4.4 NITROUS OXIDE EMISSIONS FROM COMBUSTION AND INDUSTRIAL SOURCES

4.4.1 NITROUS OXIDE ABATEMENT TECHNOLOGIES FOR NITRIC ACID PRODUCTION

Technology Description

Nitric acid (HNO_3) is an inorganic compound used primarily to make synthetic commercial fertilizer. As a raw material, it also is used for the production of adipic acid and explosives, metal etching, and in the processing of ferrous metals. Plants making adipic acid used to be high emitters of nitrous oxide (N_2O), but now that adipic acid plants in the United States have implemented nitrous oxide abatement technologies, nitric acid production itself is the largest industrial source of N_2O emissions. The nitric acid industry currently controls NO_x emissions using both nonselective catalytic reduction (nonselective catalytic reduction) and selective catalytic reduction (selective catalytic reduction) technologies to reduce N_2O to elemental nitrogen. While nonselective catalytic reduction is more effective than selective catalytic reduction at controlling N_2O, nonselective catalytic reduction units are not generally preferred in today's plants because of high-energy costs and associated high gas temperatures. Only 20% of nitric acid plants use nonselective catalytic reduction today. Additional research is needed to develop new catalysts that reduce N_2O with greater efficiency, and to improve nonselective catalytic reduction technology to make it a preferable alternative to selective catalytic reduction and other control options.

Nitric-acid plant controls for NO_x using both nonselective catalytic reduction and selective catalytic reduction technologies. Nonselective catalytic reduction is very effective at controlling N_2O.

System Concepts

- Nonselective catalytic reduction uses a fuel and a catalyst to consume free oxygen in the tail gas and convert NO_x to elemental nitrogen (Chartier, 1999). Nonselective catalytic reduction can reduce N_2O emissions by 80%-90%. (IPCC, 2000)

Representative Technologies

- The gas from the NO_x abatement is passed through a gas expander for energy recovery. Nonselective catalytic reduction units produce stack gases in the 1,000°F to 1,100°F range that require more exotic materials for constructing the expander and have higher maintenance costs.

Technology Status/Applications

- Virtually all of the nitric acid produced in the United States is manufactured by the catalytic oxidation of ammonia (EPA, 1991). During this reaction, N_2O is formed as a byproduct and is released from reactor vents to the atmosphere. While the waste gas stream may be cleaned of other pollutants – such as nitrogen dioxide – there are currently no control measures aimed at specifically eliminating N_2O emissions.

Current Research, Development, and Demonstration

RD&D Goals

- RD&D goals are focused on the catalysts used to convert NO_x into elemental nitrogen.

RD&D Challenges

- The use of a catalyst that can reduce a higher percentage of N_2O emissions is not the focus of the current research. The technology is primarily implemented in order to reduce NO_x emissions, not as an N_2O emission-reduction technology.
- Develop catalysts that reduce N_2O to elemental nitrogen with greater efficiency.
- Promote the use of nonselective catalytic reduction over other NO_x control options such as selective catalytic reduction and extended absorption.

RD&D Activities

- Information on R&D activities to develop new catalysts for nonselective catalytic reduction technologies is unavailable. To date, RD&D expenditures have been made by the industry. Estimates of future expenditures by the industry are not available.

Recent Progress

- Currently, the nitric acid industry controls for NO_x using both nonselective catalytic reduction and selective catalytic reduction technologies. Nonselective catalytic reduction is very effective at controlling N_2O, while selective catalytic reduction can actually increase N_2O emissions. Nonselective catalytic reduction units are generally not preferred in modern plants because of high energy costs and associated high gas temperatures. Only 20% of nitric acid plants use nonselective catalytic reduction.

Commercialization and Deployment Activities

- Nonselective catalytic reduction units were widely installed in nitric acid plants built between 1971 and 1977. It is estimated that approximately 20% of nitric acid plants use nonselective catalytic reduction (Choe, et al., 1993). Information on the status of the commercial development of nonselective catalytic reduction catalysts is not currently available, however.

Market Context

- Approximately 80% of current plants do not employ nonselective catalytic reduction, but instead use selective catalytic reduction or extended absorption units, neither of which are known to reduce N_2O emissions. Research is underway into materials for catalysts that are applicable for N_2O control in nitric acid plants that do not employ nonselective catalytic reduction. Nitrous oxide emissions from nitric acid production will be influenced by the degree and type of NO_x emission control efforts that are applied in both new and existing nitric acid plants.

4.4.2 NITROUS OXIDE ABATEMENT TECHNOLOGIES FOR TRANSPORTATION

Technology Description

Basic research is needed to understand the formation and magnitude of N_2O emissions from fuel combustion and catalytic-converter operation.

Nitrous oxide (N_2O) can be produced from fuel combustion and catalytic-converter operation in vehicles, primarily due to the nitrogen in the air. Little is understood about how much N_2O is produced by vehicles and under what conditions and with what catalytic-converter technology. The main research thrust in the near term is to begin to answer these basic questions.

In addition to direct emissions of N_2O, nitrogen oxide (NO_x) emissions from mobile and stationary sources have a significant impact on atmospheric N_2O levels. More than 25 million tons of NO_x is emitted annually in the United States. Following transport and chemical interactions, approximately 7 million tons of these nitrogen emissions are deposited downwind. This compares to about 11 million tons of nitrogen deposited from fertilizer application. Since the 11 million tons is reported to account for about 70% of anthropogenic N_2O emissions, the 7 million tons from atmospheric deposition appear to be significant. In the past, greenhouse gas emissions inventories have ignored the atmospheric nitrogen deposition due to uncertainties involved. Research is needed to define the contribution of NO_x emissions to nitrogen deposition and subsequent N_2O emissions, and to identify the global warming benefits from ongoing and future NO_x emissions control programs.

System Concepts

- Better understand the formation and magnitude of N_2O emissions from fuel combustion and catalytic-converter operation.
- Evaluate the climate-forcing potential atmospheric nitrogen deposition, especially from combustion sources.
- Develop emission models to assess the potential climate benefits from changes in emissions from nitrogen oxides.

Representative Technologies

- Combustion and post-combustion NO_x control technologies used in the tropospheric ozone control program.

Technology Status/Applications

- NO_x control technologies are in place due to the ozone and acid deposition programs.

Current Research, Development, and Demonstration

RD&D Goals

- Accurately understand the amount of N_2O produced in various vehicles, how it forms, and how it can be reduced.
- Develop N_2O measurement techniques for emerging gasoline and diesel engines and their emission-control systems. Measurement technology is needed for both laboratory and field measurement.
- Develop vehicle- and engine-testing programs to generate data about N_2O emissions for a variety of vehicles and engines equipped with a range of current and advanced emission-control technologies and operated over a range of real-world operating conditions.

• Research on the relationship of N_2O emissions to technologies and approaches that reduce fuel consumption by stationary and mobile combustion sources, including programs that reduce vehicle miles traveled. • Quantify the climate-forcing impacts due to NO_x emissions, nitrogen deposition, and N_2O emissions. **RD&D Challenges** • To establish linkages of NO_x emissions to climate-change impacts due to nitrogen deposition and enhance modeling capabilities to address these linkage issues.
Recent Progress
• EPA's ozone-control program has reduced emissions of NO_x.
Commercialization and Deployment Activities
• Additional NO_x emissions controls will be implemented in the future to meet ambient air quality standards for ozone and particulate matter.