Three Years Operating Experience at a NOx limit of 0.33 lbs/MBtu with Fly Ash Carbon Content of less than 5%

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The 132 MW, Mecklenburg Cogeneration Facility consists of two independently operated, identical units, which began operation in November 1992. Each unit utilizes a single Foster-Wheeler 600,000 lb/hr pulverized coal boiler. Eastern Bituminous coal is delivered to the boiler by three Williams Model DF-64 pressurized pulverizers each supplying two burners. The permitted NOx limit of 0.33 lbs/MBtu (calculated on a 30-day rolling average) is maintained with low NOx burners and an advanced over-fire air system. The burners are Foster-Wheeler four-port, controlled flow-split flame low NOx burners.

During early commercial operation the following combustion problems were common:

- Excessive secondary combustion in the upper furnace
- Furnace exit gas temperatures of >2100°F
- Desuperheating spray flows of 70 to 80 Klbs/hr
- Flyash LOI levels of 9 to 10 percent
- Visible high levels of carbon in bottom ash
- Sporadic NOx values, but within the permit limit
- Flame Stability
- Burner Fires

Due to these problems the services of STORM TECHNOLOGIES, Inc. were retained to initiate a boiler optimization program. The guiding principles of the optimization effort were the **Twelve Essentials of Optimum Combustion**.

1. **Furnace exit must be oxidizing preferably 3%.**
   Initial O_2 upper furnace traverses showed 4% on one side of the furnace and 0% on the other. Maintaining 3% excess oxygen with no reading below 2% was achieved with some minor air register and total air flow curve adjustments.

   Two oxygen monitors were installed before the economizer, at the same spacing as the burners so the side to side oxygen profile could be taken, averaged and used for the boiler O_2 control signal. The DCS allows for individual monitoring which helps the operator recognize individual burner or mill problems.

2. **Fuel lines balanced to each burner by "clean-air" test ± 2% or better.**
   Clean Air flow tests where performed and found to be within the requirements.

3. **Fuel lines balanced by "Dirty Air" test, using a Dirty Air Velocity Probe, to ± 5% or better.**
   Air flows where once again tested as coal was being fed and minor adjustments were made to the Adjustable Inner Sleeve to obtain acceptable balance.

4. **Fuel lines balanced in fuel flow to ± 10% or better.**
   An "ASME" type isokinetic sampler was used to collect coal samples from each fuel line. The samples were then weighed to determine line to line coal distribution. Excellent coal fineness had to be maintained for uniform distribution.

5. **Fuel line fineness shall be 75% or more passing a 200 mesh screen. 50 mesh particles shall be less than 0.1%.**
   Obtaining acceptable coal fineness required complete integration of the pulverizer control into the DCS. The original individual PLC control of each pulverizer didn't provide the flexibility required to obtain the desired fineness on a consistent basis. Coal fineness testing equipment was purchased and testing is performed on a routine basis.

6. **Primary airflow shall be accurately measured and controlled to ± 3% accuracy.**
   Original air flow measurement was approximately ± 20%. Installation of a custom designed, reduced area duct sections with pressure averaging pitot tubes improved measurement accuracy to ± 3%.

7. **Primary airflow/fuel flow air/fuel ratio shall be as close to 1.8 as possible when above minimum.**
Once accurate air flow measurement was obtained new primary air flow curves were developed along with the pulverizer drive speed and spinner drive speed curves to meet the operational requirements of the pulverizers while maintaining the air to fuel ratio as close as possible to the ideal 1.8:1 over the entire pulverizer load range.

8. **Fuel Line minimum velocities shall be 3,300 fpm.**
Minimum primary air flow limits where added to control logic to ensure the minimum line velocity of 3,300 fpm, this prevented burner fires by preventing coal drop out.

9. **Mechanical tolerances of burners and dampers shall be ± 1/4" or better.**
All burners and air dampers are inspected annually and tolerances are adjusted as needed.

10. **Secondary air distribution to burners should be within ± 5% to ± 10%.**
Good air flow management was determined to be critical to LOI and NOx control. Sophisticated test equipment including a water cooled probe for measuring upper furnace O_2 and temperature, a flyash sampler, and a hot-foil LOI tester were purchased and are used by station personnel on a routine basis to maintain optimum conditions.

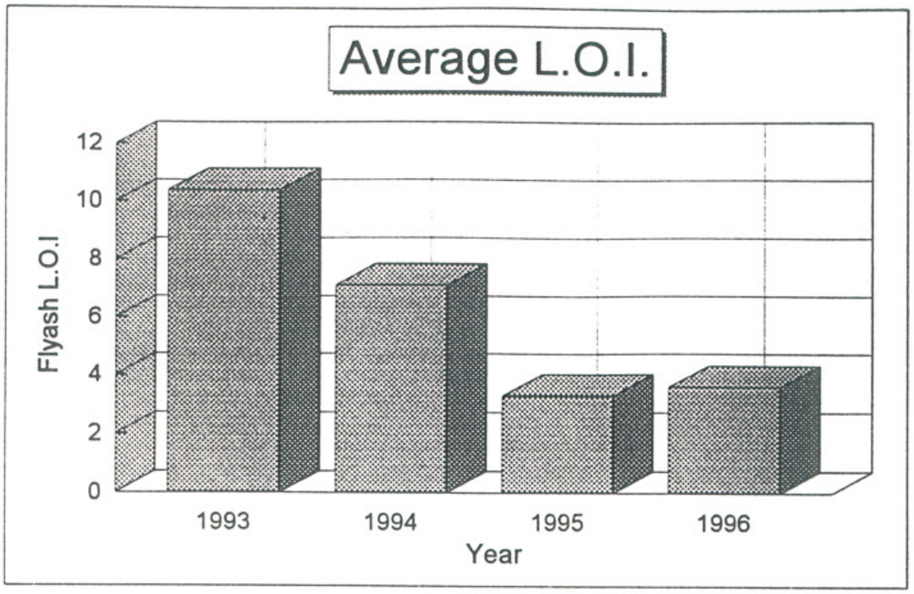
11. **Fuel feed to the pulverizers should be smooth during load changes and measured and controlled as accurately as possible. Load cell equipped gravimetric feeders are preferred.**
The originally installed Stock model 8424 gravimetric feeders provide the required smooth coal feed. Feeder calibrations are part of the plants continuing preventive maintenance program.

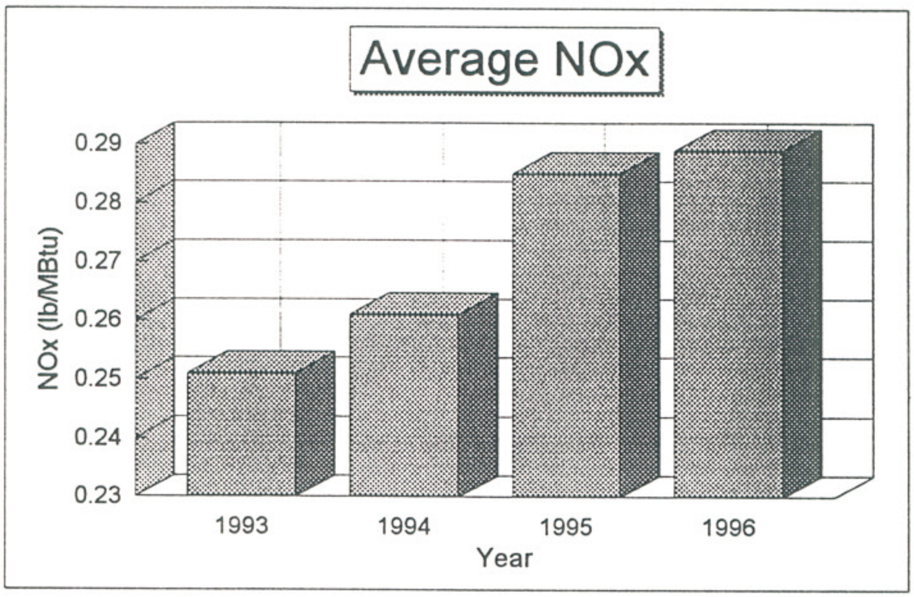
12. **Fuel feed quality and size should be consistent. Consistent raw coal sizing of feed to pulverizers is a good start.**
The plant's long term coal contract provides consistent coal quality. Additionally, the raw coal is run through a coal crusher before it is put on the storage pile.

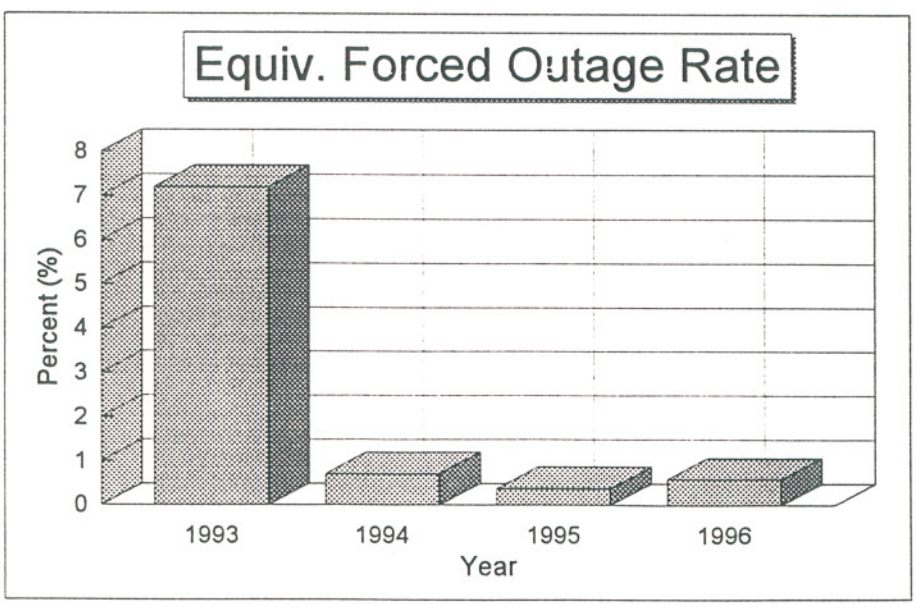
Waterwall de-slaggers were installed in the spring of 1995. They have successfully increased furnace waterwall heat absorption allowing control of exit gas temperature to 1950°F, and have further reduced de-superheater spray water flows at full load operation to 5% of steam flows.

KEYS TO SUCCESS:

- Team approach and commitment of owners, operator, and consultant to work together for the overall best performance.
- Development of operating personnel's awareness of factors regarding performance, maintainability, load response, capability and reliability (ownership of the process and results).
- Systematic approach to obtaining the 12 Essentials of Optimum combustion.
- Establishment of routine follow-up testing and tuning to preserve the performance gains.


Average L.O.I.
Flyash L.O.I
0
2
4
6
8
10
12
1993
1994
1995
1996
Year


Average NOx
NOx (lb/MBtu)
0.23
0.24
0.25
0.26
0.27
0.28
0.29
1993
1994
1995
1996
Year


Equiv. Forced Outage Rate
Percent (%)
0
1
2
3
4
5
6
7
8
1993
1994
1995
1996
Year