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Project Summary

Analysis of Long-Term NO Emission Data from Pulverized Coal-Fired Utility Boilers

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Long-term NO emission monitoring data from nine pulverized-coal-fired utility boilers were analyzed. These data were in the form of hourly averaged NO, O_2 (or CO_2), and load: NO and O_2/CO_2 were measured with certified continuous emission analyzers. The analyses were compared to the emissions limitations in both the 1971 and 1978 New Source Performance Standards (NSPS).

The comparison with the 1978 NSPS showed that seven of the nine boilers would have produced no periods of excess NO emissions on a 30-day rolling average basis. In addition, the same seven boilers would have complied with the 1978 NSPS NO_x performance test requirements.

Recommendations are made to more fully analyze the operation of two of these boilers to determine if their mode of operation could be adopted by other boilers. These boilers use permanently installed CO monitors to allow operation at the lowest practical excess air to achieve either low NO emissions or better fuel efficiency.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction and Summary

Long-term NO emission data from nine pulverized-coal-fired utility boilers were analyzed to determine the degree to which compliance was achieved with both the 1971 and 1978 New Source Performance Standards (NSPS). These standards are summarized in Table 1. Pertinent boiler characteristics are summarized in Table 2.

Table 1. Summary of 1971 and 1978 Coal NO_x NSPS

Coal Type	NO_x ng/J	NO_x lb/10^6 Btu
1971[a]		
Subbituminous	300	0.70
Bituminous	300	0.70
Lignite (Dakotas or Montana)	340	0.80
Other Lignites	260	0.60
1978[b]		
Subbituminous	210	0.50
Bituminous	260	0.60
Lignite (Dakotas or Montana)	340	0.80
Other Lignites	260	0.60

[a] 3-hr averaging period (rolling or block).
[b] 30-day rolling average.

The NO and O_2 (or CO_2) data were measured by certified analyzers.* The utilities also supplied hourly averaged unit load, monitor certification reports, and periodic coal analyses as part of the data packages.

A KVB computer program was specially modified for this study to perform the following computations:

*All analyzers were measuring NO only, not NO_x. EPA allows the use of NO-only analyzers to satisfy the requirement to measure "oxides of nitrogen."

Table 2. Boiler Pertinent Information

Utility	Station	Unit	Coal Type[a]	Boiler Mfgr[b]	Gross MWe	NO_X Controls[c]	Site Visit
Oklahoma Gas & Electric	Muskogee	4	Sub.	CE	550	Tang. + OFA	Yes
		5	Sub.	CE	550	Tang. + OFA	Yes
Omaha Public Power District	Nebraska City	1	Sub.	FW	575	Interstage air	No
Iowa Power & Light	Council Bluffs	3	Sub.	B&W	720	DRB	Yes
Pennsylvania Electric	Homer City	3	Bit.	B&W	680	DRB	Yes
Louisville Gas & Electric	Mill Creek	3	Bit.	B&W	425	DRB	No[d]
Proprietary	---	A	Sub.	CE	350	Tang. + OFA	Yes
		B	Sub.	CE	350	Tang. + OFA	Yes
Public Service New Mexico	San Juan	1	Sub.	FW	360	OFA + DRB	Yes

[a] Sub. = Subbituminous
Bit. = Bituminous

[b] CE = Combustion Engineering
FW = Foster Wheeler
B&W = Babcock & Wilcox

[c] Tang. = Tilting tangential
OFA = Overfire air
DRB = Dual register burner

[d] Detailed information obtained by letter.

1. Daily means and standard deviations of NO, O_2 (or CO_2), and load.
2. Means and standard deviations of NO and O_2/CO_2 as functions of unit load.
3. Load probability.
4. NO probability.
5. Number of periods of excess NO emissions with respect to the 1971 NSPS on both a 3-hour rolling average and 3-hour block average basis.
6. Number of periods of excess NO emissions with respect to the 1978 NSPS on a 30-day rolling average basis.

Sites were visited (see Table 2) to discuss details of monitor and boiler operation. As a result of these visits, revised computer analyses were performed for certain boilers when it was determined that some of the monitor data was of questionable validity.

The results of this study are summarized in Table 3. Note that seven of the nine boilers would have complied with the 1978 NSPS performance test and that the same boilers would not have produced any periods of excess emissions on a 30-day rolling average basis. (The "Maximum" column is the number of 30-day rolling averages obtained from the data, each of which is a potential period of excess emissions.)

Discussion

Long-term NO emissions data from nine pulverized-coal-fired utility boilers were analyzed and compared with the 1978 NSPS. Note that none of these boilers are subject to the 1978 NSPS but were included in the study because they were equipped with certified continuous emission monitors (CEM).

Each utility submitted a data package consisting of: hourly averages of NO, O_2 (or CO_2)*; CEM certification reports; and periodic coal analyses. These packages were reviewed for completeness and legibility. Discrepancies were resolved with the utility by telephone.

The hourly averages were entered on computer input sheets for analysis by a specially modified computer program. Plots were prepared of NO and O_2 (or CO_2) as a function of unit load prior to the site visits in order to identify any unusual results.

Seven of the nine boilers analyzed were visited during this assignment. Details on an eighth boiler were obtained by letter. The purpose of these visits was to hold detailed discussions with the appropriate station personnel. Topics discussed included:

1. Boiler Design--
   a. Boiler description, number of burners and burner arrangement, and heat release rate.
   b. Operation of dual register burners and/or overfire air system.

*The 1971 NSPS allows the use of either O_2 or CO_2 as a dilution correction. CO_2 was used on only one boiler.

Table 3. Analysis Summary

Boiler	Coal Type[a]	1978 NSPS Performance ng/J	Number of Valid Days	1971 NSPS NO_x Exceedances Rolling	1971 NSPS NO_x Exceedances Block	1978 NSPS NO_x Exceedances Actual	1978 NSPS NO_x Exceedances Maximum
Muskogee 4	Sub.	208	94	17	6	0	65
Revised		207	78	17	6	0	49
Muskogee 5	Sub.	179	82	16	6	0	53
Revised		[b]	21	5	2	--	--
Nebraska City 1	Sub.	228[c]	31	30	12	2	2
Council Bluffs 3	Sub.	141	96	0	0	0	67
Revised		138	63	0	0	0	34
Homer City 3	Bit.	274[c]	61	161	60	32	32
Mill Creek 3	Bit.	210	54	0	0	0	25
Unit A	Sub.	189	75	75	31	0	46
Unit B	Sub.	158	78	2	2	0	49
San Juan 1	Sub.	175	57	0	0	0	28

[a] Sub. = Subbituminous Bit. = Bituminous
[b] Insufficient data to calculate 30-day rolling average.
[c] Would not have complied with 1978 NSPS performance test.

2. Boiler Operation--
   a. O_2 versus load.
   b. Heat rate.
   c. Steam temperature problems.
   d. Slagging/fouling characteristics.
   e. Unit availability/load limitations.
   f. Ash carbon characteristics.
   g. Tube wastage.
   h. NO excess emissions.

3. CEM System--
   a. Make and model.
   b. Sampling location.
   c. Data reduction procedure.
   d. Recertification.
   e. Calibration procedure, frequency, out-of-calibration flag, and corrective action.
   f. Quality assurance program.

4. Coal Supply--
   a. Source.
   b. Nominal characteristics and variability.

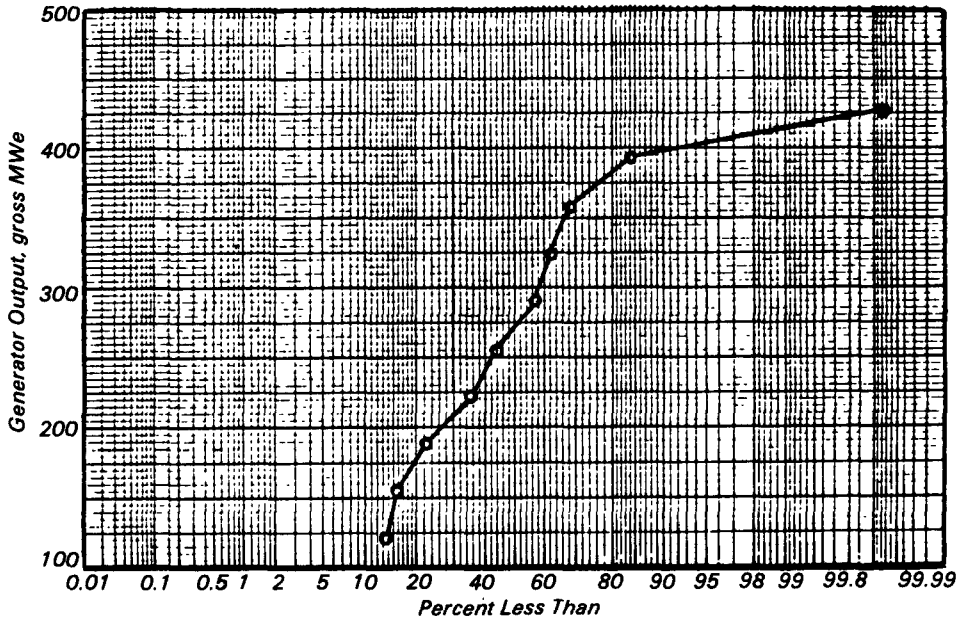

Figure 2. Mill Creek Unit 3 - load probability.

If the site visit identified some of the data as being of questionable validity, a revised computer analysis was performed, deleting these data.

The analysis is illustrated by the results computed for Mill Creek Unit 3. Figure 1 shows the boiler characteristics (NO and O_2) developed as a function of load. These characteristics were computed by sorting the data into 10 load "cells" and averaging the associated values of NO and O_2. Note the relatively flat NO emission factor across the load range. Apparently, the decrease in O_2 with load is sufficient to nearly offset the higher heat release rate. Figure 2 is the load probability distribution, representable only in terms of its median value of 270 gross MWe (63.5 percent of rating). Figure 3 indicates that the hourly averaged NO is normally distributed with a mean of 215 ng/J and a standard deviation of 27 ng/J.

Muskogee Units 4 and 5 are nominally identical, yet their NO characteristics are significantly different (Figure 4). Note that the maximum NO emission factor occurs at less than full load, and that Unit 5 indicates a significant NO decrease with loads above 200 gross MWe. The difference in O_2 characteristics (Figure 5) was deemed to be insufficient to completely resolve the difference in NO.

The NO emissions from Council Bluffs 3 and San Juan 1 were low, compared to the other boilers analyzed. Visits to these two units indicated that they were being operated with the minimum air flow practical, and that both units were equipped with CO monitors as operating adjuncts. Reasons for this mode of operation were:

Council Bluffs 3--

- Induced draft fan limitation at high load
- Fuel economy

San Juan 1--

- More stringent State of New Mexico NO_X limitation

In addition, neither unit was experiencing any unusual conditions due to low air operation; e.g., slagging, fouling, unburned carbon.

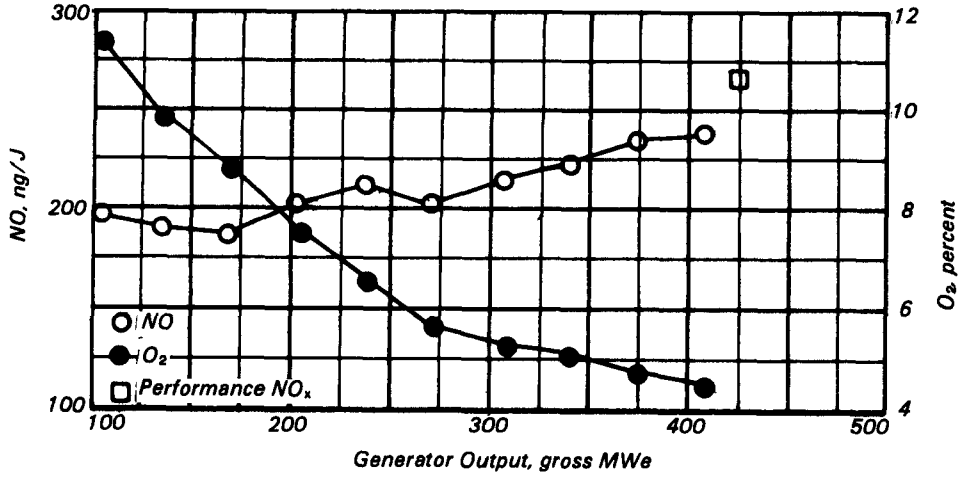

Figure 1. Mill Creek Unit 3 - boiler characteristics.

Conclusions and Recommendations

The major conclusion of this study was that seven of the nine boilers analyzed would have complied with the 1978 NSPS performance test requirements and would have produced no periods of excess NO emissions on a 30-day rolling average basis. The main exception

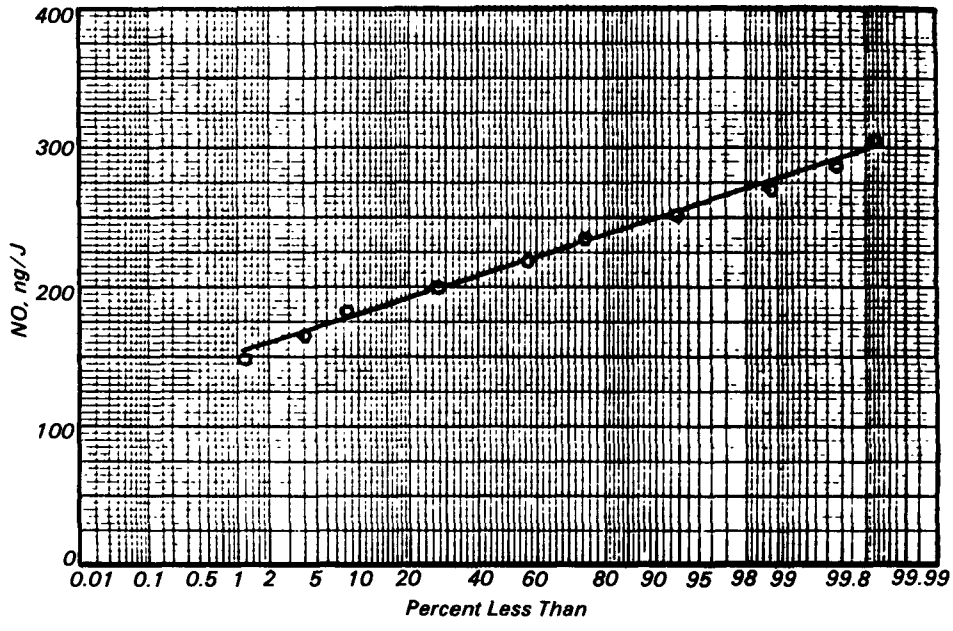

Figure 3. Mill Creek Unit 3 - NO probability.

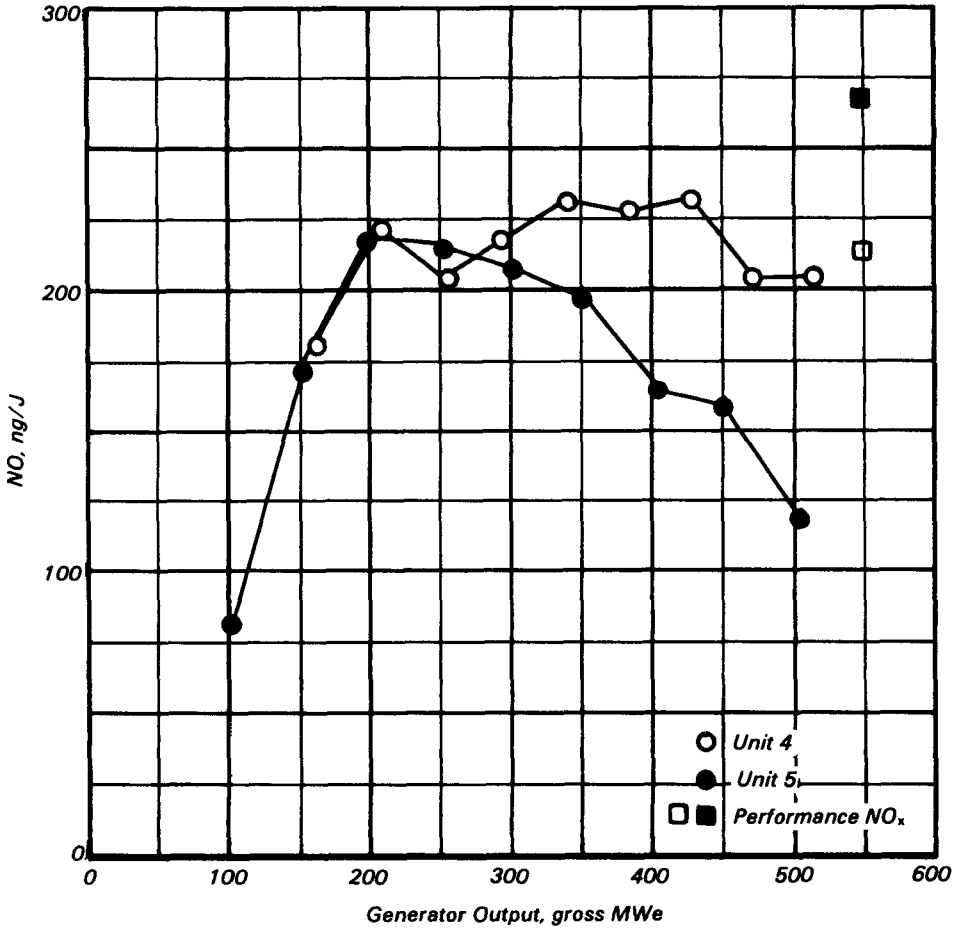

Figure 4. Muskogee Units 4 and 5 - comparison of NO characteristic.

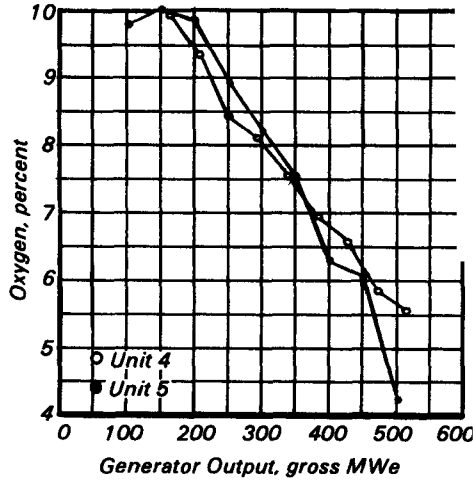

Figure 5. Muskogee Units 4 and 5 - comparison of O_2 characteristic.

(Homer City 3) is operated in a base-loaded manner; therefore, it is not possible to "average in" potentially lower NO emissions at reduced load.

It was also established that Council Bluffs 3 and San Juan 1 are low NO emission sources across their respective load ranges. This is attributed to their being operated with the lowest practical excess air with the assistance of a CO monitor.

It is recommended that the operation of these two units be documented in detail and then discussed with the respective boiler manufacturers to determine if this mode of operation could be adopted by other boilers.

It is also noted that base-loaded units behave differently with respect to 30-day NO_x rolling averages since they do not have the operational flexibility to "average in" periods of potentially lower NO emissions at lower loads to meet the 1978 NO_X standard.

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The complete report consists of two volumes, entitled "Analysis of Long-Term NO Emission Data from Pulverized Coal-Fired Utility Boilers,"
"Volume I. Technical Analysis," (Order No. PB 83-175 000; Cost: $19.00, subject to change)
"Volume II. Appendices," (Order No. PB 83-175 018; Cost: $32.50, subject to change) will be available only from:
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