Ethylene Oxide (EtO) Gas Sterilization, Safety for Workers and Community Members

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Overview

Ethylene Oxide (EtO) is a colorless, flammable, odorless gas that has been widely used by manufacturers for its antimicrobial pesticide properties. It is used to sterilize half of all sterile medical devices that cannot be treated using other methods such as steam or irradiation.[1] Due to the plastics, resins, and glass used to manufacture a majority of medical devices, EtO is often the only sterilization option available for these specific materials.[2] The EtO sterilization process involves five phases (preconditioning and humidification, gas induction, exposure, clearing, and aeration).[3] EtO is effective in microbial inactivation as a result of alkylation of cellular proteins, enzymes, and nucleic acids.[5]

Advantages and Disadvantages

EtO has been established in studies as a highly effective microbicide, and is capable of inactivating most bacteria, viruses, fungi and bacterial spores.[3] The high level of medical device material compatibility is the main reason for its extensive use.[5] EtO has the ability to sterilize medical devices that are vulnerable to extreme temperatures or moisture, without causing damage to the device, and accommodate sterilization in large quantities.[2,3] EtO sterilization is a time-consuming process that can take up to 14.5 hours. Processing includes mechanical aeration to rid the device of any residual EtO, which can be absorbed by many materials.[3] The main route of exposure to this colorless gas is inhalation, with studies demonstrating a genotoxic effect of DNA mutation or chromosomal damage.[5] Chronic inhalation exposure has been shown to increase the risk of leukemia, cognitive impairment, neurologic complications, and central nervous system depression.[3]

FDA and EPA Review Process

Due to Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) concerns of EtO release into the environment at unsafe levels, actions have been taken against sterilization facilities, including temporary shut down or closure.[8] The FDA works with device manufacturers and monitors the impact on supply chain and patient care related to these closures.[9] EtO is classified as a pesticide and is required to undergo a registration review through the EPA every 15 years to weigh the benefits versus risks in relation to health effects on humans and the environment.[1] The EPA has provided community outreach and engaged the public on EtO emissions impact on long term exposure health risks, and is actively gathering additional information to better understand the risks posed by this sterilization method.[8] As of July 27, 2022, the EPA has completed a risk assessment for surrounding communities, which will help inform any proposed regulations.[9]

EPA action items:[8,9]

- Review of the Clean Air Act regulation
- Partner with applicable agencies to reduce the rate of EtO emissions
- Engage in research to review usage and understand EtO

- Expand on the current requirements for reporting in commercial sterilizations facilities
- Expand the Toxics Release Inventory (TRI) Program requirement to incorporate specified contract sterilization facilities not included in current reporting
- Review how EtO is handled and used to identify opportunities to reduce risks of occupational exposure

The FDA is working with manufacturers and sterilization specialists on possible alternative sterilization methods and products.[2]

UPDATE - The FDA announced in January 2024, that Vaporized Hydrogen Peroxide, due to its safety and effectiveness, is an established method to be used for Medical Device Sterilization.[12] Read the full announcement here.[12]

EPA: Community Engagement and Public Health

The EPA has been working to engage the community and address concerns regarding long term community exposure (birth to 70 years), with expected plans of action.[10] The EPA emphasized that there are minimal health concerns seen with short term exposure to EtO. Health risk analysis consisted of amount of emissions, weather mapping, community details, and facility safety processes. Some commercial sterilizer sites are already working to reduce emissions by adding pollution control equipment such as emission capture devices.

UPDATE - The EPA has issued an amendment to the National Emission Standards for Hazardous Air Pollutants in March of 2024.[13] The new standard will reduce the amount of EtO emitted from a commercial sterilizer by 90 percent.[13] A few highlights include:

- Timeline – facilities will have up to 3 years to complete any upgrades, installations, and testing to meet the new standard. [13]
- Monitoring – requires continuous emission monitoring and quarterly reporting to communities and the EPA. [13]
- Impact – approximately 90 sterilization facilities across the United States are impacted by this new standard.[13]
- Cancer risk – individual risk will move from allowable emissions of 8,000 in 1 million to 100 in 1 million people after all final amendments. [13]
- Cases per year – estimated annual cancer incidence per year will move from a current risk of 0.9 to a risk of 0.1- 0.2 with the new standard. [13]

Helpful Links

EPA Launches Community Engagement Efforts on New Ethylene Oxide Risk Information
Ethylene Oxide EtO
Ethylene Oxide Gas Sterilization
Ethylene Oxide Sterilization Facility Updates
FDA Statement: Statement on Concerns with Medical Device Availability Due to Certain Sterilization Facility Closures
FDA Sterilization for Medical Devices

References

1. OCSPP US EPA. Ethylene Oxide (EtO). www.epa.gov. Published November 16, 2020. Accessed August 9, 2022. https://www.epa.gov/ingredients-used-pesticide-products/ethylene-oxide-eto
2. Center for Devices and Radiological Health. Sterilization for Medical Devices. FDA. Published online August 3, 2022. Accessed August 9, 2022. https://www.fda.gov/medical-devices/general-hospital-devices-and-supplies/sterilization-medical-devices#why
3. Center for Disease Control. Ethylene Oxide Sterilization | Disinfection & Sterilization Guidelines | Guidelines Library | Infection Control |CDC. www.cdc.gov. Published April 4, 2019. Accessed August 9, 2022. https://www.cdc.gov/infectioncontrol/guidelines/disinfection/sterilization/ethylene-oxide.html#:~:text=The%20main%20disadvantages%20associated%20with
4. McEvoy B, Wiehle SB, Gordon K, Kearns G, Laranjeira P, McLees N. Advancing the Sustainable Use of Ethylene Oxide through Process Validation. Biomedical instrumentation & technology. 2021;55(s3):35-44. doi:10.2345/0899-8205-55.s3.35
5. Panger M. United States Environmental Protection Agency Washington, D.C. 20460 Office of Chemical safety Pollution Prevention Memorandum Thru: Risk Assessment Branches 1/2 (RAB 1/2) Antimicrobials Division (7510P).; 2020. https://www.epa.gov/sites/default/files/2020-11/documents/d458706-eto-final-dra-nov-3-2020.pdf
6. Office of the Commissioner. Statement on concerns with medical device availability due to certain sterilization facility closures. FDA. Published March 24, 2020. https://www.fda.gov/news-events/press-announcements/statement-concerns-medical-device-availability-due-certain-sterilization-facility-closures
7. Center for Devices and Radiological Health .Ethylene Oxide Sterilization Facility Updates. FDA. Published online June 2, 2021. https://www.fda.gov/medical-devices/general-hospital-devices-and-supplies/ethylene-oxide-sterilization-facility-updates
8. EPA Press Office. EPA Launches Community Engagement Efforts on New Ethylene Oxide Risk Information. www.epa.gov. Published August 3, 2022. https://www.epa.gov/newsreleases/epa-launches-community-engagement-efforts-new-ethylene-oxide-risk-information
9. OAR US EPA. Ethylene Oxide Risk from Commercial Sterilizers. www.epa.gov. Published May 4, 2022. Accessed August 10, 2022. https://www.epa.gov/hazardous-air-pollutants-ethylene-oxide/forms/ethylene-oxide-risk-commercial-sterilizers
10. EPA. EPA Ethylene Oxide National Public Webinar. www.youtube.com. Accessed August 15, 2022. https://youtu.be/G904_nw2t2U
11. Al-Faruque,F. EPA lists potentially high-risk EtO plants, plans to finally publish air pollution rule by year's end. www.raps.org. https://www.raps.org/news-and-articles/news-articles/2022/8/epa-lists-potentially-high-risk-eto-plants-plans-t
12. Administration USFaD. FDA Facilitates Broader Adoption of Vaporized Hydrogen Peroxide for Medical Device Sterilization. 2024. https://www.fda.gov/news-events/press-announcements/fda-facilitates-broader-adoption-vaporized-hydrogen-peroxide-medical-device-sterilization
13. Agency USEP. National Emission Standards for Hazardous Air Pollutants: Ethylene Oxide Emissions Standards for Sterilization Facilities Residual Risk and Technology Review. https://www.epa.gov/system/files/documents/2024-03/7055_etosterilizers_final_20240301_admin_disc.pdf
14. Agency USEP. Actions to Protect Communities and Workers from Ethylene Oxide (EtO) Risk. 2024. https://www.epa.gov/hazardous-air-pollutants-ethylene-oxide/actions-protect-communities-and-workers-ethylene-oxide-eto

Initial or Update	Date	Completed by	Changes Made
Initial	08.30.2022	JU	Created
Update	4.8.2024	KK	Updated standard