Density, Gas @ 101.325 kPa @ 25 °C (Air = 1)	2.21
Density, Liquid @ −20 °C	0.972 kg/l
Critical Temperature	424.61 °K; 151.5 °C; 304.6 °F
Critical Pressure	5 755 kPa; 57.55 bar; 834.7 psia; 56.8 atm
Critical Volume	2.71 dm^3/kg
Critical Density	0.369 kg/dm^3
Critical Compressibility Factor	0.276
Latent Heat of Fusion @ 119.45 °K	75.90 kJ/kg; 18.14 kcal/kg
Flammability Limits In Air	4–22% (by volume)
Dipole Moment, Gas	4.837×10^{-30} C·m; 1.45 D
Molar Specific Heat, Gas @ 101.325 kPa @ 25 °C @ Constant Pressure	53.607 J/(mol·°K)
Molar Specific Heat, Liquid @ 0 °C	78.449 J/(mol·°K)
Viscosity, Gas @ 101.325 kPa @ 20 °C	0.010 72 mPa·s; 0.010 72 cP
Viscosity, Liquid @ −20 °C	0.280 mPa·s; 0.280 cP
Thermal Conductivity, Gas @ 101.325 kPa @ 25 °C	0.007 95 W/(m·°K) 19.0 $\times 10^{-6}$ cal/cm/(s·cm^2·°C)
Surface Tension @ −20 °C	23.1 mN/m; 23.1 dyn/cm
Solubility In Water @ 101.325 kPa (total pressure) @ 25 °C	1.07 cm^3/1.0 ml water
Refractive Index, Liquid @ Saturation Pressure, n_D @ 25 °C	1.366
Dielectric Constant, Liquid @ 27.2 °C	6.26
Autoignition Temperature	745.15 °K; 472.0 °C; 882.0 °F
Flash Point	195.15 °K; −78.0 °C; −108.4 °F

Description

Vinyl chloride is a colorless, highly flammable gas having a pleasant, sweet odor in high concentrations. Vinyl chloride is toxic and carcinogenic; at this writing a TLV standard of 5 ppm has been established. It is shipped in cylinders, single-unit tank cars, and ton multiunit tank cars, and in tank trucks and ton multiunit tanks on trucks. It is readily liquefied and is reshipped in steel cylinders as a liquefied compressed gas under its own vapor pressure 234 kPa (34 psig) at 21.1 °C. It is shipped with an inhibitor (phenol) to prevent polymerization in the cylinder.

Specifications

Vinyl chloride typically has a minimum purity of 99.9 mole% (liquid phase).

Uses

Vinyl chloride is used as an intermediate in organic synthesis and for the production of plastics by polymerization and co-polymerization.

Effects In Man and Toxicity (2)

The 1979 ACGIH has established a Threshold Limit Value (TLV) of 5 ppm (10 mg/m^3) for vinyl chloride.

It has been reported that concentrations of above 1 000 ppm slowly produce mild disturbances such as drowsiness, blurred vision, staggering gait, and tingling and numbness in the feet and hands.

The carcinogenicity of vinyl chloride has been established after notification that several workers who handled and used

vinyl chloride developed a rare form of liver cancer. Exposure of rats to vinyl chloride by inhalation at and below 500 ppm induced tumors, including angiosarcomas of the liver. Another series of experiments on the effect of exposure of rats, mice and hamsters to vinyl chloride at concentrations of 10 000; 6 000; 2 500; 500; 250; and 50 ppm have been carried out for varying periods of time. The experimental results so far reported are that tumors have been observed in groups of animals exposed to vinyl chloride at concentrations as low as 250 ppm.

Liquid vinyl chloride on skin contact may cause severe irritation and burns.

First Aid Treatment

Summon a physician at once for anyone who has been exposed to high concentrations of vinyl chloride vapor or its liquid state.

Inhalation

The victim, especially if he complains of dizziness, should be removed to an uncontaminated, well-ventilated room. Oxygen should be administered, by trained personnel only. The patient should be kept quiet and comfortably warm but not hot and a physician summoned.

Skin Contact

Remove contaminated clothes and shoes and wash the affected areas with copious quantities of water followed by soap water solution.

Eye Contact

Irrigate the eyes immediately with copious quantities of water for at least 15 minutes, holding the eyelids apart during the irrigation to insure contact of the water with all tissues of the eyes and lids. An eye specialist should be called promptly.

Precautions in Handling and Storage

An effective educational and training program should be instituted to inform the workers of the hazards involved in handling and using vinyl chloride, and the first aid measures to be followed in the event of an emergency. Vinyl chloride should be used in a well-ventilated area, preferably a hood with forced ventilation. All lines and equipment to contain vinyl chloride should be grounded. Personnel handling vinyl chloride should wear safety shoes, chemical safety gogles and/or a full face shield, and rubber gloves. For respiratory protection, self-contained breathing equipment, air-line gas masks and U.S. Bureau of Mines approved cannister type gas masks should be available in emergencies. Instant-acting safety showers and eye fountains should be conveniently located near the site of the operation. Store and use cylinders of vinyl chloride in well-ventilated area away from heat and all sources of ignition such as flames and sparks. Do not use vinyl chloride around sparking motors or other non-explosion proof equipment. Do not store reserve stocks of cylinders of vinyl chloride with cylinders containing oxygen, chlorine, or other highly oxidizing or flammable materials.

In addition, the general rules listed in Appendix I should be observed.

Leak Detection

Leaks of vinyl chloride in lines and equipment may be detected by applying soap water solution to the suspected sites; leaks will be indicated by bubble formation.

Analytical Detection

Matheson has available a Toxic Gas Detector, Model 8014K, for detection of 0.25–10 ppm vinyl chloride in the atmosphere (Model 8014-132SC detector tube). A 100-cm^3 sample of the atmosphere is drawn into the detector tube which contains a chemical reagent that absorbs and reacts with vinyl chloride. A color stain is produced which varies in length with the concentration. The length of the stain is read directly off the detector tube scale.

Disposal of Leaking Cylinders

Leaking cylinders of vinyl chloride that cannot be corrected normally may be handled in the following manner. Put on an appropriate gas mask or self-contained breathing equipment and place the cylinder in a hood with forced ventilation. Attach an appropriate regulator and check valve to the cylinder valve outlet. Introduce the vinyl chloride at a moderate rate into an adequate amount of a suitable solvent such as carbon tetrachloride, chloroform, 1,2-dichloroethane, or chlorobenzene. The resulting solution can be fractionated for recovery of vinyl chloride.

Materials of Construction

Steel is a completely satisfactory material for handling vinyl chloride. Copper and its alloys should not be used as it might result in the formation of explosive acetylides from trace impurities of acetylene. Fittings and connections for 1.5 inch and larger pipe should be flanged or butt welded. Fittings and connections for 1 inch and smaller pipe may be threaded and the appropriate joint compound used. Garlock No. 7021, 1/16 inch thick asbestos gaskets, or equivalent are satisfactory for flanged connections. Teflon, lead, and carbon are also suitable.

Cylinder and Valve Description

Vinyl chloride is shipped in DOT approved, low pressure steel cylinders. Cylinders of vinyl chloride are equipped with steel or cadmium-plated brass valves having Compressed Gas Association (CGA) valve outlet connection No. 290. The valve outlet has a thread size of 0.745 inch, with left-hand external threads accepting a bullet-shaped nipple (see Figure 1 for an illustration of the valve outlet and its mating connection). Lecture bottles have a special 5/16 inch-32 threads per inch, female outlet.

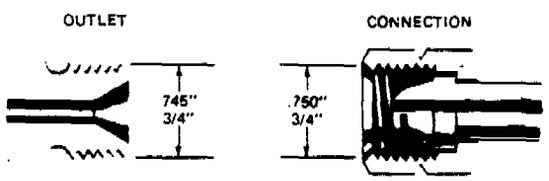

Fig. 1. CONNECTION 290 .745"-14 LH EXT. accepting a Bullet Shaped Nipple

Matheson

Safety Devices

The most commonly used device, and the one used by Matheson, is the spring-loaded safety relief valve. If the cylinder pressure becomes dangerously high usually due to overheating, the safety relief device will open (at about 2 590 kPa (375 psig)) and release gaseous vinyl chloride until the pressure again returns to a safe level.

Recommended Controls

Automatic Pressure Regulators

Matheson regulator Model 13-290 is recommended for use with vinyl chloride. This single stage regulator has an anodized aluminum body, type 316 stainless steel internal parts, a diaphragm of FEP Teflon on Neoprene and a Teflon seat. It has a delivery pressure range of 28–240 kPa (4–35 psig).

Low pressure regulator Model 71-290 is available for sensitive and accurate low pressure control. The regulator has an oversized, pancake, aluminum body, type 303 stainless steel internal parts, a Teflon-faced Butyl rubber diaphragm, a Teflon seat, and a delivery pressure of 3.4–34.5 kPa (0.5–5.0 psig).

Manual Controls

Matheson needle valve Model 61-290, of type 303 stainless steel, is available for direct attachment to the cylinder valve outlet. This valve may be equipped with a variety of outlets, such as a connection hose, ¼" inch tube fitting, or ¼ inch NPT male or female connection. It should be used only where manual flow control is needed and should not be used as a pressure control since it will not prevent pressure from building up if a system becomes clogged or if the system itself is closed. Stainless steel needle valve Model 32S or Model 59 is recommended for use with lecture bottles.

Flowmeters

Matheson Series 7600 laboratory stainless steel flowmeter units with 150mm tubes and floats or Matheson Series 7200 laboratory stainless steel flowmeter units with 65 mm tubes with a single float are recommended for use where definite flow rates must be known.

Electronic mass flowmeters, such as Matheson Series No. 8116 and No. 8160, should be used where accurate readings are required. Calibration is unaffected by temperature and pressure changes, and flow rates may be recorded from the instrument's electrical output.

Electronic Mass Flow Controllers

The Matheson Series 8240 of type 316 stainless steel and Series 8260 of type 316 stainless steel or monel are designed to control the flow of gas regardless of pressure and temperature changes. These mass flow controllers consist of a transducer, a control valve, a blind controller/power supply, a potentiometer, and a digital indicator. The transducer senses the gas flow and sends a signal to the power supply. This signal and one from the potentiometer are compared. If there is an imbalance, the power supply generates a signal for the control valve to reduce or increase the flow to correct the imbalance. The accuracy is ± 1.2%.

Shipping Regulations

Vinyl chloride, inhibited, is classified by the DOT as a flammable compressed gas and is shipped with the "Red Gas Label".

Commercial Preparation

Vinyl chloride is made by the catalyzed addition of HCl to acetylene, by thermal decomposition of ethylene chloride, or by heating the latter with alcoholic caustic alkali.

Chemical Properties

Vinyl chloride is readily polymerized to polyvinyl chloride by a variety of methods. It also may be copolymerized with other unsaturated compounds. The Cl atom in vinyl chloride is unreactive in nucleophilic substitution reactions. Vinyl chloride undergoes addition reactions similar to the olefins. The inhibitor in cylinder vinyl chloride may be removed by scrubbing with dilute caustic solution, or by fractional distillation.

Thermodynamic and Detailed Physical Data

Molecular Structure

The planar vinyl chloride molecule has the following structural parameters: bond distances: C=C 1.355 Å (1.355×10^{-10} m); C-Cl 1.728 Å (1.728×10^{-10} m); C-H 1.078 Å (1.078×10^{-10} m); bond angles: C-C-Cl 121.1°; C-C-H 126°.

The lack of reactivity of the chlorine atom in vinyl chloride, $CH_2{=}CHCl$, is attributed to resonance involving the polarized structure $\overset{-}{CH_2}\text{-}CH{=}\overset{+}{Cl}$. The resonance effect is such that the chlorine atom is bound to the carbon atom by a linkage which has double bond character and the chlorine atom therefore is less labile than in the normal C-Cl bond. Vinyl chloride has a dipole moment of 1.45 D.

Infrared Spectrum

See Figure 2 for the infrared spectrum of gaseous vinyl chloride.

Vapor Pressure (5)

The vapor pressure of liquid vinyl chloride up to 101.325 kPa (1 atm) is shown below.

Temperature, °K	Vapor Pressure		
	kPa	mbar	mmHg
167.55	0.133	1.33	1
182.35	0.667	6.67	5
189.45	1.333	13.3	10
197.45	2.666	26.7	20
206.35	5.333	53.3	40
212.05	7.999	80.0	60
219.95	13.332	133	100
231.85	26.664	267	200
245.15	53.329	533	400
259.35	101.325	1 013.25	760

The vapor pressure above 101.325 kPa (1 atm) is tabulated below (6).

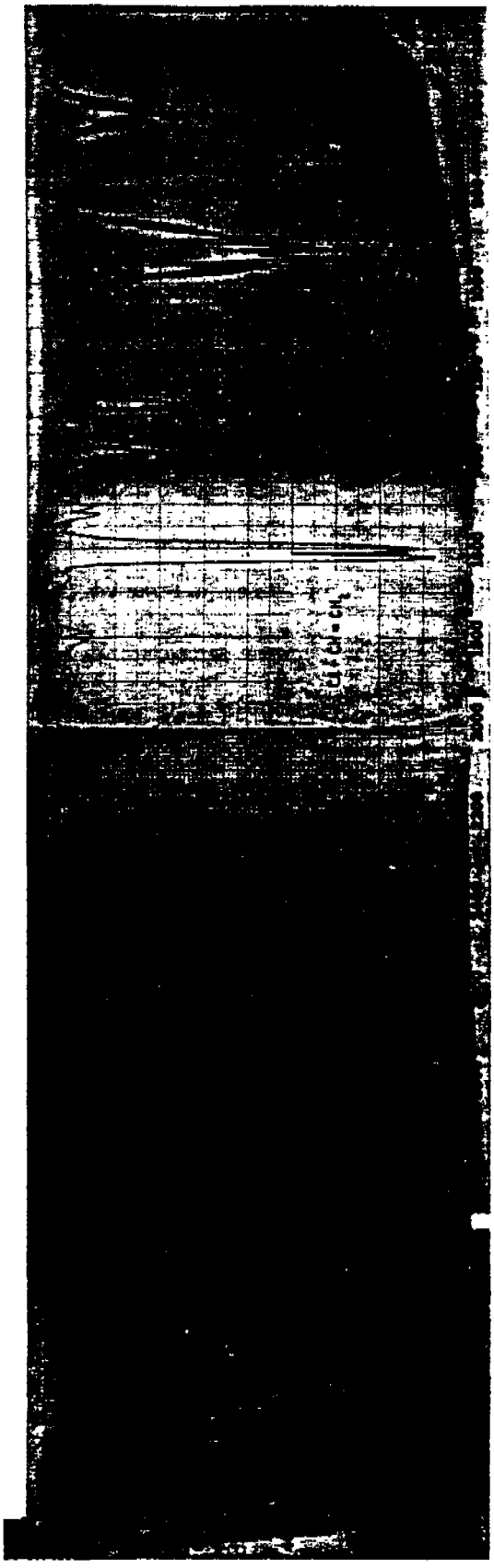

Fig. 2. Infrared spectrum of gaseous vinyl chloride; 10-cm path length cell, with KBr optics; cell pressure (complete scan) 5.333 kPa (40 mmHg) (8).

Temperature, °K	Vapor Pressure		
	kPa	bar	atm
283.15	254.326	2.54	2.51
293.15	343.492	3.43	3.39
303.15	466.095	4.66	4.60
313.15	583.632	5.84	5.76
323.15	733.593	7.34	7.24
333.15	924.084	9.24	9.12
343.15	1 137.880	11.38	11.23

Latent Heat of Vaporization, ΔHv

Temperature, °K	ΔHv, kJ/kg
213.15	388.8
233.15	376.2
259.35	357.29

Thermodynamic Data

Compressibility data for vinyl chloride are shown in Table 1.

Thermodynamic Properties of Vinyl Chloride As Ideal Gas @ 25 °C (7)

Heat Capacity, C_p°	53.723 J/(mol·°K)
Entropy, S°	263.885 J/(mol·°K)
Free Energy Function, $(G_{298}^\circ - E_0^\circ)/298$	−224.221 J/(mol·°K)
Enthalpy Difference, $H_{298}^\circ - H_0^\circ$	11.820 kJ/mol
Enthalpy of Formation, ΔH_f°	35.564 kJ/mol
Free Energy of Formation, ΔG_f°	51.882 kJ/mol

REFERENCES

[1] For extensive tabulations of the thermodynamic and physical properties of vinyl chloride, see W. Braker and A. L. Mossman, *The Matheson Unabridged Gas Data Book*, 1975, Matheson, East Rutherford, New Jersey.

[2] *The Toxic Substances List*, H. E. Christiansen, T. T. Luginbyhl, and B. S. Carroll, 1974, pp. LXXIX–LXXXI, Federal Register, Volume 39, No. 67, National Institute for Occupational Safety and Health, Rockville, Maryland.

[3] *Federal Register*, Volume 39, No. 194, Oct. 4, 1974, National Institute for Occupational Safety and Health, Rockville, Maryland.

[4] R. C. Ivey and M. I. Davis, *J. Chem. Phys.* 57, 1909–1911, (1972).

[5] *Chemical Engineers' Handbook*, 5th edition, R. H. Perry and C. H. Chilton, editors, 1973, p. 3–61, McGraw-Hill Book Co., Inc., New York, New York.

[6] J. T Rozlooskaya and M. I. Temkin, *J. Appl. Chem.* (U.S.S.R.) 19, 32 (1946).

[7] D. D. Wagman, *et al.*, *Selected Values of Chemical Thermodynamic Properties*, 1968, p. 143, Natl. Bur. Stand. Tech. Note-270-3, U. S. Government Printing Office, Washington, D. C.

[8] *The Sadtler Standard Spectra*, 1972, Sadtler Research Laboratories, Inc., Philadelphia, Pennsylvania.

[9] W. Hayduk and H. Laudie, *J. Chem. Eng. Data* 19, 253–257, (1974).

Table 1. COMPRESSIBILITY FACTORS Z, FOR GASEOUS VINYL CHLORIDE (9)

Temperature, 273.15 °K Pressure			Temperature, 323.15 °K Pressure		
kPa	atm	Z	kPa	atm	Z
52.689	0.52	0.988	101.325	1.00	0.985
101.325	1.00	0.974	190.491	1.88	0.969
119.564	1.18	0.969	330.320	3.26	0.948
142.868	1.41	0.956	419.486	4.14	0.932
167.186	1.65	0.933	574.513	5.67	0.900
173.266	1.71	0.905	731.566	7.22	0.850
			807.560	7.97	0.700
Temperature, 298.15 °K Pressure			**Temperature, 348.15 °K Pressure**		
kPa	atm	Z	kPa	atm	Z
101.325	1.00	0.981	101.325	1.00	0.988
144.895	1.43	0.975	228.994	2.26	0.972
169.213	1.67	0.969	345.518	3.41	0.954
230.008	2.27	0.961	447.856	4.42	0.939
298.909	2.95	0.945	615.043	6.07	0.911
345.518	3.41	0.916	812.626	8.02	0.869
369.836	3.65	0.888	1 033.515	10.20	0.808
395.168	3.90	0.846			