LIQUID CARBONIC CORPORATION

Subsidiary of Houston Natural Gas Corporation

135 SOUTH LA SALLE STREET • CHICAGO, ILLINOIS 60603

AREA CODE 312 346-8181

ACCEPTED

ETHYLENE OXIDE AND CARBON DIOXIDE STERILIZING GAS

FOR ECONOMIC POISON REGISTERED UNDER NO. 11491-3 SUBJECT TO ... COMMENTS.

ETHYLENE OXIDE AND CARBON DIOXIDE MIXTURE

ACTIVE INGREDIENT:
ETHYLENE OXIDE 20% BY WEIGHT
INERT INGREDIENT:
CARBON DIOXIDE 80% BY WEIGHT
TOTAL CONTENTS ________ LBS. NET
E.P.A. REG. NO. 11491-3

WARNING: CONTENTS UNDER PRESSURE!

1. Do not puncture. 2. Do not use or store near heat or open flame. Exposures above 130°F may cause bursting. Never throw containers into fire or incinerator. 3. Do not use oil or grease on valve, regulator, fittings. 4. Do not recharge without written consent of Liquid Carbonic.

WARNING: DO NOT IGNORE!

KEEP OUT OF REACH OF CHILDREN

1. Exposure to eyes, skin or clothing may cause severe irritation. Avoid contact. In case of contact, remove all contaminated clothes immediately and flush skin or eyes with plenty of water for at least 15 minutes; for eyes, get medical attention. 2. Intended for gas sterilization only. 3. Ethylene oxide is subject to polymerization; use within 2 months after receipt. 4. Instructions for use and other information are in Industrial Gas Bulletin IG-2013.

LIQUID CARBONIC CORPORATION
135 South LaSalle Street • Chicago, Illinois 60603

Form #3122

A RED DIAMOND® PRODUCT (Non Life Supporting)

File Symbol 11491-G

ACCEPTED
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11491-3 SUBJECT

LIQUID CARBONIC

Subsidiary of Houston Natural Gas Corporation

TECHNICAL SALES BULLETIN

Bulletin #IG-2013

ETHYLENE OXIDE/CARBON DIOXIDE OR DICHLORODIFLUOROMETHANE STERILIZING GAS MIXTURES

This bulletin is intended to provide safe handling guidelines for the manufacture, sale, and resultant end-use of ethylene oxide/carbon dioxide or dichlorodifluoromethane mixtures.

PROPERTIES OF ETHYLENE OXIDE

Ethylene oxide is a cyclic ether compound with the formula $(CH_2)_2O$ and a molecular weight of 44.05. Liquid ethylene oxide freezes at -111.3°C. (-168.3°F) and boils at 10.73°C. (51.3°F) at atmospheric pressure. It has a vapor pressure of 7.? psig at 21.1°C (70°F). It will readily react when in contact with moisture and catalysts, such as the anhydrous chlorides of iron, tin and aluminum. Ethylene oxide is completely soluble in water and, in the presence of a basic or acidic catalyst, will react with water to form polyethylene glycol. Ethylene oxide is soluble in alcohol, ether and many organic solvents, as well as in such solid materials as rubber, leather and plastics.

In contrast to liquid ethylene oxide, which is relatively stable to detonating agents, gaseous ethylene oxide is highly explosive and flammable in the presence of air with a source of ignition. The flammability of a substance or compound is normally referred to as its capability of being easily ignited. Thus, gaseous ethylene oxide in air is readily ignited by an electric spark, static electricity, excessive heat, an open flame or by other similar means.

The toxicity of ethylene oxide has been demonstrated in both the liquid and gaseous phases. Liquid ethylene oxide acts as a vesicant on exposed skin, and can produce serious delayed burns if clothing, shoes or gloves are not removed immediately after exposure. Vapors of ethylene oxide are moderately toxic if inhaled, and will produce irritation of the eyes and mucous membranes. A maximum tolerance of 50 ppm of the gas during an 8 hour exposure is the current TLV for ethylene oxide. Protective clothing is recommended.

ETHYLENE OXIDE MIXTURES

Due to the fact that pure [illegible] capable of being easily [illegible] generally used as a [illegible] fields. However, by diluting [illegible] with [illegible] flammability characteristics [illegible]

Mixtures of ethylene oxide and air can be [illegible] ordinary temperatures and pressures by mixing with [illegible] Studies on the flammability characteristics of [illegible] oxide-halogenated hydrocarbon (dichlorodifluoromethane [illegible]) have shown that:

1) Mixtures containing dichlorodifluoromethane and ethylene oxide in concentrations up to 12% by weight, and

2) Mixtures containing equal parts of dichlorodifluoromethane and trichloromonofluoromethane-ethylene oxide up to 11% by weight are nonflammable in any proportion of air at temperatures up to 54.4°C (130°F).

At the present time, there are several ethylene oxide mixtures which can be employed safely as sterilizing agents under normal conditions. These mixtures are shown in the table below:

Mixtures	Cylinder Content
10% Ethylene Oxide 90% Carbon Dioxide	60 & 30 lb.
20% Ethylene Oxide 80% Carbon Dioxide	60 & 30 lb.
12% Ethylene Oxide 88% Dichlorodifluoromethane	135 & 270 lb.

MODE OF ACTION

Several theories have been proposed on the manner in which ethylene oxide destroys micro-organisms. The more commonly expressed theory is based on the process of alkylation...the replacement by an hydroxy-ethyl radical of an available hydrogen atom within a chemical group such as the sulfurhydryl, amino, carboxyl or hydroxyl in a protein molecule. It is not definitely known which of these groups is actually attacked first by ethylene oxide; however, it is believed that the sulfurhydryl group is the most reactive or susceptible to the gas.

The rate at which destruction of organisms occurs appears to be related to the rate of diffusion of the gas through the cell wall and the availability or accessibility of one of the chemical groups to react with ethylene oxide. The rate of destruction also may depend upon whether the cell is in a vegetative or spore state. Research studies have reported that in the formation of a bacterial spore, the sulfurhydryl group may be protected by changes in the protein molecule, and the sterilizing action of ethylene oxide would then be restricted to one of the other chemical groups which are not as reactive.

If the process of alkylation is accepted as the mode of action, the killing of micro-organisms by ethylene oxide is a chemical interference and, probably, it is closely related to the inactivation of the cell reproductive process.

LIMITATIONS OF ETHYLENE OXIDE STERILIZATION

Deleterious Effects

Although ethylene oxide appears to be an ideal sterilant for many heat-sensitive articles, there are a number of disadvantages or limitations which require caution in its usage. One of these limitations is the deleterious effects which ethylene oxide has on plastics and rubber. Liquid ethylene oxide acts as a solvent on such acrylic plastics as "Lucite" or "Plexiglas", and it will attack plasticizers which are employed in plastics for binding purposes. Liquid ethylene oxide will also swell and produce blistering effects on various rubber components. Ethylene oxide in water solution will hemolyze red blood cells, and will effect a loss of potency of antibiotics. Certain culture media, sterilized by ethylene oxide, have been reported to be unsuitable for growing certain fastidious bacteria following exposure, due to the reaction of the sterilant with the organic components of the media. Animal diets, exposed to ethylene oxide, are also adversely affected.

The adverse effects of the various ethylene oxide-inert gas mixtures are more readily observed with the halohydrocarbon diluents than with the carbon dioxide mixtures. The liquid halohydrocarbons, particularly dichlorodifluoromethane and trichloromonofluoromethane are solvents for many plastics including those noted above, and "Polystyrene".

FACTORS AFFECTING THE STABILITY OF STERILIZING GAS MIXTURES

Sterilizing gas mixtures consisting of 10-20% ethylene oxide with either dichlorodifluoromethane or carbon dioxide as the carrier gas represents a product which has a high sterilizing efficiency.

Unfortunately, due to the extreme reactivity of ethylene oxide, problems exist in the areas of storage life and proper handling. The main area of concern is the decomposition (polymerization) of the ethylene oxide molecules.

The nature of the decomposition reaction in most cases leads to the formation of a low molecular weight polymer - polyethylene glycol polymer. As a general description, this product is usually referred to in the industry as nonvolatile residue or abbreviated N.V.R. N.V.R. not only forms in sterilizing gas mixtures but also in storage containers of pure ethylene oxide when proper handling instructions are not followed. The physical characteristics of N.V.R. are such that it is easily removed from storage containers, cylinders, transfer lines and various customer equipment by solubilization in hot water in the temperature range of 180-200°F. Steam cleaning to remove N.V.R. is not recommended because it tends to harden the residue, making it more difficult to remove from containers and transfer lines. This phenomenon is probably due to the fact that excessively high temperatures increase the molecular weight of the polymer through further reaction.

From a chemical point of view, the formation of N.V.R. is a catalyzed polymerization reaction. In the case of ethylene oxide, the polymer is catalyzed by all acids and bases, both protonic and Lewis type acids. Therefore, alkaline and acidic cleaning of containers, transfer lines and equipment is not to be recommended because of the danger of residual acid or base remaining in addition to moisture which also catalyzes the polymerization of ethylene oxide. Another phenomenon associated with catalytic reactions is the strong dependency of the rate of polymerization on the surface area-to-volume ratio (S/V). Because of the sensitivity of polymerization on S/V, sandblasting or abrasive cleaning of containers is not recommended since this procedure increases the surface area of the container and further promotes the formation of N.V.R. Due to the etching effect of strong acids, this type of cleaning also will increase the surface area of containers.

The formation of N.V.R. being a chemical reaction is very strongly affected by temperature -- the rate of reaction increasing with increasing temperature. Therefore, sterilizing gas mixtures should be used in areas that are as cool as possible, and the cylinder mixtures should be kept away from all sources of heat, especially sunlight, etc. The cooler the storage or use area, the less will be the amount of N.V.R. formation.

The least catalytic material of construction for transfer lines, etc., is stainless steel, the preferred material if costs permit. It is recommended that customers use stainless steel for valve fittings and general piping wherever possible.

In summary, the following should be considered by the user:

1) Check ethylene oxide for N.V.R.

2) Stainless steel for valves, fittings, transfer lines, etc.

3) Low temperature storage and use areas - must be less than 130°F.

4) Use dry nitrogen for purging equipment lines.

5) Minimize inventory time.

6) Avoid all sources of moisture, acids and bases.

7) Use hot water for cleaning and <u>not steam.</u>

EQUIPMENT

Equipment utilizing ethylene oxide sterilizing gas mixtures is commercially available from a number of reputable manufacturers. This equipment is of various types including but not limited to ethylene oxide gas mixture sterilizers, combination ethylene oxide gas mixture-steam sterilizers, portable ethylene oxide gas mixture sterilizers, and mattress and bedding disinfectors utilizing ethylene oxide sterilizing gas mixtures.

It is recommended that complete collateral information be obtained from the equipment manufacturer prior to the use of either the equipment or the ethylene oxide sterilizing gas mixture.

DIRECTIONS FOR USE

To obtain maximum sterilization with ethylene oxide gas mixtures, consideration must be given to the factors which govern the effectiveness of the sterilant. Temperature, gas concentration, humidity and duration of exposure determine whether or not a high degree of sterilization is attained. The following are generally regarded as the optimum conditions for using these gas mixtures and as such are the recommended conditions for using our products:

Temperature	120°F - 140°F (49°C - 60°C)
Gas Concentration	500-1000 mg ethylene oxide/liter
Relative Humidity	35% - 50%
Duration of Exposure	2-6 hours

Ethylene oxide will not kill dehydrated spores. Equipment must be precleaned and presoaked in water for a minimum of one (1) hour immediately prior to exposure with ethylene oxide. Articles that cannot be immersed in water must be sterilized in an ethylene oxide device with a built-in automatic moisture-vapor pretreatment rehydration system. Also of importance is the relationship of the exposure time to the gas concentration; when using our mixtures of ethylene oxide and a diluent gas such as carbon dioxide or dichlorodifluoromethane, the gas concentration in a pre-evacuated chamber is at an adequate level to insure sterilization. Thus the exposure time is kept at a minimum. However, when a non-vacuum sterilizer is used, a considerably longer exposure time is required due to the dilution effect of the gas already in the chamber.

Following the recommendations in the sterilizer manufacturer's collateral literature will insure proper operation of the equipment. The previous instructions are intended only as guidelines for proper use of our product with the general types of equipment.

LITERATURE SOURCES

1) The Journal of Hospital Research, Vol. I, April 1963, No. 2

2) Manufacturing Chemists Association, Chemical Safety Data Sheet SD-38, "Properties and Essential Information For Safe Handling and Use of Ethylene Oxide", 1971.

3) "Ethylene Oxide Storage and Handling", Union Carbide Chemical Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, New York.

4) "Non-Inflammable Ethylene Oxide Sterilant", U. S. Patent No. 2,891,838, 1959

5) "Ethylene Oxide Sterilization", The Journal of Hospital Research, Vol. VII, February, 1969, No. 1

6) "Polymerization of Ethylene Oxide", Ind. & Eng. Chem., Vol. 53, P. 903, 1961