

ANNUAL PROJECT REPORT
AS OF December 2001

1. PROJECT SPONSOR: Ohio Power / AEPSC
221 N. Front Street
Columbus, Ohio 43215

2. PROJECT MANAGER: Peter Scheckermann, P.E.

AEP Pro Serv
221 N. Front St., 3rd Floor
Columbus, OH 43215
(614) 223 – 3216
e - mail: pscheckermann@aep.com

3. OCDO GRANT NO. CDO / D – 00 – 13

4. This is the Final Report

5. PROJECT TITTLE: GAVIN PLANT – AOD SYSTEM
DEMONSTRATION PROJECT

6. PROJECT TERM: FROM 02 / 01 / 2001 TO 12 / 31 / 2001

7. BUDGET:

<u>CO – SPONSORS NAME</u>	<u>COST SHARE</u>
<u>OCDO</u>	<u>\$ 5.00 Million</u>
<u>OHIO POWER / AEPSC</u>	<u>\$ 18.92 Million</u>

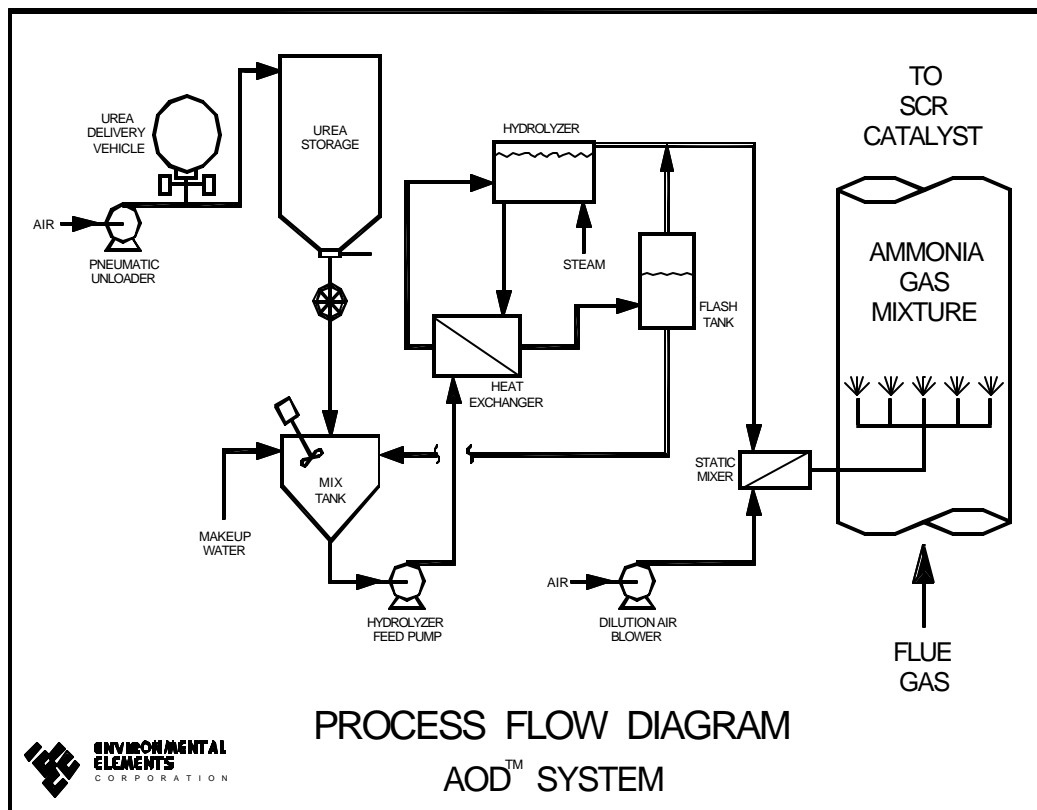
Total Project Cost: \$ 23.92 Million

I. ABSTRACT

8. OVERVIEW OF PROJECT & OBJECTIVES:

The objective of this project was to demonstrate that the Ammonia on Demand™ System (AOD™ as shown in Figure 1) that hydrolyzes solid, non-toxic urea could be successfully applied to a full-scale commercial Ohio high sulfur coal burning utility steam generator to produce ammonia for use in the NOx reduction Selective Catalytic Reduction (SCR) process. Before this Project's successful demonstration of this technology, AOD™ had only been applied to a smaller SCR (600 lb/hr) process for an oil-fired boiler. The specific technical objective for this project was to demonstrate that the system can, safely and cost-effectively, produce ammonia, from urea, at varying rates to match the SCR process' demands, up to a capacity of 7,000 lb/hr (the equipment was designed for 10,500 lb/hr), in an environmentally friendly manner, with a rapid response time to meet the changing boiler load demands, at Gavin Plant Units 1 & 2.

Figure 1: Ammonia on Demand (AOD™) Process Flow Diagram



9. WORK DONE AND CONCLUSIONS:

The primary conclusion achieved from the performance of this Project is that it demonstrated the AOD™ system's successful hydrolysis process of granular urea for the production of ammonia, on a large-scale basis (7,000 pounds per hour), for use in the Selective Catalytic Reduction (SCR) process to remove NOx. The first full-scale production unit was the installation at Ohio Power Company's two-1300 MW steam generating units located at the Gavin Plant in Cheshire, Ohio. Previously, this technology had only been applied to a much smaller SCR process for an oil-fired boiler, with an ammonia production rate of 600 lb / hr. This project successfully demonstrated the operational goal of reliably producing up to 7,000 lb / hr of ammonia to support the operation of the Gavin SCR process to achieve the required NOx emissions reductions to comply with US EPA emission limitations imposed during the 5-month 2001 Ozone Season.

AOD™ System Description at the Gavin Plant

This commercial system consists of a urea railcar and truck unloading site, a bulk dry storage facility, mix tanks, a solution feed tank, transfer and recycle solution transfer pumps, solution storage tanks, a heat exchanger, hydrolyzers with preheaters and spargers, a recycle solution storage tank, an ammonia flow control valve system and in line static flue gas mixers.

The AOD™ process (refer to Figure 1), consists of first dissolving granular urea in water in the mix tanks, then pumping the solution to an intermediate feed storage tank, then to the hydrolyzer. The urea is hydrolyzed at temperatures and pressures in excess of 400° F and 300 psig in order to create a mixture containing ammonia, and carbon dioxide dissolved in solution. Steam (sparger steam) is then injected into the hydrolyzer to strip this ammonia and carbon dioxide from the solution. A mist eliminator in the hydrolyzer collects any unreacted urea. Pressure control valves reduce the hydrolyzer vapor pressure. The unused spent urea solution is recycled back to the mix tank, via a recycle storage tank, resulting in zero liquid discharge and minimal water makeup demand. The ammonia-rich product gas stream from the hydrolyzer, controlled by a flow valve, which responds directly to the SCR demand signal for ammonia, is thoroughly mixed with heated ambient air to reduce its concentration to about 5 wt.% ammonia at full load. This mixture of ammonia vapor and air is injected into the flue gas stream.

The system was installed and started up in the first four months of 2001. The system was commissioned during May, 2001; and the full-scale demonstration was performed from May through the end of September. The testing and optimization efforts to complete the OCDO Work Scope occurred during the month of October, while the corrosion and deposit collection efforts were completed in December. The project's Total Cost

was \$23,916,531. This included the AOD™ system's design, installation, and operation to perform the demonstration and testing Scope of Work (SOW) as required in the OCDO Grant; and it included the cost of Urea for the October testing and optimization efforts. AEPSC, as agent for Ohio Power Company, was the sole sponsor for this project, and its' engineering division served as the design engineer, construction firm and AOD™ start up and OCDO SOW test / optimization manager.

AOD™ Advantage for the Continued Use of Ohio High Sulfur Coal

For all other electric utilities and for the 23 additional AEP power plant boiler units required by the US EPA to install the SCR NOx removal process, the hydrolysis of solid, non-toxic urea technology, provides utilities with a safe, environmentally friendly, and regulatory free alternative to the use of anhydrous ammonia or aqueous ammonia, systems that is readily acceptable to the public. The anhydrous ammonia system and the aqueous ammonia systems with produce product ammonia gas with concentrations above 20 wt. %, both systems trigger stringent Federal and State regulations that impede their use.

US EPA requires that selected utilities (including AEP) comply with NOx emission tonnage budgets by May, 2003 under Section 126 and by May, 2004 under the NOx SIP Call rule. These requirements mandate that utilities limit NOx tonnages to emissions rates that are equivalent to less than 0.15 lbm / MM Btu. The installation of the SCR process has proven that it can remove enough NOx to allow them to meet, or exceed this requirement. For example, the current baseline NOx emissions level at Gavin Plant before installation of the SCR NOx control system was 0.47 lbm / MM Btu. In order to comply with the statewide emission rate of less than 0.15 lbm / MM Btu, the Gavin Plant was required to achieve at least a 70% NOx reduction. This forced AEPSC to install the SCR process on each unit at Gavin, with a Total Capital Investment of \$ 175 million, not including the AOD™ system, which cost an additional \$ 24 million.

The AOD™ hydrolysis of urea system has no hazardous substances integral to its process. The dry solid fertilizer grade granular urea ($[\text{NH}_2]_2\text{CO}$) will be delivered to the plant in covered hopper railcars or trucks. The unloading and storage systems are totally enclosed to eliminate any dusting or leaching concerns. Only demineralized water (H_2O) is mixed with urea in the hydrolysis process. The product of this process is a Product Gas stream composed of 15 wt. % ammonia (NH_3), 20 wt. % carbon dioxide (CO_2); and 65 wt. % water (H_2O) in a vapor mixture. This vapor mixture is diluted with ambient air and then it is injected into the flue gas that goes into the SCR system. It should be noted that the ammonia concentrations always remain well below 20 wt.

%, which is the material threshold limit that defines Ammonia as hazardous.

The regulated permitting and operational reporting requirements for the AOD™ system are greatly simplified when compared to the use of the alternative anhydrous ammonia or aqueous ammonia systems. The anhydrous ammonia system and the aqueous ammonia systems produce ammonia concentrations above 20% and this triggers the stringent Federal and state regulations. The additional cost of installing this Demonstration Project AOD™ system was \$9.23 / KW, which is \$4.88 / KW more than the estimated cost of the anhydrous ammonia system. But this cost represents the first AOD™ large system installation attempted by AEPSC, and includes an added (unexpected) learning experience and trial and error cost. It is expected that AEPSC will be able to “fine tune” and reduce its’ future AOD™ System costs. These second wave units’ cost will be much closer to its’ originally estimated capital cost of ~ \$ 6.50 / KW. This differential, of ~ \$ 2.00 / KW however, is a minor cost to pay when compared to the expected total compliance cost of using the originally selected anhydrous ammonia system.

Additionally, the capital cost of this first full-scale AOD™ hydrolysis of urea demonstration project was \$437 / ton of NOx reduced. Again, the future “fined tune” unit cost is expected to much closer to the originally estimated \$ 315 / ton of NOx removed. This cost did not include the cost of the SCR process, but did include its operations and maintenance costs for the 5-month ozone season. By comparison, the original selected anhydrous ammonia system was estimated to cost \$227 / ton of NOx reduced, while the 29% aqueous ammonia system was estimated to cost \$339 / ton of NOx reduced.

Ohio produced approximately 22.4 million tons of coal for delivery to domestic utilities during 2000. The Eastern power plants within the AEP system, most of which are scheduled for SCR system installations by May 1, 2004, received more than 14 million tons of this coal, half of which went to Gavin Plant. The successful use of the AOD™ as a safe, environmentally friendly, regulatory free; and publicly acceptable alternative to provide ammonia on a large commercial stage for use in the SCR process will result in Utilities not having to import Western Powder River Basin coal into Ohio’s traditional coal markets. Thus, saving a potential significant reduction in the use of high sulfur Ohio coal.

10. PLANS FOR COMING YEAR: NONE

This project was completed on December 31st, 2001 per the project's term as issued in the Grant.

II. HIGHLIGHTS / ACCOMPLISHMENTS

11. This OCDO Grant' money helped AEP's Ohio Power Company to successfully demonstrate that urea can be used as an effective source of reagent ammonia for the commercial size Gavin Plant coal-fired power plant boilers equipped with SCR NO_x control system. This demonstration project evaluated and verified the adequacy of the correct scale up sizing of the individual equipment provided, the performance of the materials of construction, and the ability of the system to provide an Ammonia Product Gas to meet full load demand capacity, and that it did change its output quickly in response to the power boiler load demand changes.

The first load of urea was delivered to the plant in mid April, 2001. The various components of the system were initially operated and tested, during the last 2 weeks in April, and each component was verified / modified to meet design specification performance levels. Following the SCR unit startup in early May, 2001, the AOD™ urea hydrolysis system was fully commissioned and debugged.

The system demonstrated, during the following 5 months, that it did indeed have the ability to meet large increases and decreases in demand, including the critical need to increase from 75 % of design to 100 %; and likewise its' ability turn down from 100% load demand to a 50 % operational demand. The AOD™ control system was shown to have excellent data acquisition and recording capabilities that permitted the full documentation of all executed demonstration tests.

This project also demonstrated during the first "ozone season" (May through September, 2001), that the AOD™ system was 98.5 % available, and that it was able to produce the ammonia levels required by the SCR process. The performance of the AOD™ system was observed and documented, with special attention to record its' ability to follow demand load. Changes were made to components and / or operating procedures to improve performance during this demonstration period in order to successfully accomplish commercial operation.

The system was shut down at the end of September 2001, and the TEST OPTIMIZATION Program was performed during the month of October.

Following shutdown, all critical components, especially the pumps, heat exchangers, piping and tanks, and the hydrolyzers were carefully inspected for signs of corrosion, fouling, damage and any other conditions which may signal a need to further modify the selection of materials and / or the design or method of operation. No significant corrosion was found.

III. ARTICLES / PRESENTATIONS

12. **Installation and Start-Up of the First Large Scale AOD™ Process on two 1,300 MW Coal-Fired Mid-West Utility Boilers**, this was a poster presentation at the 2001 Conference on SCR and SNCR for NOx Control sponsored by DOE's National Energy Technology Laboratory, Pittsburgh, PA, May 2001. This presentation dealt with the design and expected operation of the Gavin AOD system.

Design and Operation of a Safe Alternative to Anhydrous Ammonia: Urea-Based Ammonia-on-Demand (AOD[Ⓢ]) at AEP's Gavin Station

[written by Robert T. Glesmann, and Sheila M. Haythornthwaite of Environmental Elements Corporation (EEC); and Peter Scheckermann, AEP Pro Serv, Inc. (AEP)] and presented by Hamilton Walker of EEC at the 2001 COAL-GEN Conference, Chicago, IL July, 2001. This paper and presentation dealt with the design and startup of the Gavin AOD system.

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[written by Robert T. Glesmann, and Sheila M. Haythornthwaite of EEC, and Peter Scheckermann, AEP] and presented by Hamilton Walker of EEC at the EPA / DOE / EPRI "Mega-Symposium", Chicago, IL August, 2001. This paper and presentation dealt with the design and startup of the Gavin AOD system.

Design and Operation of a Safe Alternative to Anhydrous Ammonia: AOD™ at AEP's Gavin Station,

Peter Scheckermann of AEP Pro Serv, Inc. was the presenter at the EPRI 2001 Workshop on Selective Catalytic Reduction, Baltimore, MD November 2001. This presentation included operating results from the AOD™ its' first full 2001 ozone season, that was completed on September 30th, 2001.