



Project Summary

Evaluation of Nitrogen Oxide Emissions Data From TVA Coal-Fired Boilers

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Current EPA emission factors (AP-42) for nitrogen oxides (NO_x) from utility coal-fired boilers do not account for variations either in emissions as a function of generating unit load, or in designs of boilers of the same general type, particularly wall-fired boilers. TVA has recently compiled short-term NO_x emissions data from 30 units at 11 TVA coal-fired plants. These units include cyclone, cell burner, single wall, opposed wall, single tangential, and twin tangential boiler firing designs. In this study, the NO_x emission rates from each boiler were calculated and compared with the calculated rate for each boiler type using AP-42. Additional recent NO_x data (from non-TVA boilers) were also obtained from the literature, along with the data used to develop the current AP-42 emission factors. Analysis of all these data indicates that: (1) to varying degrees, NO_x emissions increase with increasing load for all except single- and opposed-wall-fired boilers; (2) using the current AP-42 quality rating scheme for the six boiler types, factoring in the TVA and recent literature data results in improved quality ratings for all NO_x emission factors—"A" (excellent) for those of 4 of the 6 boiler types, "B" (good) for those of cell burners, and "C" (fair) for those of opposed wall-fired boilers; and (3) there was no evident relationship between NO_x emissions and fuel nitrogen content or fuel ratio (fixed carbon to volatile matter).

This Project Summary was developed by EPA's Air and Energy Engi-

neering 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).

Background

The current EPA emission factors document (AP-42) provides information to estimate nitrogen oxide (NO_x) emissions from various coal-fired utility boilers burning bituminous and subbituminous coal. The emission factors, expressed as pounds of NO_x per ton of coal burned, relate amount of NO_x emitted to amount of fuel burned.

Emission factors are provided for three major boiler types: cyclone, tangentially fired, and wall-fired utility boilers (Table 1). No emission factors are given for subclasses of these major boiler types; i.e., for single- or twin-furnace tangential units; single-wall-fired units; horizontally opposed wall-fired units; or cell-burner wall-fired units.

The U.S. EPA's Air and Energy Engineering Research Laboratory has initiated a study to determine whether the AP-42 document could be revised to include emission factors for each boiler subclass, and to account for factors such as boiler design and coal type.

To this purpose, NO_x emission data and corresponding operating conditions and coal information were obtained from the Tennessee Valley Authority (TVA) for 30 boilers at 10 TVA coal-fired plants in Alabama, Kentucky, and Tennessee. These units encompass all three major boiler types, and all subclasses in the tangential and wall categories. These data were sum-



marized and then compared to NO_x emissions data calculated from the AP-42 emission factor. Further analysis of the TVA data consisted of evaluating NO_x emissions as a function of unit load. Initially, only NO_x data from TVA units were to be evaluated. However, TVA data were limited for several boiler types, so it was necessary to include NO_x data from non-TVA units.

Table 1. AP-42 Emission Factors^a

Utility Boiler Type	Emission Factor lb of NO _x /ton of coal
Cyclone	37
Tangentially Fired ^b	15
Wall-Fired ^c	21

^a From AP-42 Section 1.1 at applicable load range of 60-110%.

^b Includes single- and twin-furnace units.

^c Includes single-wall, horizontally opposed-wall, and cell-burner units.

The most recent NO_x data were obtained through a literature search and from the seven references cited in the current AP-42 that are the basis for the current AP-42 emission factors. These data were combined with the TVA data by specific boiler category and used to: (1) determine if the TVA data could be used to modify the AP-42 emission factors; (2) determine if current AP-42 emission factors are consistent with measured values; (3) identify any trends, such as NO_x as a function of load; and (4) determine new average NO_x emission rates for each boiler subclass.

Finally, the emission factor rating was reviewed to determine if including additional data would improve the factor ratings for each boiler type. The rating is a measure of the quantity and quality of data used to generate the emission factors.

Results

Cyclone Furnaces

NO_x emissions from 12 cyclone furnaces ranged from 0.79 to 1.87 lb/mBtu,* with an average of 1.22 lb/mBtu (33 lb/ton**). This average is 11% lower than the AP-42 rate of 1.37 lb/mBtu. However, the TVA units averaged 1.61 lb/mBtu, which is 18% higher than the AP-42 rate. The non-TVA units averaged 1.11 lb/mBtu.

* 1 lb/mBtu (m=10⁶) = 0.43 g/MJ

** 1 lb/ton = 0.5 g/kg

Cell-Burner Wall-Fired Units

NO_x emissions from five cell-burner units ranged from 0.71 to 1.7 lb/mBtu, with an overall average of 1.21 lb/mBtu (33 lb/ton). This average is 55% higher than the current AP-42 rate of 0.78 lb/mBtu. The TVA units averaged 1.53 lb/mBtu, which is approximately twice the AP-42 rate. The non-TVA units averaged 1.02 lb/mBtu. This clearly indicates that the cell-burner units should be in a separate category from other wall-fired boilers. However, data from more cell-burner units are needed to define the emission factor and improve the rating.

Horizontally Opposed Wall-Fired Units

NO_x emissions from three horizontally opposed wall-fired units ranged from 0.69 to 1.24 lb/mBtu, with an overall average of 0.94 lb/mBtu (25 lb/ton). This average is 12% higher than the current AP-42 rate of 0.78 lb/mBtu. The TVA units averaged 0.76 lb/mBtu, which compares well with the AP-42 rate; however, the non-TVA units averaged 1.08 lb/mBtu. This shows that horizontally opposed units may need a separate category; however, more data are needed to define the emission factor and improve the rating.

Single-Wall-Fired Units

NO_x emissions from 15 single-wall-fired units ranged from 0.59 to 1.12 lb/mBtu, with an overall average of 0.85 lb/mBtu (23 lb/ton). This average is 9% higher than the current AP-42 rate of 0.78 lb/mBtu. The TVA units averaged 0.81 lb/mBtu, which is only 3% higher than the AP-42 rate, while the non-TVA units averaged 0.90 lb/mBtu. Sufficient data are available to modify the emission factor for this category.

Single-Furnace Tangential Units

NO_x emissions from 17 single-furnace tangentially fired units ranged from 0.38 to 0.75 lb/mBtu, with an overall average of 0.56 lb/mBtu (15 lb/ton), which corresponds exactly to the current AP-42 emission rate. The TVA units averaged 0.48 lb/mBtu, which is 16% lower than the AP-42 rate. The average for the non-TVA units was 0.60 lb/mBtu.

Twin-Furnace Tangential Units

NO_x emissions from 12 twin-furnace tangentially fired units ranged from 0.55 to 0.72 lb/mBtu, with an overall average of 0.62 lb/mBtu (17 lb/ton). This average is

11% higher than the AP-42 rate of 0.56 lb/mBtu. The TVA units averaged 0.62 lb/mBtu and the non-TVA units averaged 0.63 lb/mBtu. There are sufficient data to modify the emission factor for this category.

Emission Factor Ratings

AP-42 rates emission factors for pulverized coal-fired dry bottom units and cyclone furnaces. Ratings are based on the number of units tested:

- A = 10 or more units (excellent)
- B = 6-9 units
- C = 2-5 units
- D = 1 unit (poor)

The current AP-42 shows an "A" rating for pulverized-coal, dry-bottom boilers. This rating is deceptive in that it includes both tangentially fired and wall-fired boilers. The AP-42 references indicate that only seven tangentially fired boilers and seven wall-fired units were tested. The current rating for cyclone furnaces is "B."

The number of units and ratings for the AP-42-referenced boilers, the TVA boilers, and the boilers identified from the literature are compared in Table 2, which shows that emission factor ratings can be generated for boiler subclasses by combining all the data. By doing so, "A" ratings are obtained for all subclasses except for cell-burners ("B") and horizontally opposed wall-fired boilers ("C").

Conclusions

The review and analysis of the NO_x emission data from both TVA and non-TVA units, lead to the following conclusions for each boiler type.

Cyclone Furnaces

1. There is a correlation between NO_x and unit load; i.e., NO_x increased with increasing load.
2. The emission factor rating improves from "B" to "A" with these data.
3. There are no correlations between NO_x and fuel nitrogen or fuel ratio (fixed carbon to volatile matter).

Cell-Burner Wall-Fired Units

1. There is a correlation between NO_x and unit load; i.e., NO_x increases with unit load.
2. There is no current emission factor rating for cell-burner units; however, these five units would be rated "B."
3. There are no correlations between NO_x and fuel nitrogen or fuel ratio.

Horizontally Opposed Wall-Fired Units

1. There are not enough data to determine a correlation between unit load and NO_x emissions.
2. There is no current emission factor rating for horizontally opposed units; however, these three units would be rated "C."
3. There are no correlations between NO_x and fuel nitrogen or fuel ratio.

Single-Wall-Fired Units

1. There is a correlation between NO_x and unit load; i.e., NO_x increased with increasing load.

2. There is no current emission factor rating for single wall-fired units; however, these 15 units would be rated "A."
3. There are no correlations between NO_x and fuel nitrogen or fuel ratio.

Single-Furnace Tangentially Fired Units

1. There is a slight increase in NO_x as unit load increases.
2. There is no current emission factor rating for this subclass; however, these 17 units would be rated "A."
3. There are no correlations between NO_x and fuel nitrogen or fuel ratio.

Twin-Furnace Tangentially Fired Units

1. There is a slight correlation between NO_x and load; i.e., NO_x increased with increasing load.
 2. There is no current emission factor rating for this subclass; however, these 12 units would be rated "A."
 3. There are no correlations between NO_x and fuel nitrogen or fuel ratio.
- Table 3 summarizes the average NO_x emissions from TVA and non-TVA units for each type of boiler.

Table 2. Comparison of AP-42 Emission Factor Ratings

Firing Configuration	Number of Units				NO _x Emission Factor Rating			
	AP-42 ^a	TVA	Literature ^b	Combined	AP-42 ^a	TVA	Literature ^b	Combined
Pulverized Coal-Fired Dry Bottom ^c	14	28	10	52	A	A	A	A
Cell Burner Wall-Fired	2	2	1	5	NR ^d	C	D	B
Horizontally Opposed Wall-Fired	0	1	2	3	NR	D	C	C
Single Wall-Fired	5	9	1	15	NR	B	D	A
Single-Furnace Tangentially Fired	5	7	5	17	NR	B	C	A
Twin-furnace Tangentially Fired	2	9	1	12	NR	B	D	A
Cyclone Furnace	8	2	2	12	B	C	C	A

^a AP-42 referenced boilers.

^b Additional boilers from literature search.

^c Includes cell-burner wall-fired; horizontally opposed wall-fired; single wall-fired; single-furnace tangentially fired; and twin-furnace tangentially fired units.

^d NR = No rating given in AP-42.

Table 3. Summary of Average NO_x Emissions from TVA and Non-TVA Units

Boiler Type	TVA Units (lb/mBtu)	Non-TVA Units (lb/mBtu)	Average of TVA and Non-TVA Units (lb/mBtu)	AP-42 ^a (lb/mBtu)
Cyclone Furnaces	1.61	1.11	1.22	1.37
Cell-Burner, Wall-Fired Units	1.53	1.02	1.21	0.78
Horizontally Opposed, Wall-Fired Units	0.76	1.08	0.94	0.78
Single-Wall-Fired Units	0.81	0.90	0.85	0.78
Single-Furnace, Tangentially Fired Units	0.48	0.60	0.56	0.56
Twin-Furnace, Tangentially Fired Units	0.62	0.63	0.62	0.56

^a Calculated by using 13,500 Btu/lb.

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Jullan W. Jones is the EPA Project Officer (see below).
The complete report, entitled "Evaluation of Nitrogen Oxide Emissions Data From
TVA Coal-Fired Boilers," (Order No. PB93-138865/AS; Cost: \$27.00; subject to
change) will be available only from
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