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ECONOMICS AND BENEFITS OF CONVERTING FROM ANHYDROUS AMMONIA TO AMMONIUM HYDROXIDE FOR NOx CONTROL AT THE COMMERCE REFUSE TO ENERGY FACILITY

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ABSTRACT

The Commerce Refuse to Energy Facility, which is operated by the Los Angeles County Sanitation Districts (Districts), first burned refuse in late 1986. This facility was the first U.S. refuse plant to use anhydrous ammonia for NOx control. Although technically effective and economical, the system was converted from anhydrous ammonia (gaseous) to ammonium hydroxide (liquid or aqua ammonia) in May 1995. This change was made to eliminate the potential release of gaseous ammonia if an accidental leak occurred.

This paper will include discussions on: 1) the design layout of the new system, 2) the capital cost of the conversion, 3) the change in operating cost, and 4) NOx emissions before and after the conversion.

DISCUSSION

The Commerce plant is located near Los Angeles, CA which is in an EPA air emission non-attainment area. As a result, the plant was required to have NOx control when it was constructed. Exxon's thermal DeNOx process with ammonia injection as a non-catalytic NOx control was used. This process was considered the "best available control technology" (BACT) by the South Coast Air Quality Management District (AQMD). The AQMD, however, considered ammonia injection an "innovative technology" since it had not been proven with refuse firing. The NOx permit limits at Commerce are:

1) 225 ppm corrected to 3% oxygen for a 15 minute period
2) 190 ppm corrected to 3% oxygen for a 1 hour period
3) 40 lb. for a 1 hour period
4) 825 lb/day

The DeNOx process proved very effective for NOx control averaging 110 ppm corrected to 3% oxygen and 24 lb/hour. The process had 100% availability and thus never caused lost production or down time of the plant for the eight years it was in operation. The process was simply a pressurized tank, a vaporizer, a flow control valve, and solenoid valves to control the elevation in the furnace for the injection.

A 75 hp compressor was originally used to provide carrier air to provide better mixing as the ammonia was injected into the furnace. Initial system performance testing, however, indicated adequate mixing without carrier air so the compressor was not used.

In 1992, a new law through the California Health and Safety Codes required a special Risk Management Prevention Plan (RMPP) study done for acutely hazardous chemical which included anhydrous ammonia. The study identified potential risks to the employees and the public of an accidental leak of ammonia. The study identified some piping changes which were completed and included a dispersion model of the "most credible" gaseous ammonia leak.

Although the model showed that the likelihood and dispersion concentration was acceptable, it required that the a leak be shut off within 6 minutes. This 6 minute response required that Districts' operating staff and not the Fire Department be the "first responder".

The "first responder", according to the CA Safety Code, requires an initial 24 hours of training and an 8 hour annual refresher for all the operating staff. Equipment needed included: several self contained breathing apparatus (SCBA), one time use Class "A" protective suits which fully contain the entire body and SCBA, and de-contamination showers and related equipment. The cost of this equipment is approximately $20,000.

PILOT STUDY

We began looking for alternatives to gaseous ammonia. The two likely choices were urea and ammonium hydroxide. Urea is a solid, water soluble form of ammonia and ammonium hydroxide is ammonia dissolved in demineralizer water with up to 30% ammonia. Urea injection for NOx control is a patented process which requires a license fee and purchase of the design and equipment by the patent holder. Although both chemicals appeared technically acceptable, ammonium hydroxide was chosen for its lower cost and the chemistry was closer to the existing system.

The next decision was the process. One option was to vaporize the liquid just before it entered the furnace to preserve the existing gaseous injection system. The second option was to atomize the liquid directly into the furnace. The atomization option was chosen for the following reasons:

1) the vaporizer had a high operating and maintenance cost
2) atomization would have better mixing with the flue gas since it would have a higher injection velocity and the liquid would flash to steam further mixing the ammonium hydroxide

In 1994, a full scale pilot system was installed and tested using a 1,000 gallon tank of 15% ammonium hydroxide, a 240 psi positive displacement pump, and several spray nozzles. This three month study was so successful that the full scale system went into design immediately using the same pump and nozzles.

FINAL DESIGN

Attachment 1 shows the P & ID drawing of the process which was installed in May 1995. All the wetted parts are stainless steel except for the tank which is carbon steel. All the process equipment is mounted within the containment of the tank in the event of a leak.

The ammonium hydroxide is filtered at the outlet of the tank, pressurized to 240 psi with one of two 2.2 gpm positive displacement pumps, filtered again, and then either recirculated thru a control valve back to the suction of the pumps or fed thru a flow meter to the furnace nozzles.

The main ammonium hydroxide supply line which runs from the containment to the furnace is a 1" socket welded 304 stainless steel schedule 40 pipe. At the furnace, the supply line is split to feed three solenoid valves for the three furnace injection levels which have four nozzles at each level.

The three levels are approximately 30', 35', and 45' above the elevation of the refuse grates. The top level is used for full load conditions and the lower two for reduced load conditions.

Although four nozzles are on each level, we are currently only using two nozzles per level. The NOx controller can call for as little as 13 lb/hr of ammonia which is equal to 0.2 gpm total or 0.1 gpm per nozzle. At 0.1 gpm, the nozzles have a pressure drop of 10 psig across the orifice which is the minimum to atomize properly.

The original design had an instrument air purge of the nozzles which is now not in use. This was intended to cool and keep the unused nozzles unplugged. When we found the pilot test nozzles in working condition even after being in place for a year without a purge, we decided to eliminate the air purge for the new nozzles.

NOx is controlled automatically by using the NOx signal at the stack for controlling the recirculation valve. If NOx goes up, the recirculation valve closes slightly to force more ammonium hydroxide to the nozzles.

A demineralizer water line was run to the ammonium hydroxide tank to allow for dilution of the ammonium which is normally delivered at 30%. Dilution to 15% was used in the design to make the process safer and to avoid triggering the RMPP safety code study. The 30% ammonium hydroxide is also less expensive than 15% since it requires half as many deliveries for the same amount of ammonia. The water line is also piped to the suction of the process to allow for flushing the equipment for maintenance.

During the 30% ammonium hydroxide delivery to the tank, the ammonium is not metered in at the same rate as the demineralizer water and, therefore, on-line mixing of the tank is needed. This mixing is provided by a high volume pump which recirculates the content of the tank for four hours starting when the ammonium hydroxide delivery first begins.

CAPITAL COST OF SYSTEM

The only items salvaged from the old system were the 12,000 gallon tank and the power and control wires from the tank to the control room. The following itemizes the costs of the ammonium hydroxide system:

1) Concrete containment for tank	$15,000
2) Underground pipes and conduit	$ 4,000
3) Drain/clean tank & add new valves & safeties	$ 8,000
4) Pumps, filters, flow meters, and control valve	$ 9,000
5) Piping contract including stainless pipe	$21,000
6) Electrical panel and installation	$ 7,000
7) Instrumentation wiring and programming	$ 4,000

TOTAL:	$68,000

Some of these costs are high because we had to accommodate keeping the old system running while the new system was being installed. We first installed a temporary tank in order to clean and pipe the old tank. Then during an outage, the power and control wiring was moved from the old to the new equipment.

The $68,000 is offset by not needing to buy $20,000 in "first responder" safety equipment if we had kept the old system.

OPERATING AND MAINTENANCE COSTS

The cost of the ammonia accounts for a majority of the operating and maintenance cost. For the four years before the change, we averaged 24 lb/hr or 178,700 lb/year of anhydrous ammonia which cost $0.17/lb or $30,400/year. Since optimizing the new system, we have averaged 23 lb/hr or 171,300 lb/year of ammonia as ammonium hydroxide which cost $0.25/lb or $42,800/year.

The new system also eliminates the annual "first responder" training required by the RMPP. For an 8 hour course for the 25 operators, the annual cost would be $ 8,000. Also eliminated is the annual reporting and plan update required by the RMPP process.

We feel the maintenance costs will be similar since the only differences are the old system had a high pressure tank and a vaporizer and the new system has a 1/2 hp pump and strainers.

In summary, the annual O & M costs for the old system is $38,400 ($30,400 chemical and $8,000 training) and the new system is $42,800 for a difference of $4,400 per year.

NOx EMISSIONS

Although we have had only a few months of running time with the ammonium hydroxide system, overall NOx emissions have remained the same and short term NOx spikes have gone down slightly.

Figure 1 shows the daily average NOx and ammonia flow before and after the May 15, 1995 conversion to ammonium hydroxide. Note that ammonia flow with the new system was very high for the first two months. This was done to insure we would not violate any of the permit conditions while giving us time to better understand how the new system would react.

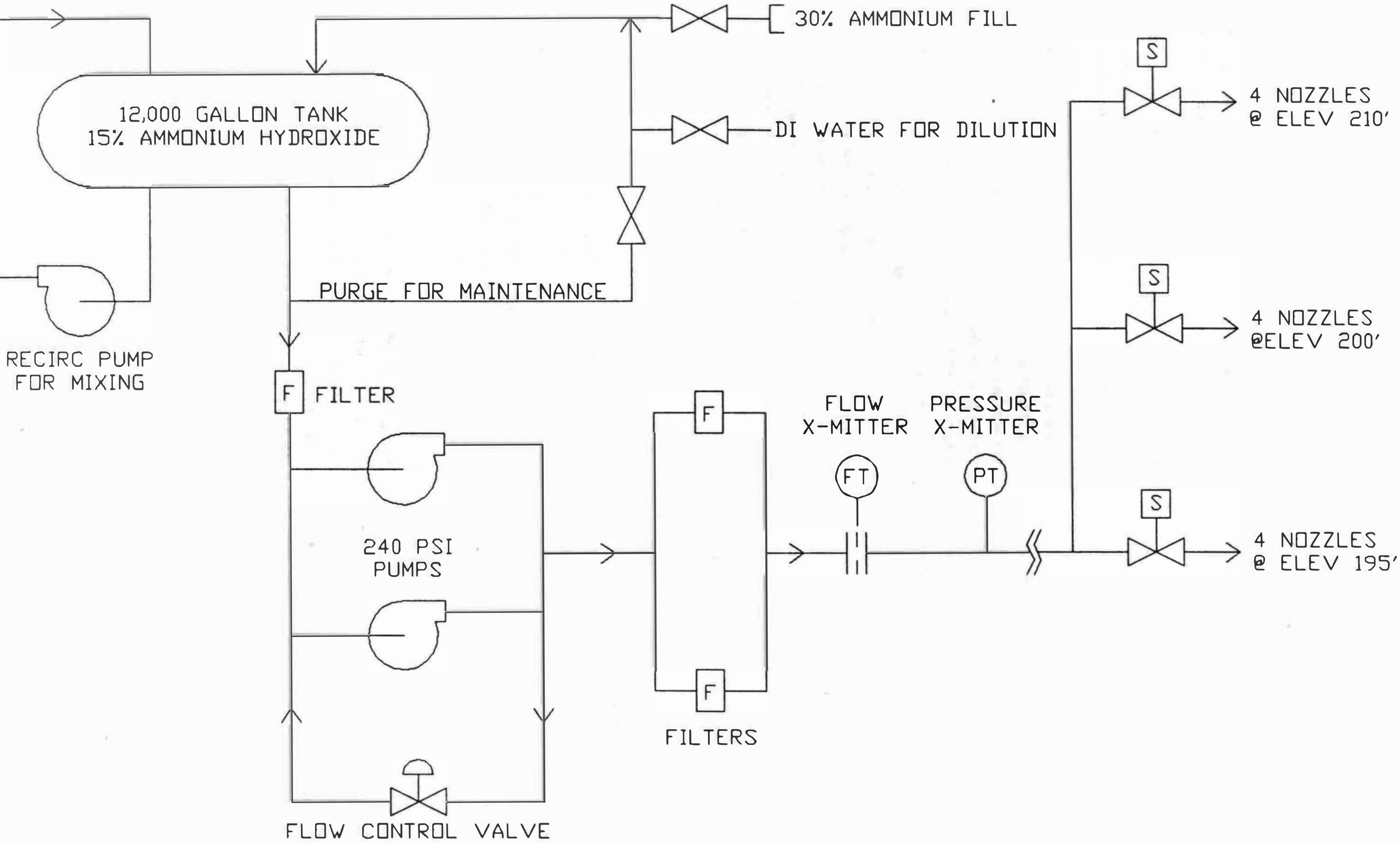
For the last two months, the automatic NOx controller was returned to a scheme similar to the old ammonia system. This has resulted in NOx emissions and ammonia flow very close to the old system.

Figure 2 shows the trend of the highest 15 minute average of NOx for each day before and after the May 15th conversion. The maximum 15 minute is important to examine because we have a permit condition for the 15 minute average and it shows how fast the NOx controller can react to a spike in NOx. Note again that for the first two months of the new system, the 15 minute average was dropping as we were able to tune the controller with a high flow of ammonia. For the last two months, we adjusted the controller to return ammonia flow to a normal level.

Figure 3 compares the anhydrous ammonia to ammonium hydroxide systems by graphing the percent of time in which the 15 minute NOx was at each NOx level shown. The ammonium hydroxide curve includes only data for the last two months to allow for a more consistent comparison of the control conditions. This graph shows that the new system controls NOx spikes more consistently then the old system.

SUMMARY

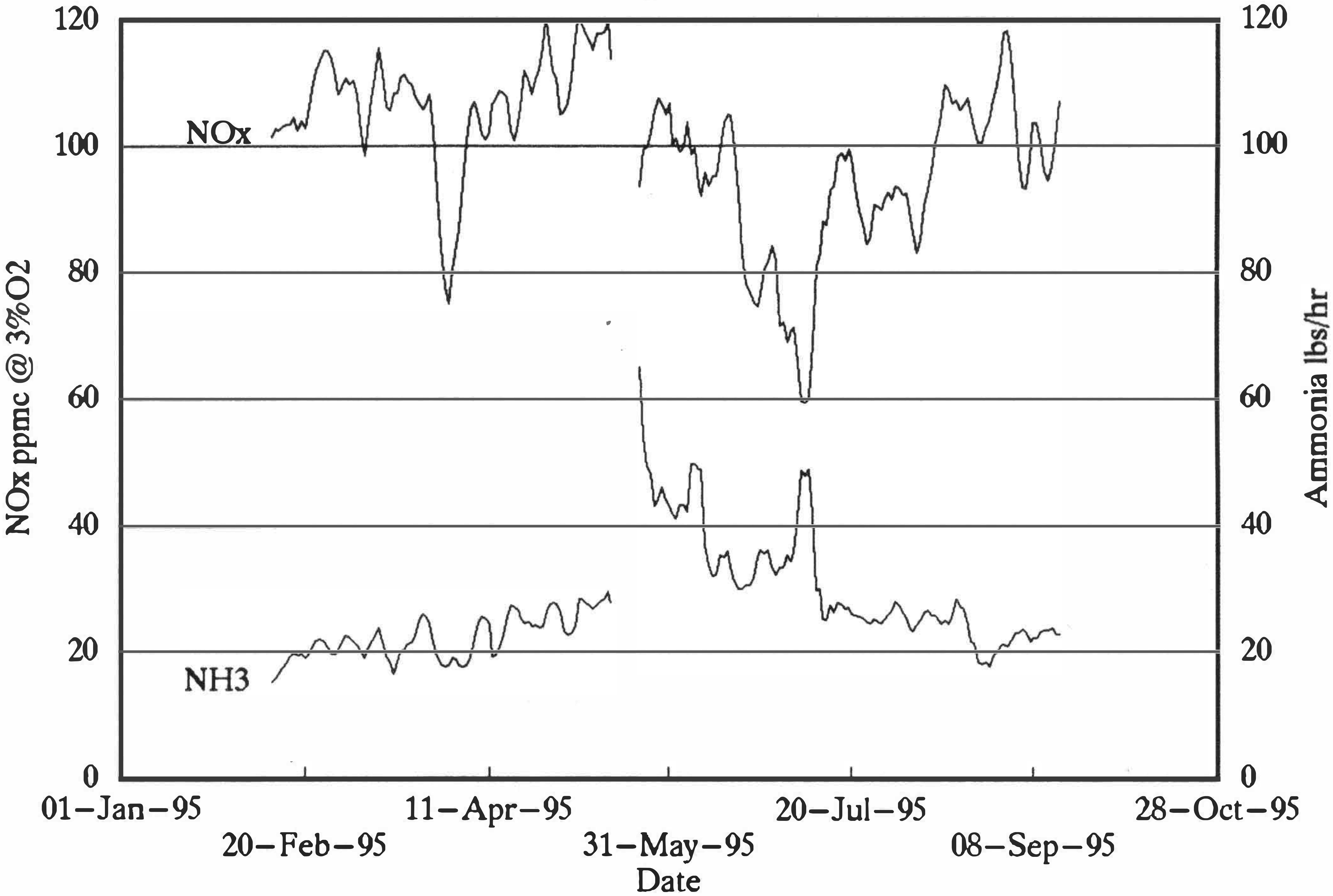
The conversion from anhydrous ammonia to ammonium hydroxide was done to minimize the potential of an accidental release of ammonia gas. The capital cost of the conversion was $68,000, however, it negated the need to purchase $20,000 in safety equipment. The O&M costs are $4,400 higher, although we believe the system can be further optimized to reduce this cost. The installation has been successful with improved NOx removal.



Ammonium Hydroxide NOx Control System
CREF
Attachment 1

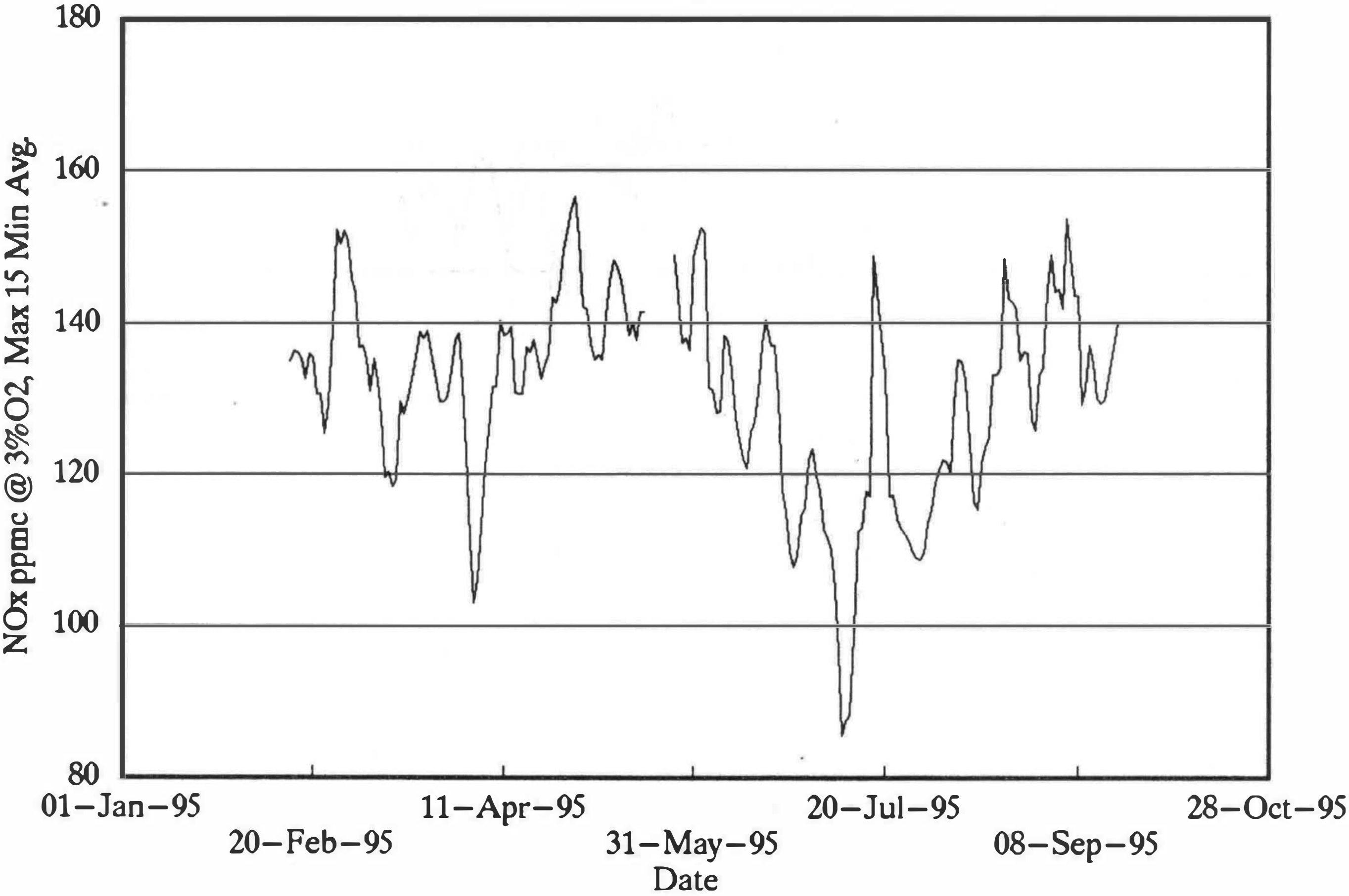
NOx / Ammonia Trend

Figure 1



Trend of Maximum NOx 15 Min. Avg. Each Day

Figure 2



NOx Emissions By Ammonia Type

Figure 3