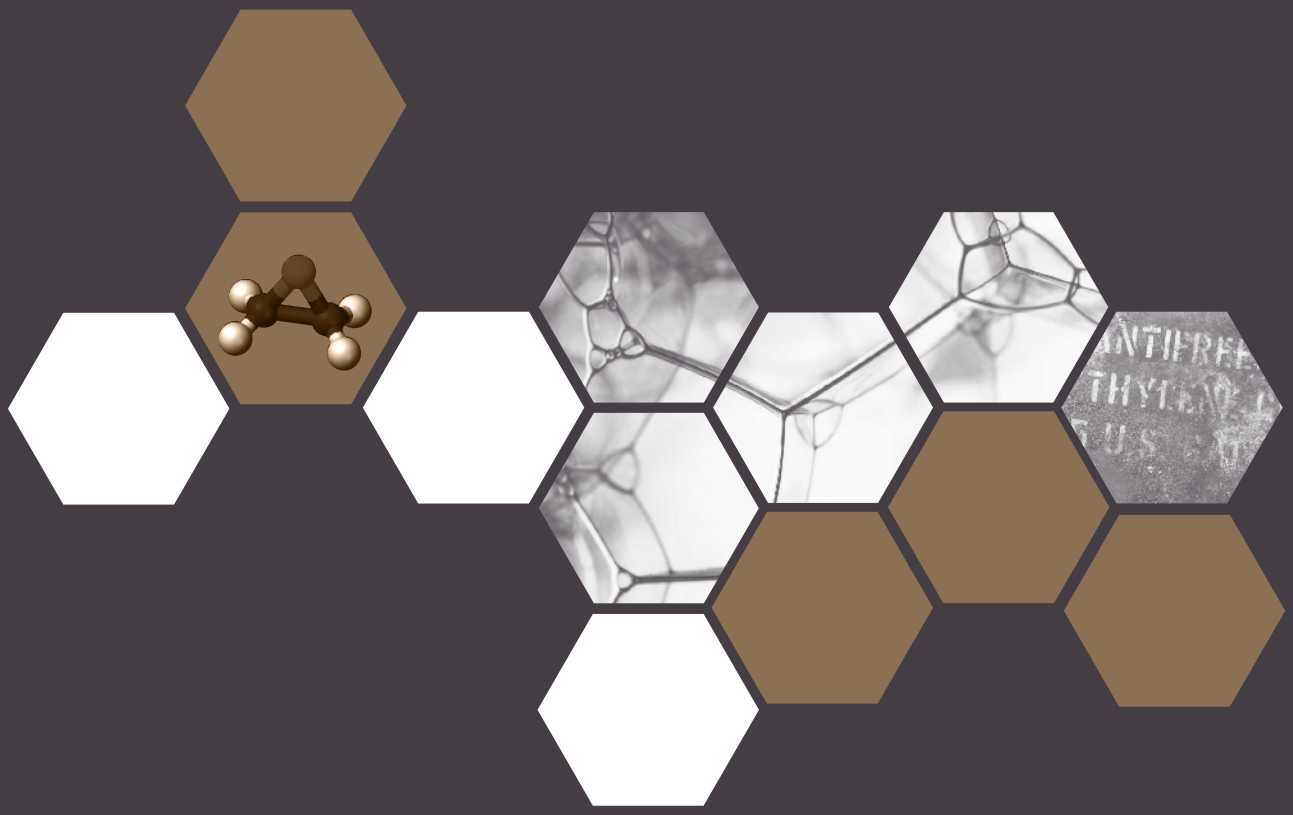
ethyleneoxide

third edition



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To the Reader

Manual Preparation

As members and affiliated companies of the American Chemistry Council, we support efforts to improve the industry's responsible management of chemicals. To assist in this effort, the American Chemistry Council's Ethylene Oxide/Ethylene Glycols Panel supported the creation and publication of this manual. The Panel is comprised of the following companies:

Balchem Corporation/ARC Specialty Products

BASF Corporation

Bayer Material Science LLC

Celanese Ltd.

Champion Technologies

Croda, Inc.

The Dow Chemical Company

Eastman Chemical Company

Honeywell

Shell Chemical LP

The development of this manual was led by the Panel's Ethylene Oxide Safety Task Group (EOSTG), a group comprised of producers and users of ethylene oxide. The EOSTG functions to generate, collect, evaluate and share information to support product stewardship with regard to ethylene oxide. The EOSTG formed a manual work group, chaired by Keith Vogel of Lyondell Chemical Company, to lead the development of this document. The following work group members provided significant contributions:

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Ralph Gingell	Shell Chemical LP
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8.0 Equipment Preparation and Maintenance

8.1 Introduction

When equipment in EO service must be opened for testing, inspection or repairs, facility requirements applicable to handling of flammable and toxic liquids and gases are strictly observed. All EO is removed from the system and either returned to the process or disposed of in accordance with federal, state, and local regulations.

Storage tanks and lines are thoroughly cleaned and purged with dry nitrogen before equipment is placed in or returned to EO service. Contaminants such as oxygen, water, and cleaning chemicals are completely removed to avoid dangerous reactions.

8.2 Preparation for Inspection or Maintenance

Preparations for Entry

Where applicable, the user must follow the requirements of the OSHA confined space standard (29 CFR 1910.146). Equipment is cleaned and purged of EO before beginning any maintenance work. If it is impractical or not possible to reduce airborne concentrations in and around the equipment below 1 ppm, OSHA regulations require that appropriate personal protective equipment be worn. See Section 7.5 for further discussion. The use of a gas detector for measuring ppm ranges of EO is required by federal regulations to verify that equipment is free of EO before allowing personnel to enter equipment. [29 CFR 1910.146 (OSHA confined space entry regulation) and 29 CFR 1910.1047 (EO-specific OSHA regulation)].

An important prerequisite to maintenance work on EO equipment is the development and use of a robust safe work plan that educates all affected personnel regarding applicable hazards. An effective work plan also includes other relevant components, such as an explanation of the importance of using proper personal protective equipment, of observing applicable safety precautions in each work task, and of observing other measures appropriate to working with EO.

Equipment being worked on is thoroughly drained and blown free of liquid EO with nitrogen. The equipment is then washed with cool water to remove residual liquid EO and drained to an appropriate wastewater treatment system. If EO polymer is present, refer to the discussion below, “Special Issues with Ethylene Oxide Polymer.” Care should be taken that hydrates are not formed during the water washing, since the melting points of EO/water mixture can be as high as 52°F (11.1°C) (see Table 2.2 in Chapter 2). Dispose of rinse water in accordance with applicable regulatory requirements and in a manner that is protective of personnel. (It should be noted that even dilute solutions of EO in rinse water have caused severe chemical burns. See Chapter 7). Once equipment is substantially free of liquid EO, steam purging can be used to remove traces of EO to allow for equipment entry. While steam purging, sudden condensing of steam may produce a vacuum in equipment that is not rated for vacuum service.)

Prior to entry, the equipment is isolated from the process and from potential sources of hazard. Atmosphere is tested for the presence of EO. Levels of EO must be low enough so personnel can safely enter. Persons entering equipment, vessels, or any confined space that has been in EO service are equipped with appropriate respiratory protection (see Section 7.5) unless it is demonstrated that the atmosphere inside the equipment, vessel or confined space does not present a hazard and measured EO levels do not otherwise require respiratory protection under OSHA.

Special Issues with EO Polymer

In systems storing pure EO, it is common for polymer to form and to accumulate gradually, especially where the EO is relatively stagnant. Polymer can retain EO after washing, and the polymer can gradually release the retained EO even after the equipment initially tests free of EO. To address this scenario, one effective practice is to wait several hours after the initial purging and rinsing steps and retest before opening the storage system to the atmosphere.

Low molecular weight polymer can generally be removed from EO by steaming or washing with hot water. Before using hot water or steam – both of which would be reactive with EO – to further decontaminate equipment, the equipment should be substantially free of EO. Adequate

isolation of EO systems to be cleaned will help prevent introduction of water or steam into other equipment still containing EO.

High molecular weight polymer is generally removed by physical means, such as high pressure water blasting.

Polymer residues can contain residual EO. The residues may be flammable and may present a health hazard, and EO may continue to evolve from polymer. If polymer cannot be removed by warm water washing, personnel entering a vessel to undertake physical cleaning should be provided with appropriate personal protective equipment. OSHA regulations require respiratory equipment if free EO levels cannot be reduced to less than 1ppm.

Mothballing

Equipment which has been in EO service, but is being removed from service, is decontaminated by washing or steam cleaning to less than 1 ppm of EO. Before washing or steam cleaning, such equipment is disconnected or blinded from "live" equipment. Consider maintaining carbon steel equipment under a nitrogen blanket to prevent rust formation.

8.3 Preparation of Internal Surfaces

Foreign material on internal surfaces of EO-containing equipment can cause slow self-polymerization of EO, resulting in a buildup of the polymerized material on those surfaces. This self-polymerization can be minimized by removing foreign matter such as welding slag, loose debris, and rust on internal surfaces prior to putting equipment into service.

Cleaning can be accomplished by shot or grit blasting, or by chemical methods. Shot blasting creates dust and debris, which is then removed. It is helpful to maintain a dry air purge during blasting. Purging the equipment as soon as possible after the blasting helps prevent rust formation. Where equipment surfaces, such as pipework, are inaccessible to blast cleaning, chemical methods may be used.

Chemical cleaning may involve the use of hazardous materials, and it may damage equipment if not properly specified and performed. The use of a qualified cleaning specialist is helpful in making such specifications and in performing the cleaning. A variety of chemical cleaning processes are available for preparing metal surfaces for EO service depending on what surface contaminants are present, including:

- Alkaline or detergent degreasing, followed by thorough rinsing.
- Acid cleaning, if the metal is carbon steel. The presence of both carbon and stainless steel creates complexities that suggest the use or consultation with appropriately qualified engineers before undertaking acid cleaning. Acid cleaning is followed by thorough rinsing of the equipment.

Acid-based cleaning often uses EDTA or citric acid. It may or may not be preceded by a degreasing step. If the system to be cleaned contains mild steel, a neutralization and passivation step is performed. Sodium nitrite is typically used for passivation. The system is thoroughly flushed with water (oxygen-free, if available) and dried by blowing with dry, hot nitrogen. Equipment is left under nitrogen pressure until ready to receive EO. Failure to adequately passivate or to keep material under nitrogen blanket will result in significant rust formation.

CAUTION:

EO is highly reactive. It is extremely important to remove all residues of cleaning chemicals because EO may react violently with them after the equipment is returned to EO service.

The effectiveness of a particular chemical cleaning procedure can be evaluated in advance using a test sample of the same metal as the surfaces to be cleaned.

8.4 Leak Repair Clamps

Clamp-on or bolt-on, split body style leak repair clamps have been used for temporary mitigation of small EO leaks from piping, valves, and vessels. Leak repair clamps can often be obtained "off-the-shelf," or they can be engineered to fit, depending on the application. The user must evaluate the relative risk of using clamps. Many common leak repair sealants are not suitable for use in EO service due to the potential for chemical reactivity.

Prior to the use of a sealant in a leak repair clamp, determine its potential reactivity with EO. This can be effectively accomplished by testing for reactivity with EO in a calorimeter. If a sealant is reactive with EO, there is the potential to generate a hot spot due to the heat of reaction, which could initiate an EO decomposition reaction. Because EO can be an aggressive solvent, the effectiveness and long-term durability of leak repair sealants to be used in EO service should be determined before use. Testing can help make this determination.

As with any moving stem valve, valves in EO service may experience fugitive emissions leaks. It is generally preferable to avoid leak repairs while a system is online. If an EO valve packing gland has to be repaired by drilling, tapping, and installing a sealant injection fitting for injection of a sealant, carefully control the localized frictional heat generated during the drilling on the valve body to help prevent approaching the decomposition temperature of EO.

8.5 Preventive Maintenance

A routine preventive maintenance program for EO equipment helps achieve proper operability of the system. Key components for internal inspections include checking the integrity of monitoring equipment and detecting polymer formation in the system. Other areas of focus for an inspection program are no flow or low flow zones in a piping network and small bore instrumentation tubing, both of which have the potential for polymer buildup. Nozzles for instrumentation and inlets to pressure relief valves are also generally included as areas for inspection as part of a routine maintenance program.

To help prevent polymer formation, include consideration of purging spare and offline piping and equipment as part of the maintenance program.

8.6 Equipment Commissioning

Before returning equipment to service after maintenance, leak testing is conducted. This is commonly done by closing, capping, and plugging all bleed valves with all flange covers tight. Equipment and piping is pressurized with nitrogen to a pressure at or near the normal operating pressure of the equipment. All new or disturbed flange connections and other fittings can be leak tested while holding the pressure for an appropriate period.

Some techniques commonly used to detect leaks before putting EO equipment into service include:

- Soap test
- Helium leak test using a portable mass spectrometer
- Vacuum test (on equipment rated for vacuum service)

Detected leaks are repaired before introducing EO into the system. After introducing EO into the system, all flange connections are rechecked as soon as possible using a gas detector capable of detecting EO at ppm levels.