FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

BACKGROUND DOCUMENT

FOR

U AND P WASTES AND MULTI-SOURCE LEACHATE (F039)

VOLUME E:

GASEOUS U AND P WASTES

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1.0 INTRODUCTION

1.1 Regulatory Background

Section 3004(m) of the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) on November 8, 1984, requires the U.S. Environmental Protection Agency (EPA or the Agency) to promulgate treatment standards for certain hazardous wastes based on the Best Demonstrated Available Technology (BDAT) for those wastes. More than 500 of these hazardous wastes were listed as of December 1988 (see Title 40, Code of Federal Regulations, Part 261 (40 CFR Part 261)). The Agency divided the listed hazardous wastes into five groups. The wastes in each group were examined to determine whether further land disposal is protective of human health and the environment (see 40 CFR Part 268). The five groups and their respective dates of promulgation of treatment standards are:

- Solvent and dioxin wastes — November 7, 1986
- "California List" wastes — July 8, 1987
- "First Third" wastes — August 8, 1988
- "Second Third" wastes — June 8, 1989
- "Third Third" wastes — On or before May 8, 1990

Several wastes included in this schedule were regulated ahead of schedule, and several wastes in the "First Third" or "Second Third" group of wastes were deferred to the "Third Third" group of wastes. Treatment standards for the Third Third wastes will become effective no later than May 8, 1990. On and after this date, wastes regulated in the "Third Third" rulemaking will have to comply with applicable treatment standards prior to "land disposal" as defined in 40 CFR Part 268.

This document provides the Agency's rationale and technical support for developing method-based treatment standards for the three gaseous U and P wastes: ethylene oxide (U115), nitric oxide (P076), and nitrogen dioxide (P078). These standards are applicable to the wastes as listed as well as to any wastes generated by the management or treatment of the listed waste. Treatment standards are specified for both nonwastewater and wastewater forms of each listed hazardous waste. For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1% (weight basis) total suspended solids[1] and less than 1% (weight basis) total organic carbon (TOC). Wastes not meeting the wastewater definition must comply with treatment standards for nonwastewaters. In general, numerical treatment standards were developed for wastes that are amenable to quantification in hazardous waste matrices, and treatment standards specifying methods of treatment were developed for wastes that are not amenable to quantification in hazardous waste matrices using current analytical methods.

The Agency's legal authority and promulgated methodology for establishing treatment standards and the petition process for requesting a variance from the treatment standards are summarized in EPA's Methodology for Developing BDAT Treatment Standards (Reference 1).

U wastes include discarded commercial chemical products, manufacturing chemical intermediates, off-specification commercial chemical products, container and inner liner residues, and residues, including contaminated water, soil, or debris resulting from the cleanup of a spill, that are identified as toxic wastes. P wastes include discarded commercial chemical products, manufacturing chemical intermediates, off-specification commercial chemical products, container and inner liner residues, and residues, including contaminated water, soil, or debris resulting from the cleanup of a spill, that are identified as acutely hazardous wastes. Section 2.0 discusses the definition of U and P wastes in greater detail.

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[1]The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids are measured by Method 209c (Total Suspended Solids Dried at 103 to 105°C in Standard Methods for the Examination of Water and Wastewater (Reference 2).

1.2 User's Guide to the Five-Volume U and P Waste and Multi-Source Leachate (F039) Background Document Set

In the interest of clarity, the Agency has reorganized the "Third Third" background documents that were prepared for proposal of the Third Third Rule. Multi-source leachate (F039) and the majority of the U and P waste codes addressed in the Third Third Rule are now covered in a five-volume set of background documents.

The five-volume background document set is organized as follows:

- Volume A - Wastewater forms of organic U and P wastes and multi-source leachate (F039) for which there are concentration-based treatment standards;
- Volume B - U and P wastewaters and nonwastewaters with methods of treatment as treatment standards;
- Volume C - Nonwastewater forms of organic U and P wastes and multi-source leachate (F039) for which there are concentration-based treatment standards;
- Volume D - Reactive U and P wastewaters and nonwastewaters with methods of treatment as treatment standards; and
- Volume E (this document) - Gases.

The development of treatment standards for the majority of the U and P wastes is described in Volumes A, B, C, and D. However, three of these wastes, ethylene oxide (U115), nitric oxide (P076), and nitrogen dioxide (P078), are significantly different in form (i.e., gases), and therefore have been assigned to a separate volume. Methods of treatment are being promulgated as BDAT treatment standards for these wastes, as listed in Table 1-1. This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated and for developing treatment methods for these wastes.

The Agency considers as empty any cylinder at ambient pressure that held hazardous waste that is a compressed gas (see 40 CFR 261.7(b)(2)), even if the cylinder previously contained any of the three gaseous U and P wastes. As a result, an empty cylinder would not be considered a nonwastewater form of a hazardous waste. A cylinder that is above ambient pressure, that contains any of these gases, and that is to be disposed of, is considered a nonwastewater form of the particular U or P gaseous waste it held, and thus would be subject to the BDAT treatment standards for that waste discussed in this document. Pressurized cylinders containing any of the three gaseous U and P wastes may not be land-disposed in their present form but must undergo treatment before land disposal can occur.

1.3 Summary of Contents; Volume E

This background document provides the Agency's rationale and technical support for developing treatment standards for the three gaseous U and P wastes: ethylene oxide (U115), nitric oxide (P076) and nitrogen dioxide (P078). Section 2.0 of this document presents a description of the industry that may be affected by the land disposal restrictions and the waste characterization data for these wastes. The Agency estimates that there are approximately 33 facilities that may be affected by this rule. The four-digit Standard Industrial Classification (SIC) codes associated with the industry generating these gases are 2869 (Industrial Organic Chemicals, Not Elsewhere Classified) and 2819 (Industrial Inorganic Chemicals, Not Elsewhere Classified). Section 2.0 also includes EPA's rationale for combining these waste codes into two treatability groups.

Section 3.0 lists the applicable and demonstrated treatment technologies for the gaseous wastes. EPA's rationale for identifying BDAT and methods of treatment as treatment standards for these wastes is also included in Section 3.0. The BDAT treatment standard for P076 (nitric oxide) and P078 (nitrogen dioxide) nonwastewaters is contact with a caustic reducing solution. For P076 and P078 wastewaters, the BDAT treatment standard is also contact with a caustic reducing solution. For U115 (ethylene oxide) nonwastewaters, the BDAT treatment standard is thermal or chemical oxidation. For U115 wastewaters, the BDAT treatment standard is any one of the following treatment trains:

- Thermal oxidation;
- Chemical oxidation followed by carbon adsorption; or
- Wet air oxidation followed by carbon adsorption.

Section 4.0 describes the Agency's rationale for establishing methods of treatment for these wastes rather than concentration-based treatment standards. Section 5.0 acknowledges the persons involved in developing these waste regulations. Section 6.0 lists the references cited in this document. Appendix A provides a list of facilities that may potentially generate U and P gaseous wastes.

Table 1-1

BDAT TREATMENT STANDARDS FOR GASEOUS U AND P WASTES
(METHODS OF TREATMENT)

U115 (ETHYLENE OXIDE) WASTEWATERS

- Thermal oxidation;
- Chemical oxidation followed by carbon adsorption; or
- Wet air oxidation followed by carbon adsorption

U115 (ETHYLENE OXIDE) NONWASTEWATERS

- Thermal oxidation; or
- Chemical oxidation.

P076 (NITRIC OXIDE) WASTEWATERS AND NONWASTEWATERS

- Contact with a caustic reducing solution.

P078 (NITROGEN DIOXIDE) WASTEWATERS AND NONWASTEWATERS

- Contact with a caustic reducing solution.

2.0 INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

This section describes the industries affected by the land disposal restrictions for U115, P076, and P078, the available waste characterization data, and the determination of waste treatability groups.

2.1 Industry Affected

Industries that generate U115, P076, and P078 include both the organic chemical and inorganic chemical industries. Appendix A identifies 33 facilities that may generate these wastes.

2.2 Waste Characterization

Ethylene oxide (U115) is a colorless gas that is used as a petroleum demulsifier, fumigant, rocket propellant, industrial sterilant, and fungicide, as well as a reagent in the manufacture of glycol and higher glycols, surfactants, acrylonitrile, and ethanolamines.

Nitric oxide (P076) is a colorless gas that is used to bleach rayon, in the preparation of nitrosyl carbonyls, and as an intermediate in the production of nitric acid from ammonia.

Nitrogen dioxide (P078) is a red to brown gas that is used as a nitrating agent, an oxidizing agent, a catalyst, an oxidizer for rocket fuels, a polymerization inhibitor for acrylates, and as a reagent in the manufacture of nitric acid.

In the proposed rule, EPA stated that while U115, P076, and P078 are highly toxic, it is unlikely that they will exist as wastes that require land disposal. For example, since it is difficult to "spill" a gas onto soil or into water, it is unlikely that these wastes could exist as spill residues. Since the Agency could not determine the existence of any land disposal scenarios for these wastes, the only concern addressed in the proposed rule was the possibility that containers of these wastes could be land-disposed in a cleanup situation. EPA solicited comments from anyone who might already be land-disposing these wastes or anyone who might do so in the future.

In response, several commenters pointed out that U115, P076, and P078 share two unique disposal problems: (1) the treatment and disposal of damaged or otherwise nonrecyclable or nonreusable cylinders (such as ethylene oxide cylinders stored past their expiration date), and (2) the treatment and disposal of wastewater forms of these wastes (generated from emergency blow-down of processing equipment or routine plant maintenance). The wastewater forms of these wastes are currently diluted and injected into deep wells. Other nonwastewater forms of gaseous wastes potentially requiring land disposal include contaminated soil or debris from cleanup of an ethylene oxide spill (ethylene oxide is used in industry in the liquid state and may not immediately "flash" to vapor if spilled), and process vessel residues generated during routine cleaning operations. Another wastewater form of gaseous waste potentially requiring land disposal includes scrubber water. Therefore, these gaseous wastes are expected to range from low levels of toxic constituents in water to pure gaseous forms of the compound.

2.3 Determination of Waste Treatability Groups

In the course of developing treatment standards, EPA combined the wastes included in this document (U115, P076, and P078), as well as all other Third Third U and P wastes, into treatability groups based on similarities in composition, structure, and functional groups present within the structure of the chemical. The industries that generate these wastes were also considered in establishing these groups. These waste treatability groups take into account differences in the applicability and effectiveness of treatment for those particular wastes.

Although ethylene oxide, nitric oxide, and nitrogen dioxide exhibit similar physical properties, they have significantly different chemical properties. These differences affect the applicability and effectiveness of treatment technologies on the wastes, to the extent that ethylene oxide, an organic gas, requires some form of oxidation as treatment while nitric oxide and nitrogen dioxide, both inorganic gases, require treatment in a reducing solution. As a result, these wastes have been divided into two treatability groups, an ethylene oxide group and a nitrogen oxide group. Table 2-1 lists the constituents in the ethylene oxide and nitrogen oxide waste treatability groups.

Table 2-1

CONSTITUENTS IN WASTE TREATABILITY GROUPS FOR GASEOUS U AND P WASTES

ETHYLENE OXIDE WASTE TREATABILITY GROUP

- U115 - Ethylene Oxide

NITROGEN OXIDE WASTE TREATABILITY GROUP

- P076 - Nitric Oxide
- P078 - Nitrogen Dioxide

3.0 IDENTIFICATION OF APPLICABLE, DEMONSTRATED, AND BEST TECHNOLOGY

This section presents the Agency's rationale for determining the best demonstrated available technology (BDAT) for treatment of gaseous U and P wastes, including the Agency's determination of:

- Applicable technologies;
- Demonstrated technologies; and
- The best demonstrated available technology (BDAT) for treatment of these wastes.

In determining BDAT, the Agency first determines which technologies are potentially applicable for treatment of the waste(s) of interest. The Agency then determines which of the applicable technologies are demonstrated for treatment of the waste(s) of interest. Next, the Agency determines which of the demonstrated technologies is "best" for the purpose of establishing BDAT. Finally, the Agency determines whether the best demonstrated technology is available for treatment of the waste(s) of interest.

3.1 Applicable Treatment Technologies

To be applicable, a technology must theoretically be usable to treat the waste in question or to treat a waste that is similar in terms of parameters that affect treatment selection. Detailed descriptions of technologies that are applicable to treat listed hazardous wastes are provided in this section and in EPA's Treatment Technology Background Document (Reference 3).

When the Third Third treatment standards were proposed, the Agency believed that all three of the U and P gaseous wastes (U115, P076, and P078) were probably generated as gases and that industry typically reused or recovered compressed gases. In addition, the Agency had very limited treatment data for U115, no treatment data for P076 and P078, and no information with which to determine applicable treatment technologies. As a result, EPA proposed a treatment standard of "Recovery as a Method of Treatment" for all P076, P078, and U115 wastes. Following proposal, EPA received several comments supplying information on treatment technologies for all three wastes. Based on these comments, EPA has determined treatment technologies applicable to the specific land disposal problems associated with the gaseous wastes. These wastes include damaged cylinders unacceptable for recycling or reuse (nonwastewater forms) and rinsewater used to clean such cylinders (wastewater forms), as well as tank washwater, spill residue, and emergency blowdown water. The following subsections present applicable treatment technologies for nonwastewater and wastewater forms of the three U and P gaseous wastes.

3.1.1 Nonwastewaters

Since nonwastewater forms of the U and P gaseous wastes may contain hazardous constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of hazardous constituents in the waste. The Agency has identified the following treatment technologies as applicable for treatment of nonwastewater forms of these wastes:

Ethylene Oxide Waste Treatability Group

- Chemical oxidation;
- Thermal oxidation; and
- Recovery.

Nitrogen Oxide Waste Treatability Group

- Contact with a caustic reducing solution; and
- Recovery.

These treatment technologies were identified based on current waste treatment practices and engineering judgment.

Chemical Oxidation

Chemical oxidation is a destruction technology in which dissolved organic compounds are chemically oxidized to yield carbon dioxide, water, salts, and simple organic acids. This technology generates one treatment residual, treated effluent. The treated effluent may require further treatment for organic constituents by carbon adsorption.

Thermal Oxidation

Thermal oxidation (incineration) is a destruction technology in which energy, as heat, is transferred to the waste to destabilize chemical bonds and destroy organic constituents. The three types of incinerator design applicable to U and P organic wastes are fluidized-bed, rotary kiln, and liquid injection incineration.

In a fluidized-bed incinerator, solid and semi-solid wastes are injected into the fluidized-bed material (generally sand and/or incinerator ash), where they are heated to their ignition temperature. Heat energy from the combustion reactions is then transferred back to the fluidized bed. Ash is removed periodically during operation and during bed change-outs.

In a liquid injection incinerator, liquid wastes (such as equipment wash water or scrubber water) are atomized and injected into the incinerator. In general, only wastes with low or negligible ash contents are amenable to liquid injection incineration. Therefore, this technology does not generate an ash residual.

In a rotary kiln incinerator, solid and semi-solid wastes (such as contaminated soil) are fed into the elevated end of the kiln, and the rotation of the kiln mixes the waste with hot gases to heat the waste to its ignition temperature. Ash is removed from the lower end of the kiln. Combustion gases from the kiln enter the afterburner for complete destruction of organic waste constituents. Other wastes (such as liquids and gases) may also be injected into the afterburner.

Combustion gases from the incinerator are then fed to a scrubber system for cooling and removal of entrained particulates and acid gases, if necessary. This process generates scrubber water. Fluidized-bed and rotary kiln incinerators also generate ash.

Recovery

Recovery of gases consists of recycling and reusing the gases from damaged or otherwise unusable cylinders. Total recycle and reuse of a waste in the same process or another process eliminates the generation of the waste and consequently generates no residuals.

Contact with a Caustic Reducing Solution

One commenter (Reference 4) supplied information describing the treatment of nitric oxide and nitrogen dioxide in a caustic reducing solution. Nitric oxide and nitrogen dioxide undergo hydrolysis reactions in aqueous solutions to form nonhazardous nitrites and nitrates. Industrial application of this process as a treatment technology consists of dispersing nitric oxide or nitrogen dioxide wastes into a caustic solution containing an appropriate concentration of a weak reducing agent. The reducing agent and caustic pH ensure a neutral effluent solution with no oxidation potential.

The chemistry behind this technology consists of nitric oxide and nitrogen dioxide reacting simultaneously with water to form nitrous acid:

$$NO + NO_2 + H_2O \rightarrow 2HNO_2$$

In addition, nitrous acid will react to form nitric acid, nitric oxide, and water:

$$3HNO_2 \rightleftharpoons HNO_3 + 2NO + H_2O$$

The alkaline solution helps drive this reaction to the less corrosive nitrous oxide.

The presence of reducing agents also helps drive the $HNO_3 \rightleftharpoons HNO_2$ equilibrium to the less corrosive HNO_2. For example, iron(II) sulfate will react with nitric acid to form nitrous acid:

$$HNO_3 + 2Fe^{2+} + 2H^+ \rightarrow HNO_2 + 2Fe^{3+} + H_2O$$

Finally, the alkaline solution will convert the nitrous acid and nitric acid to nitrites and nitrates:

$$HNO_3 + OH^- \rightarrow NO_3^- + H_2O$$
$$HNO_2 + OH^- \rightleftharpoons NO_2^- + H_2O$$

These reactions are just two of many possible reactions taking place with a NO_x mixture, most with similar equilibrium constants and potential. Different chemical compounds exist and react on a micro level, depending on local stoichiometry. Individual facilities using this treatment technology would have to monitor the reaction conditions carefully, using oxidation/reduction indicators and tests for remaining oxidation potential, to ensure complete conversion of the NO_x wastes to nitrites and nitrates. The indicators chosen, as well as the tests for residual oxidation potential, will depend to a large extent on the reducing agents and types of caustic solution selected.

3.1.2 Wastewaters

Since wastewater forms of the gaseous U and P wastes may contain hazardous constituents at treatable concentrations, applicable treatment technologies include those technologies that destroy or reduce the total amount of hazardous constituents in the waste. The Agency has identified the following treatment technologies as applicable for treatment of wastewater forms of these wastes:

Ethylene Oxide Waste Treatability Group

- Chemical oxidation;
- Thermal oxidation;
- Wet air oxidation;

- Biological treatment; and
- Carbon adsorption.

Nitrogen Oxide Waste Treatability Group

- Contact with a caustic reducing solution.

These treatment technologies were identified based on current waste treatment practices and engineering judgment.

The concentrations and types of waste constituents present in the gaseous U and P wastewaters generally determine which technology is most applicable. Carbon adsorption, for example, is often used as a polishing step following primary treatment by biological treatment or wet air oxidation. Typically, carbon adsorption is applicable for treatment of wastewaters containing less than 0.1% total organic constituents. Wet air oxidation and biological treatment are applicable for treatment of wastewaters containing up to 1% total organic constituents.

Chemical Oxidation

The description of chemical oxidation was given previously for nonwastewaters in Section 3.1.1. This description also applies to wastewaters.

Thermal Oxidation

The description of thermal oxidation was given previously for nonwastewaters in Section 3.1.1. This description, particularly that of liquid injection incineration, also applies to wastewaters.

Wet Air Oxidation

Wet air oxidation is a destruction technology in which organic constituents in wastes are oxidized and destroyed under high pressure at elevated temperatures in the presence of dissolved oxygen. This technology is applicable for wastes comprised primarily of water and up to 10% total organic constituents. Wet air oxidation generates one treatment residual, treated effluent. The treated effluent may require further treatment for organic constituents by carbon adsorption.

Biological Treatment

Biological treatment is a destruction technology in which organic constituents in wastewaters are biodegraded. This technology generates two treatment residuals, treated effluent and waste biosludge.

Carbon Adsorption

Carbon adsorption is a separation technology in which organic constituents in wastewaters are selectively adsorbed onto activated carbon. This technology generates two treatment residuals, treated effluent and spent activated carbon. The spent activated carbon can be reactivated and recycled, or can be incinerated.

Contact With a Caustic Reducing Solution

The description of contact with a caustic reducing solution was given previously for nonwastewaters in Section 3.1.1. This description also applies to wastewaters.

3.2 Demonstrated Treatment Technologies

To be demonstrated, a technology must be employed in full-scale operation for treatment of the waste in question or a similar waste. Technologies available only at pilot- or bench-scale operations are not considered in identifying demonstrated technologies. The demonstrated treatment technologies for nonwastewater and wastewater forms of ethylene oxide and nitrogen oxide wastes are:

	Ethylene Oxide Wastes	Nitrogen Oxide Wastes
Nonwastewaters	• Thermal oxidation • Chemical oxidation	• Contact with a caustic reducing solution
Wastewaters	• Thermal oxidation • Chemical oxidation • Wet air oxidation • Carbon adsorption	• Contact with a caustic reducing solution

3.2.1 Nonwastewaters

The Agency has identified contact with a caustic reducing solution as a demonstrated technology for treatment of nonwastewater forms of the nitrogen oxide wastes, and thermal and chemical oxidation as demonstrated technologies for treatment of nonwastewater forms of ethylene oxide wastes. EPA has received numerous comments from industry describing their use of a reduction treatment technology for treatment of nitrogen oxide wastes and use of oxidation treatment technologies for treatment of ethylene oxide wastes.

The Agency believes that oxidation is demonstrated for treatment of ethylene oxide nonwastewaters based on industry comments and because ethylene oxide is similar in chemical structure to other organic U and P wastes that have been successfully treated by oxidation on a full-scale operational basis.

Nitrogen oxide wastes, on the other hand, are not amenable to oxidation, since they are inorganic oxidation products. Therefore, the Agency believes that a reduction technology would effectively treat these wastes, and based on industry's comments (Reference 4), believes that contact with a caustic reducing solution is a demonstrated treatment technology for nitrogen oxide nonwastewaters.

The Agency no longer believes that recovery is a demonstrated technology for treatment of either ethylene oxide or nitrogen oxide nonwastewaters, based on information obtained during the comment period. Industry commented that recovery often poses health and safety problems. In the specific case of ethylene oxide cylinder recovery, commenters reported that damaged cylinders pose significant risk of explosion and thus are very dangerous to store and handle; moreover, most cylinder-handling firms refuse to take damaged cylinders. Commenters reported that they have been promptly treating their damaged cylinders on site using chemical and thermal treatment.

3.2.2 Wastewaters

The Agency has identified contact with a caustic reducing solution as a demonstrated technology for treatment of wastewater forms of the nitrogen oxide wastes, and thermal oxidation, chemical oxidation, wet air oxidation, and carbon adsorption as demonstrated technologies for treatment of wastewater forms of ethylene oxide wastes. EPA has received numerous comments from industry describing their use of a reduction treatment technology for treatment of nitrogen oxide wastes and oxidation treatment technologies for treatment of ethylene oxide wastes.

The Agency believes that both oxidation and carbon adsorption technologies are demonstrated for treatment of ethylene oxide wastewaters based on industry comments and because ethylene oxide is similar in chemical structure to other organic U and P wastes that have been successfully treated by oxidation and carbon adsorption technologies (separately) on a full-scale operational basis.

Nitrogen oxide wastes, on the other hand, are not amenable to oxidation, since they are inorganic oxidation products. Therefore, the Agency believes that a reduction technology would effectively treat these wastes, and based on industry's comments (Reference 4), believes that contact with a caustic reducing solution is a demonstrated treatment technology for nitrogen oxide wastewaters.

The Agency is not aware of any facilities that recover (recycle and reuse) ethylene oxide or nitrogen oxide wastewaters on a full-scale operational basis; therefore, recycle and reuse is not considered to be demonstrated for these wastewaters at this time.

The Agency is aware of facilities that use biological treatment for ethylene oxide wastewaters, and therefore believes biological treatment is demonstrated for these wastewaters. The Agency is not aware of any facilities that use biological treatment for nitrogen oxide wastes, and therefore does not believe that biological treatment is demonstrated for these wastewaters.

3.3 Identification of Best Demonstrated and Available Technology (BDAT)

Best demonstrated and available technology (BDAT) is determined based on a thorough review of all the treatment performance data available on the waste of concern or wastes judged to be similar. The treatment performance data that were evaluated for these wastes are presented in Section 4.0. Following the identification of "best," the Agency determines whether the best demonstrated technology is "available." An available treatment technology is one that (1) is not a proprietary or patented process that cannot be purchased or licensed from the proprietor (i.e., it must be commercially available), and (2) substantially diminishes the toxicity of the waste or substantially reduces the likelihood of migration of hazardous constituents from the waste.

3.3.1 Nonwastewaters

The Agency is considering oxidation processes to be BDAT for treatment of ethylene oxide nonwastewaters and contact with a caustic reducing solution to be BDAT for treatment of nitrogen oxide nonwastewaters. The oxidation processes identified as BDAT for ethylene oxide nonwastewaters are either thermal oxidation (incineration) or chemical oxidation. Both of these treatment methods are expected to destroy the organic constituents of concern in these wastes and therefore are both considered "best."

The Agency is promulgating thermal and chemical oxidation for ethylene oxide nonwastewaters and contact with a caustic reducing solution for nitrogen oxide nonwastewaters as treatment standards, rather than specifying recovery as the treatment standard, which was the proposed treatment standard. EPA recognizes that in some cases cylinder recovery may not be feasible. As such, EPA is establishing chemical or thermal oxidation treatment methods as treatment standards for cylinder recovery. The promulgation of BDAT treatment standards as methods of treatment, however, does not preclude a facility from utilizing recycle or reuse operations in accordance with 40 CFR 261.

The Agency believes that both oxidation treatment processes are commercially available and provide substantial reduction of waste toxicity, based on industry comments (see Section 4.0). Likewise, the Agency believes that contact with a caustic reducing solution is commercially available and provides substantial reduction of waste toxicity, based on an industry comment (Reference 4).

3.3.2 Wastewaters

The Agency is considering oxidation processes to be BDAT for treatment of ethylene oxide wastewaters and contact with a caustic reducing solution to be BDAT for treatment of nitrogen oxide wastewaters. The oxidation processes identified as best for ethylene oxide wastewaters are thermal oxidation (incineration), chemical oxidation, and wet air oxidation. In addition, carbon adsorption is to follow chemical or wet air oxidation to ensure effective treatment of ethylene oxide. The Agency believes that it is sound engineering judgment to include a final step of carbon adsorption following oxidation. This step will ensure that ethylene oxide is removed from the wastewater matrix. Additionally, spent carbon from treating these wastewaters becomes a nonwastewater form of this waste (54 Federal Register 26630-1, June 23, 1989) and would thus have to undergo a final oxidation step, most likely thermal oxidation (incineration). EPA believes that incineration is the most successful method of treatment for a wide variety of organic wastes, and would assure ultimate destruction of all ethylene oxide present in the wastewater.

The Agency believes that all three oxidation treatment processes are commercially available and provide substantial reduction of waste toxicity, based on industry comments (see Section 4.0). Wet air oxidation was not specifically discussed by commenters; however, EPA believes that wet air oxidation is an effective technology for treating ethylene oxide wastewaters (see the BDAT Treatment Technology Background Document, Reference 3), and therefore is also setting it as BDAT, when performed in series with carbon adsorption.

The Agency is not promulgating biological treatment as BDAT for treatment of ethylene oxide wastewaters, because of the concern that possible shock loads of these wastes would disable a plant's working organisms and allow these wastes to exit untreated in the effluent.

The BDAT treatment standards for ethylene oxide and nitrogen oxide nonwastewaters and wastewaters are listed in Table 3-1.

Table 3-1

BDAT TREATMENT STANDARDS FOR GASEOUS U AND P WASTES
(METHODS OF TREATMENT)

U115 (ETHYLENE OXIDE) WASTEWATERS

- Thermal oxidation;
- Chemical oxidation followed by carbon adsorption; or
- Wet air oxidation followed by carbon adsorption.

U115 (ETHYLENE OXIDE) NONWASTEWATERS

- Thermal oxidation; or
- Chemical oxidation.

P076 (NITRIC OXIDE) WASTEWATERS AND NONWASTEWATERS

- Contact with a caustic reducing solution.

P078 (NITROGEN DIOXIDE) WASTEWATERS AND NONWASTEWATERS

- Contact with a caustic reducing solution.

4.0 TREATMENT PERFORMANCE DATA

This section discusses the data used to identify the applicable, demonstrated, and available technologies for treatment of ethylene oxide and nitrogen oxide nonwastewaters and wastewaters.

Two commenters (References 6 and 7) suggested establishing concentration-based treatment standards based on chemical or thermal oxidation (incineration) for nonwastewaters, and on incineration, biological treatment, or carbon adsorption for nonwastewaters. One commenter (Reference 6) supplied limited process and treatment information on incineration for nonwastewaters and on incineration or biological treatment for wastewaters. This information is summarized in Table 4-1. Unfortunately, these limited data did not fulfill the data quality requirements specified in the Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") (Reference 10); therefore, concentration-based treatment standards cannot be calculated based on these data. However, the data indicate substantial treatment of ethylene oxide nonwastewater by incineration and of ethylene oxide wastewater by incineration and biological treatment.

One commenter (Reference 4) described their treatment method of venting nitrogen oxide gases into a caustic reducing solution, which yields a neutral, nonhazardous solution of nitrates and nitrites. Due to the lack of supporting technical data, the Agency is unable to calculate concentration-based treatment standards based on this treatment method; however, based on this information, the Agency is considering "contact with a caustic reducing solution" as an available and demonstrated treatment technology for nitric oxide and nitrogen dioxide wastewaters and nonwastewaters.

Table 4-1

ETHYLENE OXIDE WASTEWATER AND
NONWASTEWATER TREATMENT DATA

Wastewater

Waste:	Ethylene Oxide Underground Storage Tank Washwater at Concentration of 26.23 ppm Ethylene Oxide.
Treatment A:	Absorbed in Nitrogen and Destroyed in Flare. Wastewater Residual at Concentration of <0.5 ppm Ethylene Oxide.
Treatment B:	Biological Waste Treatment Wastewater Residual at Concentration of <0.5 ppm Ethylene Oxide.

Nonwastewater

Waste:	Ethylene Oxide Underground Storage Tank Sandblasting Residue at Concentrations of 1 to 10 ppm Ethylene Oxide.
Treatment:	Commercial Hazardous Waste Incineration 99.99% DRE (Destruction and Removal Efficiency) for Ethylene Oxide.

Source: Union Carbide Corporation (Reference 6).

5.0 ACKNOWLEDGEMENTS

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The following personnel from Radian Corporation were involved in preparing this document: John Williams, Program Manager; Mary Willett, Project Director; and John Horstman, Task Leader.

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Appendix A

LIST OF FACILITIES THAT MAY GENERATE U AND P GASEOUS WASTES

Ethylene oxide (U115) is a colorless gas that is used as a petroleum demulsifier, fumigant, rocket propellant, industrial sterilant, and fungicide, as well as a reagent in the manufacture of ethylene glycol and higher glycols, surfactants, acrylonitrile, and ethanolamines.

Nitric oxide (P076) is a colorless gas that is used to bleach rayon, in the preparation of nitrosyl carbonyls, and as an intermediate in the production of nitric acid from ammonia.

Nitrogen dioxide (P078) is a red to brown gas that is used as a nitrating agent, an oxidizing agent, a catalyst, an oxidizer for rocket fuels, a polymerization inhibitor for acrylates, and as a reagent in the manufacture of nitric acid.

The facilities listed in Table A-1 are producers or users of ethylene oxide, nitric oxide, and nitrogen dioxide, and are therefore potential generators of these U and P wastes.

Table A-1

FACILITIES THAT MAY GENERATE U115, P076, AND P078

U115 (Ethylene Oxide)

Plant Name	Plant Location
BASF Corporation, Chemicals Division	Geismar, LA
Celanese Chemical Company, Inc.	Clear Lake, TX
Dow Chemical U. S. A.	Plaquemine, LA
Eastman Kodak Company	Longview, TX
ICI Americas, Inc.	Bayport, TX
National Distillers and Chemical Corporation	Morris, IL
PD Glycol	Beaumont, TX
Shell Oil Company	Geismar, LA
Sun Olin Chemical Company	Claymont, DE
Texaco Chemical Company	Port Neches, TX
Union Carbide Corporation	Seadrift, TX
Union Carbide Corporation	Taft, LA
Conoco	Houston, TX
Balchem Corporation	Statehill, NY
Scott Specialty Gases	Plumsteadville, PA
Liquid Air Corporation	Georgia
Liquid Air Corporation	Washington
Matheson Gas Products	Secaucus, NJ
Phillips Petroleum Company	Bartlesville, OK

P076 Nitric Oxide

Plant Name	Plant Location
Matheson Gas Products, Inc.	Cucamonga, CA
Matheson Gas Products, Inc.	East Rutherford, NJ
Matheson Gas Products, Inc.	Gloucester, MA
Matheson Gas Products, Inc	Gonzales, LA
Matheson Gas Products, Inc.	Joliet, IL
Matheson Gas Products, Inc.	La Porte, TX
Matheson Gas Products, Inc.	Morrow, GA
Matheson Gas Products, Inc.	Newark, CA
Matheson Gas Products, Inc.	Twinsberg Township, OH
Air Products & Chemicals, Inc.	Allentown, PA
Scott Specialty Gases	Plumsteadville, PA
Liquid Air Corporation	Texas
Sardoz Chemical Company	North Carolina
Aldrich Chemical Company	Wisconsin

Table A-1 (Continued)

FACILITIES THAT MAY GENERATE U115, P076, AND P078

P078 Nitrogen Dioxide

Plant Name	Plant Location
Cepex Midwest	Nebraska
Aldrich Chemical Company	Wisconsin
Air Products & Chemicals, Inc.	Allentown, PA
Scott Specialty Gases	Plumsteadville, PA
Liquid Air Corporation	Texas
Matheson Gas Products, Inc.	Secaucus, NJ

Note: This list of facilities was compiled from information in References 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, and 15. Some of these facilities may no longer use or manufacture these chemicals, and some may be corporate headquarters for companies that handle the chemicals at other sites.