APPENDIX A

Operating Permit Application Forms

NMED - AIR QUALITY BUREAU
2048 GALISTEO
SANTA FE, NM 87505
TELEPHONE: (505) 827-1494

NEW MEXICO ENVIRONMENT DEPARTMENT
AIR QUALITY BUREAU

OPERATING PERMIT APPLICATION FORM
(20.2.70 NMAC)

Please answer all questions in each section.
Use the abbreviation "NA" for "not applicable" wherever appropriate.
Specific instructions corresponding to numbers in brackets are on the back of each page.

SECTION 1 - GENERAL INFORMATION: (Subsection D of 20.2.70 NMAC)[1]

1. Company Name[2] U.S. Department of Energy (DOE)/Los Alamos National Laboratory (LANL) 2. Application Date: November 27, 2002

3. Company Mailing Address: 528 35th Street, Los Alamos, NM 87544 4. Phone: (505) 667-5105

5. Owner's Name [3]: DOE, National Nuclear Security Administration 6. Phone: (505) 667-5105

7. Owner's Mailing Address: Office of Los Alamos Site Operations, 528 35th Street, Los Alamos, NM 87544

8. Plant or Facility Name [4]: Los Alamos National Laboratory 9. Phone: (505) 664-5265

10. Plant Mailing Address: P.O. Box 1663, Los Alamos, NM 87545

11. Plant Operator [5]: University of California 12. Phone: (505) 664-5265

13. Plant Operator Address: P.O. Box 1663, Los Alamos, NM 87545

14. Responsible Official [6]: Ralph E. Erickson Title: Director, Office of Los Alamos Site Operations 15. Phone: (505) 667-5105
James L. Holt Associate Director for Operations, LANL (505) 667-0079

16. Responsible Official Address: Office of Los Alamos Site Operations, 528 35th Street, Los Alamos, NM 87544

17. Person to Contact at Site [7]: Steve Fong 18. Title: General Engineer 19. Phone: (505) 665-5534

20. Company Air Permit Contact [8]: Jean Dewart, Group Leader, RRES-MAQ 21. Phone: (505) 665-8855

22. Company's State of Incorporation or Registration to do Business: N/A – Federal Agency

23. Company's Corporate or Partnership Relationship to any other Air Quality Permittee [9]: N/A

24. Name of Parent Company [10]: N/A

25. Address of Parent Company: N/A

26. Names of Subsidiary Companies [11]: N/A

27. Previous Air Quality Permits Issued to this facility (Permit Numbers): 632, 634, 636, 1081, 2195, 2195B, 2195-F, GCP-3-2195G

28. Other Air Quality Permits Issued to this Applicant (Permit Numbers): N/A

29. Reason this source must have an 20.2.70 NMAC operating permit [12]: Major source (>100 tons/year) for nitrogen oxide, volatile organic compound, and carbon monoxide emissions

30. This Operating Permit Application is for (check one): X New Permit; Permit Renewal; Minor Modification; Significant Modification.

If this Application is for Permit Renewal or Modification give: Current Operating Permit No. ________ ; Expiration Date ________

31. Is this a permanent source? [13]: X Yes No. If No, how long will this site be occupied? ________

32. Is this a portable source? [14]: Yes X No

32A. If yes, provide identifying numbers (Example: source unit numbers, equipment serial numbers, etc..): N/A

32B. If yes, date of anticipated relocation: N/A 32C. If yes, date of anticipated startup: N/A

33. Plant Operational Periods: (Subparagraph D(5)(f) of 20.2.70.300 NMAC)

33A. Specify standard operational periods:

8 hours per day, 8 am to 5 pm, 5 days per week, 5 weeks per month, 12 months per year.

33B. Specify maximum operational periods:

24 hours per day, ______ am to ______ pm, 7 days per week, 5 weeks per month, 12 months per year.

33C. Max Operational Hours in a Year 8760

34. Describe briefly type of plant and nature of process(es) and products [15]:

LANL is a government laboratory primarily engaged in national security and nuclear weapons research

Plant Primary SIC code [16]: 9711 Plant Secondary SIC code [17]: NA

35. Describe briefly any process(es) or products associated with any alternative operating scenarios described in this application [18]:

N/A

Plant Primary and Secondary SIC codes for this alternative process(es): N/A

36. Plant's Maximum Allowable Capacity (Specify Units) [19]:

Hourly: N/A Daily: N/A Annual: N/A

37. Plant Location [20]:

37A. County: Los Alamos 37B. Direction and distance from nearest town: Los Alamos

37C. Range: ******* Township: ******* Section: ******* 37D. Latitude: ******* Longitude: *******

37E. UTM Zone: ******* UTMH: ******* UTMV: *******

38. Plant Elevation 7220 Feet above mean sea level

39. Ownership of Land at Plant site (Private, State, Federal, etc.): Federal

NOTE: If the land at the plant site is Indian land, contact the Air Pollution Control Bureau permitting staff for assistance.

40. Distance, in meters, of plant site to nearest residence, school or occupied structure [21]: 1.5 km N (Royal Crest Trailer Park)

41. Is U.S.G.S. quadrangular map (or equivalent) attached with Plant location marked? [22]: X Yes, No.

42. Identify all Class-1 areas, Indian Lands, Bernalillo County, and neighboring states that are within 50 miles of the facility, and give their radial distances in miles: Taos Pueblo (43), Picuris Pueblo (35), Jicarilla Apache Indian reservation (42), San Juan Pueblo (12), Santa Clara Pueblo (6), San Ildefonso Pueblo (3), Pojoaque Pueblo (8), Nambe Pueblo (15), Tesuque Pueblo (12), Çochiti Peblo (8), Santo Domingo Pueblo (17), Zia Pueblo (19), San Felipe Pueblo (24), Santa Ana Pueblo (25), Jemez Pueblo (12), Sandia Pueblo (38), Laguna Pueblo (48), Bernallio County (35), Bandelier Wilderness (0), Pecos Wilderness (35), San Pedro Wilderness Park (27)

******* This information has been removed for operational security purposes. Please contact ENV-MAQ at (505) 665-8855 for a hard copy of the original page.

SECTION 2A - RAW MATERIALS PROCESSED [23]: (Paragraph 4 of Subsection D of 20.2.70.300 NMAC)
(Complete only if needed to determine emissions or if an applicable requirement exists for materials processed)

(Use additional sheets if necessary)

Unit No. [24]	Material [25]	Composition [26]	Condition [27]	Quantity Used [28] (Specify Units)
N/A[(a)]				

SECTION 2B - MATERIALS PRODUCED: (Paragraph 4 of Subsection D of 20.2.70.300 NMAC)
(Complete only if needed to determine emissions or if an applicable requirement exists for materials produced)

(Use additional sheets if necessary)

Unit No.	Material [29]	Composition	Condition	Production Rates (Specify Units)
Asphalt Plant	Asphalt	Mixture of asphalt tar and aggregate varies by batch.	N/A	13,000 tons per year

SECTION 3A - LIQUID STORAGE TANKS - MATERIAL DATA [30]: (Paragraphs 5 and 6 of Subsection D of 20.2.70.300 NMAC)
(Complete asterisk * columns only if the tank has an applicable requirement or if necessary to calculate emissions)

(Use additional sheets if necessary)

Tank No. [31]	Liquid Stored [32]	Liquid Composition [33]	* Liquid Density (lb/gal)	* Vapor Molecular Weight (lb/lb-mole)	* Average Storage Temp., T_{av} (°F)	* True Vapor Pressure at T_{av} (psia)	* Maximum Storage Temp., T_{max} (°F)	* True Vapor Pressure at T_{max} (psia)
TA-15-435	Mineral Oil	100% Paraffinic Mineral Oil	7.16	Varies	59	<0.0002	71	<0.0002
TA-15-436	Mineral Oil	100% Paraffinic Mineral Oil	7.16	Varies	59	<0.0002	71	<0.0002
TA-15-461	Mineral Oil	100% Paraffinic Mineral Oil	7.16	Varies	59	<0.0002	71	<0.0002
TA-15-462	Mineral Oil	100% Paraffinic Mineral Oil	7.16	Varies	59	<0.0002	71	<0.0002
TA-15-473	Mineral Oil	100% Paraffinic Mineral Oil	7.16	Varies	59	<0.0002	71	<0.0002
TA-15-474	Mineral Oil	100% Paraffinic Mineral Oil	7.16	Varies	59	<0.0002	71	<0.0002
TA-35-197	Dielectric Oil	100% Petroleum Hydrocarbons	7.3	N/A	59	<0.001	71	<0.001
TA-36-141	Dielectric Oil	100% Petroleum Hydrocarbons	7.3	N/A	59	<0.001	71	<0.001
TA-36-142	Dielectric Oil	100% Petroleum Hydrocarbons	7.3	N/A	59	<0.001	71	<0.001
TA-53-640	Mineral Oil	100% Paraffinic Mineral Oil	7.16	Varies	59	<0.0002	71	<0.0002
TA-53-1058	Scintillation Oil	Mixture of: Paraffinic Mineral Oil and butyl-PBD	7.16	Varies	59	<0.0002	71	<0.0002
TA-53-1071-C	Scintillation Oil	Mixture of: Paraffinic Mineral Oil and butyl-PBD	7.16	Varies	59	<0.0002	71	<0.0002
TA-53-1071-A	Scintillation Oil	Mixture of: Paraffinic Mineral Oil and butyl-PBD	7.16	Varies	59	<0.0002	71	<0.0002
TA-53-1071-B	Scintillation Oil	Mixture of: Paraffinic Mineral Oil and butyl-PBD	7.16	Varies	59	<0.0002	71	<0.0002
TA-3-779	No. 2 Fuel Oil	Diesel	7.39	130	59	<0.02	71	<0.02

SECTION 3B - LIQUID STORAGE TANKS - TANK DATA: (Paragraphs 5 and 6 Subsection D of 20.2.70.300 NMAC)
(Complete asterisk * columns only if the tank has an applicable requirement or if necessary to calculate emissions)

(Use additional sheets if necessary)

Tank No. [34]	Date Installed/ Modified[35]	Capacity (gal)	* Tank Diameter (ft)	* Roof Type [36]	* Seal Type[37]	* Vapor Space Height (ft) [38]	* Roof/ Shell Color [39]	* Paint Cond-ition [40]	* Annual Throughput (gal/yr) [41]	* Turnovers per Year [42]
TA-15-435	1990	12000	12	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-15-436	1990	12000	12	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-15-461	1998	12000	12	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-15-462	1998	12000	12	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-15-473	1997	21000	10	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-15-474	1997	21000	10	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-35-197	1999	40000	12	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-36-141	1986	24500	10	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-36-142	1986	24500	10	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-53-640	1992	60000	22	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-53-1058	1989	20000	11	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-53-1071-C	1992	12000	10	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-53-1071-A	1992	20000	11	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-53-1071-B	1992	20000	11	FX	N/A	N/A	N/A	N/A	N/A	N/A
TA-3-779	1999	228,000	35	FX	N/A	6.5	Gray/Light	Good	500,000	2.44

SECTION 4A - SOLID MATERIAL STORAGE - MATERIAL DATA[43]: (Paragraph 5.d of Subsection D of 20.2.70.300 NMAC)
(Complete asterisk * columns only if necessary to calculate emissions or if there is an applicable requirement for material storage)

(Use additional sheets if necessary)

Storage Unit No.[44]	Storage Material Name	* Emission Unit(s), Process or Operation Served [45]	Storage Type [46]	Storage Material Composition [47]	* Date Installed or Modified
N/A					

SECTION 4B - SOLID MATERIAL STORAGE - STORAGE DATA [48]: (Paragraph 5.d of Subsection D of 20.2.70.300 NMAC)
(Complete asterisk * columns only if necessary to calculate emissions or if there is an applicable requirement for material handling)

(Use additional sheets if necessary)

Storage Unit No. [49]	Transfer or Transport Method [50]		* Maximum Hourly Throughput (specify units)	* Annual Throughput (specify units)	Dust Control Method (During Storage and Transfer) [51]
	Incoming	Outgoing			
N/A					

SECTION 5 - FUEL USEAGE AND FUEL DATA [52]: (Paragraph 5.d of Subsection D of 20.2.70.300 NMAC)
(Complete asterisk * column only if needed to determine or regulate any emissions or if there is an applicable requirement for the fuel)

(Use additional sheets if necessary)

Emission Unit No. [53]	Type of Equipment [54]	Equipment Manufacturer and Model No.	Equipment Rated Capacity [55]	* FUEL DATA [56]				
				Fuel Type [57]	Amount Per Year [58]	Lower Heating Value [59]	% of Sulfur [60]	% of Ash [61]
S-127 Air Curtain Destructor	Engine	John Deere 4 Cylinder Model 4045D	76 hp max.	Diesel	N/A	137,000 Btu/gal	N/A max.	N/A max.
			normal				N/A ave.	N/A ave.
T-350 (2) Air Curtain Destructor	Engine	John Deere 6 cylinder Model 6068D	125 hp max.	Diesel		137,000 Btu/gal	N/A max.	N/A max.
			normal				N/A ave.	N/A ave.
TA-21-RC	Rock Crusher Engine	Detroit Diesel Model S-40	200 hp max.	Diesel	N/A	137,000 Btu/gal	N/A max.	N/A max.
			100 hp normal				N/A ave.	N/A ave.
TA-16-1484-BS-1	Boiler	Sellers Model 183H.P.-SH-LN390	7.47 MMBtu/hr max.	Natural Gas	870 MMscf/yr(b)	1030 Btu/scf	N/A max.	N/A max.
			6.35 MMBtu/hr normal				N/A ave.	N/A ave.
TA-16-1484-BS-2	Boiler	Sellers Model 183H.P.-SH-LN390	7.47 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			6.35 MMBtu/hr normal				N/A ave.	N/A ave.
TA-16-1485-BS-1	Boiler	Sellers Model 227H.P.-SH-LN390	9.23 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			7.84 MMBtu/hr normal				N/A ave.	N/A ave.
TA-16-1485-BS-2	Boiler	Sellers Model 227H.P.-SH-LN390	9.23 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			7.84 MMBtu/hr normal				N/A ave.	N/A ave.
TA-48-1-BS-1	Boiler	Sellers Model 15 Seniors-150	6.28 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			5.34 MMBtu/hr normal				N/A ave.	N/A ave.

SECTION 5 - FUEL USEAGE AND FUEL DATA [62]: (Paragraph 5.d of Subsection D of 20.2.70.300 NMAC)
(Complete asterisk * column only if needed to determine or regulate any emissions or if there is an applicable requirement for the fuel)

(Continued)

Emission Unit No. [63]	Type of Equipment [64]	Equipment Manufacturer and Model No.	Equipment Rated Capacity [65]	* FUEL DATA [66] Fuel Type [67]	Amount Per Year [68]	Lower Heating Value [69]	% of Sulfur [70]	% of Ash [71]
TA-48-1-BS-2	Boiler	Cleaver Brooks Model CB-700-150	6.28 MMBtu/hr max.	Natural Gas	870 MMscf/yr[(b)]	1030 Btu/scf	N/A max.	N/A max.
			5.34 MMBtu/hr normal				N/A ave.	N/A ave.
TA-48-1-BS-6	Boiler	Cleaver Brooks Model CB-700-200 1558	8.40 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			7.14 MMBtu/hr normal				N/A ave.	N/A ave.
TA-53-365-BHW-1	Boiler	Sellers Model 15 Seniors-2-200-w	8.37 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			7.11 MMBtu/hr normal				N/A ave.	N/A ave.
TA-53-365-BHW-2	Boiler	Sellers Model 15 Seniors-2-200-w	8.37 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			7.11 MMBtu/hr normal				N/A ave.	N/A ave.
TA-55-6-BHW-1	Boiler	Sellers Model 350 H.P. W-LN490	14.6 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			12.4 MMBtu/hr normal				N/A ave.	N/A ave.
TA-55-6-BHW-2	Boiler	Sellers Model 350 H.P. W-LN490	14.6 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			12.4 MMBtu/hr normal				N/A ave.	N/A ave.
TA-59-1-BHW-1	Boiler	Cleaver Brooks Model CB-700-150	6.28 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			5.34 MMBtu/hr normal				N/A ave.	N/A ave.
TA-59-1-BHW-2	Boiler	Cleaver Brooks Model CB-700-150	6.28 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			5.34 MMBtu/hr normal				N/A ave.	N/A ave.
TA-50-2	Boiler	Superior Model MS6-5-1500-S260-M	12.6 MMBtu/hr max.	Natural Gas		1030 Btu/scf	N/A max.	N/A max.
			10.7 MMBtu/hr normal				N/A ave.	N/A ave.

SECTION 5 - FUEL USEAGE AND FUEL DATA [72]: (Paragraph 5.d of Subsection D of 20.2.70.300 NMAC)
(Complete asterisk * column only if needed to determine or regulate any emissions or if there is an applicable requirement for the fuel)

(Continued)

Emission Unit No. [73]	Type of Equipment [74]	Equipment Manufacturer and Model No.	Equipment Rated Capacity [75]	* FUEL DATA [76]				
				Fuel Type [77]	Amount Per Year [78]	Lower Heating Value [79]	% of Sulfur [80]	% of Ash [81]
N/A(c)	Remaining Exempt Boilers and Process Heaters (Low NO_x)	Various	max.	Natural Gas	870 MMscf/yr(b)	1030 Btu/scf	N/A max.	N/A max.
			<6.3 normal				N/A ave.	N/A ave.
	Remaining Exempt Boilers and Process Heaters (Uncontrolled)	Various	max.				N/A max.	N/A max.
			≤5.0 normal				N/A ave.	N/A ave.
TA-3-22-1 TA-3-22-2 TA-3-22-3	Power Plant Boilers	Edgemoor Iron Works (2) Models 4008 and 4009 Union Iron Works (1) Model 102824	210 MMBtu/hr max.	Natural Gas	4,000 MMscf/yr	1030 Btu/scf	5gr/100scf max.	N/A max.
			178.5 MMBtu/hr normal				N/A ave.	N/A ave.
			210 MMBtu/hr max.	No. 2 Fuel Oil	500,000 Gallons	137,000(h) Btu/gal	0.34 max.	N/A max.
			178.5 MMBtu/hr normal				N/A ave.	N/A ave.
TA-21-357-1 TA-21-357-2 TA-21-357-3	Steam Plant Boilers	Industrial Boiler Company Model 3WB350HCG0	12 MMBtu/hr max.	Natural Gas	60 MMscf/yr	1030 Btu/scf	N/A max.	N/A max.
			10.2 MMBtu/hr normal				N/A ave.	N/A ave.
			12 MMBtu/hr max.	No. 2 Fuel Oil	10,000 Gallons	137,000 Btu/gal	0.34 max.	N/A max.
			10.2 MMBtu/hr normal				N/A ave.	N/A ave.
TA-33-G-1	Generator	Kohler Model 1600 ROZD	1,600 kW max.	No. 2 Fuel Oil	N/A	137,000 Btu/gal	0.34 max.	N/A max.
			1,500 kW normal				N/A ave.	N/A ave.
TA-60-BDM(d)	Asphalt Plant Dryer	BDM Engineering Model TM526	25 MMBtu/hr N/A max.	Propane	N/A	N/A	0.5 max.	N/A max.
			normal				N/A ave.	N/A ave.
			25 MMBtu/hr N/A max.	Natural Gas	N/A	N/A	0.75 max.	N/A max.
			normal				N/A ave.	N/A ave.

SECTION 6 - AIR POLLUTION UNITS and CONTROL EQUIPMENT DATA [82]: (Paragraphs 5.e and 7.a of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 5)

(Use additional sheets if necessary)

Emission Unit No.[83]	Process or Operation [84]	Is Air Pollution Control Equipment Installed (Yes/No) [85]	Air Pollution Control Equipment No.[86]	AIR POLLUTION CONTROL EQUIPMENT DATA		AIR POLLUTION CONTROL EQUIPMENT EFFICIENCY DATA		Applicable Requirements for this Process and/or Control [87]
				Equipment Type [88]	Manufacturer and Model No. [89]	% by Weight [90]	Method of Determination [91]	
TA-3-73	Barber Greene Asphalt Plant	Yes	1	Multiple Cyclone and Wet Scrubber	Barber-Greene Model CB-50	93	Manufacturer's Rating	See Sections 3.2.6 and 3.2.7
TA-60-BDM	BDM Engineering Asphalt Plant	Yes	1	Cyclone	BDM Engineering Model 84M	70	Manufacturer's Rating	See Sections 3.2.6 and 3.2.7
			2	Baghouse	BDM Engineering Model 18000M	99.9		
TA-35-213	Beryllium Machining	Yes	1	Pre-Filter	Varies[e]	48% PM	Manufacturer's Rating	See Sections 3.3.6 and 3.3.7
			HS5-2990	HEPA Filter	Varies[e]	99.95 % Be PM	Filter Performance Test	See Sections 3.3.6 and 3.3.7
TA-3-141	Beryllium Machining	Yes	2	Cartridge Filter	Varies[e]	99.9% Be and Be Alloy Particulate	Manufacturer's Rating	See Sections 3.3.6 and 3.3.7
			HS5-7320 HS5-7330	HEPA Filter	Varies[e]	99.95% Be and Be Alloy Particulates	Filter Performance Test	See Sections 3.3.6 and 3.3.7
TA-3-102	Beryllium Machining	Yes	1	HEPA Filter	Varies[e]	99.95% Be Particulates	Filter Performance Test	See Sections 3.3.6 and 3.3.7
			2	Baghouse	Varies[f]	N/A	N/A	See Sections 3.3.6 and 3.3.7

SECTION 6 - AIR POLLUTION UNITS and CONTROL EQUIPMENT DATA [92]: (Paragraphs 5.e and 7.a of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 5)

(Continued)

Emission Unit No. [93]	Process or Operation [94]	Is Air Pollution Control Equipment Installed (Yes/No) [95]	Air Pollution Control Equipment No. [96]	AIR POLLUTION CONTROL EQUIPMENT DATA		AIR POLLUTION CONTROL EQUIPMENT EFFICIENCY DATA		Applicable Requirements for this Process and/or Control [97]
				Equipment Type [98]	Manufacturer and Model No. [99]	% by Weight [100]	Method of Determination [101]	
TA-55-PF4	Beryllium Machining	Yes	FF-854 FF-855 FF-858 FF-859 FF-852 FF-853	HEPA Filters	Varies[(e)]	99.95% Be and Al Particulates	Filter Performance Test	See Sections 3.3.6 and 3.3.7
S-127 (1) T-350 (2)	Air Curtain Destructors (3)	No						See Sections 3.1.6 and 3.1.7
TA-16-1484-BS-1	Low NO_x Boiler	No						See Sections 3.4.6 and 3.4.7
TA-16-1484-BS-2	Low NO_x Boiler	No						See Sections 3.4.6 and 3.4.7
TA-16-1485-BS-1	Low NO_x Boiler	No						See Sections 3.4.6 and 3.4.7
TA-16-1485-BS-2	Low NO_x Boiler	No						See Sections 3.4.6 and 3.4.7
TA-48-1-BS-1	Boiler	No						See Sections 3.4.6 and 3.4.7
TA-48-1-BS-2	Boiler	No						See Sections 3.4.6 and 3.4.7
TA-48-1-BS-6	Boiler	No						See Sections 3.4.6 and 3.4.7
TA-53-365-BHW-1	Boiler	No						See Sections 3.4.6 and 3.4.7
TA-53-365-BHW-2	Boiler	No						See Sections 3.4.6 and 3.4.7

SECTION 6 - AIR POLLUTION UNITS and CONTROL EQUIPMENT DATA [102]: (Paragraphs 5.e and 7.a of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 5)

(Continued)

Emission Unit No.[103]	Process or Operation [104]	Is Air Pollution Control Equipment Installed (Yes/No) [105]	Air Pollution Control Equipment No.[106]	AIR POLLUTION CONTROL EQUIPMENT DATA		AIR POLLUTION CONTROL EQUIPMENT EFFICIENCY DATA		Applicable Requirements for this Process and/or Control [107]
				Equipment Type [108]	Manufacturer and Model No. [109]	% by Weight [110]	Method of Determination [111]	
TA-55-6-BHW-1	Boiler	No						See Sections 3.4.6 and 3.4.7
TA-55-6-BHW-2	Boiler	No						See Sections 3.4.6 and 3.4.7
TA-59-1-BHW-1	Boiler	No						See Sections 3.4.6 and 3.4.7
TA-59-1-BHW-2	Boiler	No						See Sections 3.4.6 and 3.4.7
TA-50-2	Boiler	No						See Sections 3.4.6 and 3.4.7
N/A	Remaining Exempt Boilers and Process Heaters	No						See Sections 3.4.6 and 3.4.7
TA-3-22-1 TA-3-22-2 TA-3-22-3	Power Plant Boilers (3)	Yes	1	Flue Gas Recirculation Fans	Robinson Industries	Average 70% reduction of NO_x	2002 Source Test	See Sections 3.10.6 and 3.10.7
TA-21-357-1 TA-21-357-2 TA-21-357-3	Steam Plant Boilers (3)	No						See Sections 3.13.6 and 3.13.7
TA-33-G-1	Generator	No						See Sections 3.8.6 and 3.8.7
TA-15-563	Carpenter Shop	No						See Sections 3.5.6 and 3.5.7
TA-3-38	Carpenter Shop	No						See Sections 3.5.6 and 3.5.7

SECTION 6 - AIR POLLUTION UNITS and CONTROL EQUIPMENT DATA [112]: (Paragraphs 5.e and 7.a of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 5)

(Continued)

Emission Unit No.[113]	Process or Operation [114]	Is Air Pollution Control Equipment Installed (Yes/No) [115]	Air Pollution Control Equipment No.[116]	AIR POLLUTION CONTROL EQUIPMENT DATA		AIR POLLUTION CONTROL EQUIPMENT EFFICIENCY DATA		Applicable Requirements for this Process and/or Control [117]
				Equipment Type [118]	Manufacturer and Model No. [119]	% by Weight [120]	Method of Determination [121]	
TA-52-11	Paper Shredder	Yes	1	Cyclone	Security Engineered Machinery (SEM)	90	Manufacturer's Rating	See Sections 3.9.6 and 3.9.7
TA-55-DG-1 TA-55-DG-2 TA-55-DG-3	Degreasers (3)	No						See Sections 3.7.6 and 3.7.7
TA-21-RC	Rock Crusher	Yes	1	Water Spray	N/A	92	EPA's AP-42, 1995, Section 11.19.2-2	See Sections 3.12.6 and 3.12.7
TA-15-435	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-15-436	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-15-461	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-15-462	Storage Tank	No						See Sections 3.14.6 and 3.14.7

SECTION 6 - AIR POLLUTION UNITS and CONTROL EQUIPMENT DATA [122]: (Paragraphs 5.e and 7.a of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 5)

(Continued)

Emission Unit No.[123]	Process or Operation [124]	Is Air Pollution Control Equipment Installed (Yes/No) [125]	Air Pollution Control Equipment No.[126]	AIR POLLUTION CONTROL EQUIPMENT DATA		AIR POLLUTION CONTROL EQUIPMENT EFFICIENCY DATA		Applicable Requirements for this Process and/or Control [127]
				Equipment Type [128]	Manufacturer and Model No. [129]	% by Weight [130]	Method of Determination [131]	
TA-15-473	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-15-474	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-35-197	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-36-141	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-36-142	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-53-640	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-53-1058	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-53-1071-A	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-53-1071-B	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-53-1071-C	Storage Tank	No						See Sections 3.14.6 and 3.14.7
TA-3-779	Storage Tank	No						See Sections 3.14.6 and 3.14.7

SECTION 7 - AIR POLLUTION EMISSION RATES [132]: (Paragraph 5.c of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 6, and tank-flashing emissions estimates.)

(Use additional sheets if necessary)

Emission Unit No.[133]	ALLOWABLE AIR POLLUTANT EMISSION RATES (after control equipment) [134]												Emission Rate Units in
	Pollutant-1 NO_x	Pollutant-2 CO	Pollutant-3 SO_x	Pollutant-4 PM	Pollutant-5 PM_{10}	Pollutant-6 VOC	Pollutant-7 HAP	Pollutant-8 Be	Pollutant-9 Al	Pollutant-10 ----------	Pollutant-11 ----------	Pollutant-12 ----------	
S-127 (1) T-350 (2) Air Curtain Destructors (3)[g]													pounds/hr
	38.2	23.7	2.0	32.4	24.4	61.3	5.6	--	--				tons/yr
TA-3-73 Barber-Greene Asphalt Plant[g]	--	--	--	33.8	--	--	--	--	--				pounds/hr
	0.16	2.60	0.03	0.46	0.46	0.05	0.05	--	--				tons/yr
TA-60-BDM BDM Engineering Asphalt Plant[g]	--	--	--	35.4	--	--	--	--	--				pounds/hr
	0.16	2.60	0.03	0.06	0.06	0.05	0.05	--	--				tons/yr
TA-35-213 Beryllium Machining													pounds/hr
	--	--	--	--	--	--	--	0.36 gm/yr	--				gm/yr
TA-3-141 Beryllium Machining													pounds/hr
	--	--	--	--	--	--	--	3.5 gm/yr	--				gm/yr
TA-3-102 Beryllium Machining													pounds/hr
	--	--	--	--	--	--	--	0.064 gm/yr	--				gm/yr
TA-55-PF4 Beryllium Machining													pounds/hr
	--	--	--	--	--	--	--	2.99 gm/yr	2.99 gm/yr				gm/yr
TA-55-1 TA-55-2 TA-55-3 Degreasers[g]													pounds/hr
	--	--	--	--	--	0.1	0.1	--	--				tons/yr

SECTION 7 - AIR POLLUTION EMISSION RATES [135]: (Paragraph 5.c of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 6, and tank-flashing emissions estimates.)

(Continued)

Emission Unit No.[136]	ALLOWABLE AIR POLLUTANT EMISSION RATES (after control equipment) [137]												Emission Rate Units in
	Pollutant-1 NO_x	Pollutant-2 CO	Pollutant-3 SO_x	Pollutant-4 TSP	Pollutant-5 PM_{10}	Pollutant-6 VOC	Pollutant-7 HAP	Pollutant-8 Be	Pollutant-9 Al	Pollutant-10 ________	Pollutant-11 ________	Pollutant-12 ________	
TA-16-1484-BS-1 TA-16-1484-BS-2 TA-16-1485-BS-1 TA-16-1485-BS-2 TA-48-BS-1 TA-48-BS-2 TA-48-BS-6 TA-53-365-BHW-1 TA-53-365-BHW-2 TA-55-6-BHW-1 TA-55-6-BHW-2 TA-59-BHW-1 TA-59-BHW-2 TA50-2 & All Remaining Exempt Boilers and Process Heaters[(g)]													pounds/hr
	37.2	31.9	0.3	3.3	3.3	2.4	0.8	--	--				tons/yr
TA-3-22-1 TA-3-22-2 TA-3-22-3 Boilers	9.0/9.9	7.4/6.8	2.6/68.7	1.4/2.7	1.4/2.7	1.0/0.3	--	--	--				pounds/ hr/boiler[(i)]
	99.6	81.3	36.9	15.7	15.7	11.1	3.8[(g)]	--	--				tons/yr
TA-21-357-1 TA-21-357-2 TA-21-357-3 Steam Plant Boilers[(g)]													pounds/hr
	3.1	2.5	0.3	0.2	0.2	0.2	0.06	--	--				tons/yr
TA-33-G-1 Generator	40.3	33.7	5.5	1.4	1.4	0.7	--	--	--				pounds/hr
	18.1	15.2	2.5	0.6	0.6	0.3	0.01	--	--				tons/yr
LANL-FW-CHEM Facility-Wide Chemical Use[(g)]													pounds/hr
	--	--	--	--	--	30	13	--	--				tons/yr
TA-15-563 Carpenter Shop[(g)]													pounds/hr
	--	--	--	2.81	2.81	--	--	--	--				tons/yr

SECTION 7 - AIR POLLUTION EMISSION RATES [138]**:** (Paragraph 5.c of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 6, and tank-flashing emissions estimates.)

(Continued)

Emission Unit No.[139]	ALLOWABLE AIR POLLUTANT EMISSION RATES (after control equipment) [140]												Emission Rate Units in
	Pollutant-1 NO_x	Pollutant-2 CO	Pollutant-3 SO_x	Pollutant-4 TSP	Pollutant-5 PM_{10}	Pollutant-6 VOC	Pollutant-7 HAP	Pollutant-8 Be	Pollutant-9 Al	Pollutant-10 ______	Pollutant-11 ______	Pollutant-12 ______	
TA-3-38 Carpenter Shop[(g)]													pounds/hr
	--	--	--	3.07	3.07	--	--	--	--				tons/yr
TA-52-11 Paper Shredder[(g)]													pounds/hr
	--	--	--	13	13	--	--	--	--				tons/yr
TA-21-RC Rock Crusher	6.2	1.3	0.4	--	--	0.5	--	--	--				pounds/hr
	6.4	1.4	0.4	0.98	0.71	0.5	0.0096	--	--				tons/yr
TA-3-779 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	0.03	0.03	--	--				tons/yr
TA-15-435 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-15-436 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr

SECTION 7 - AIR POLLUTION EMISSION RATES [141]: (Paragraph 5.c of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 6, and tank-flashing emissions estimates.)

(Continued)

Emission Unit No.[142]	**ALLOWABLE AIR POLLUTANT EMISSION RATES (after control equipment) [143]**												**Emission Rate Units in**
	Pollutant-1 NO_x	**Pollutant-2** CO	**Pollutant-3** SO_x	**Pollutant-4** TSP	**Pollutant-5** PM_{10}	**Pollutant-6** VOC	**Pollutant-7** HAP	**Pollutant-8** Be	**Pollutant-9** Al	**Pollutant-10** ———	**Pollutant-11** ———	**Pollutant-12** ———	
TA-15-461 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-15-462 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-15-473 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-15-474 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-35-197 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-36-141 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-36-142 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-53-640 Storage Tank[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr

SECTION 7 - AIR POLLUTION EMISSION RATES [144]: (Paragraph 5.c of Subsection D of 20.2.70.300 NMAC)
(List all Air pollution units of plant, including the units listed in Sections 3 thru 6, and tank-flashing emissions estimates.) (Continued)

Emission Unit No.[145]	**ALLOWABLE AIR POLLUTANT EMISSION RATES (after control equipment) [146]**												**Emission Rate Units in**
	Pollutant-1 NO_x	**Pollutant-2** CO	**Pollutant-3** SO_x	**Pollutant-4** TSP	**Pollutant-5** PM_{10}	**Pollutant-6** VOC	**Pollutant-7** HAP	**Pollutant-8** Be	**Pollutant-9** Al	**Pollutant-10** ________	**Pollutant-11** ________	**Pollutant-12** ________	
TA-53-1058[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-53-1071-A[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-53-1071-B[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
TA-53-1071-C[(g)]													pounds/hr
	--	--	--	--	--	<0.03	--	--	--				tons/yr
													pounds/hr
													tons/yr
													pounds/hr
													tons/yr
													pounds/hr
													tons/yr
													pounds/hr
													tons/yr
													pounds/hr
													tons/yr

SECTION 8 - STACK PARAMETERS [147]: (Paragraph 5.h of Subsection D of 20.2.70.300 NMAC)
(Complete only if dispersion modeling is required or if there is an applicable requirement for stack parameters)

(Use additional sheets if necessary)

Stack No. [148]	Emission Unit No. [149]	Stack Height (ft) [150]	Stack Inside Exit Diameter (ft) [151]	Stack Direction [152]	STACK EXIT GAS CONDITIONS [153]		
					Temp. (°F)	Velocity (ft/sec) [154]	Moisture % by Vol
N/A							

SECTION 9 - COMPLIANCE MONITORING DEVICES AND EQUIPMENT [155]: (Paragraph 5.e of Subsection D of 20.2.70.300 NMAC)
(Use additional sheets if necessary)

Monitor Unit No. [156]	Parameter To Be Monitored [157]	Pollutant To Be Monitored or Measured [158]	Type of Monitor or Instrument [159]	Monitor Manufacturer and Model Number	Range [160]	Sensitivity [161]	Accuracy [162]	Monitored Emission Unit No. [163]	Location of Monitor [164]
1	Particulate Emissions	Beryllium	Continuous Air Monitor (CAM)	Graseby Anderson Model RF-02-111	N/A	0.005μg	approx. 20%	TA-3-141	Sampling probe located on exhaust stack, filter sent to lab weekly
1	Fuel Flow	N/A	Volumetric Flow Meter	Roots Model 175/CD	0-9,999,999 ft^3	1 ft^3	1%	TA-16-1484-BS-1 TA-16-1484-BS-2	Fuel Inlet, readings taken in field
1	Fuel Flow	N/A	Volumetric Flow Meter	Roots Model 175/CD	0-9,999,999 ft^3	1 ft^3	1%	TA-16-1485-BS-1 TA-16-1485-BS-2	Fuel Inlet, readings taken in field
1	Fuel Flow	N/A	Volumetric Flow Meter	Equimeter Model 4" T-18 MK II	0-9,999,999 ft^3	1 ft^3	1%	TA-55-6-BHW-1	Fuel Inlet 12 feet from burners. Readings taken monthly
1	Fuel Flow	N/A	Volumetric Flow Meter	Equimeter Model 4" T-18 MK II	0-9,999,999 ft^3	1 ft^3	1%	TA-55-6-BHW-2	Fuel Inlet 12 feet from burners. Readings taken monthly
1	Natural Gas Fuel Flow	N/A	Volumetric Flow Meter	ABB/Bailey/Fisher & Porter Model 10SM1000 Swirlmeter and 50VM1000 Vortex 4 Flow Computer	3-210 kSCF/hr	0.02 kSCF/hr	0.5%	TA-3-22-1 TA-3-22-2 TA-3-22-3	Fuel Inlet 40 feet prior to burners, recorder in control room
2	No. 2 Fuel Oil Fuel Flow	N/A	Volumetric Flow Meter	Bailey Model BQ74221	4-1576 gal/hr	2 gal/hr	5%	TA-3-22-1 TA-3-22-2 TA-3-22-3	Fuel Inlet 10 feet prior to burners, recorder in control room
1	Natural Gas Fuel Flow	N/A	Volumetric Flow Meter	Bailey Model B074221 and Rosemount Model 1151DP4E12B1	1-16 kSCF/hr	0.02 kSCF/hr	10%	TA-21-357-1 TA-21-357-2 TA-21-357-3	Fuel Inlet 6 feet prior to burners, recorder in control room
2	No. 2 Fuel Oil Fuel Flow	N/A	Volumetric Flow Meter	Taylor Model 503TB-01260-A0100-1000	1-150 gal/hr	0.5 gal/hr	5%	TA-21-357-1 TA-21-357-2 TA-21-357-3	Fuel Inlet 12 feet prior to burners, recorder in control room.
1	Kilowatt		Kilowatt-hour Meter	N/A[j]	N/A[j]	N/A[j]	N/A[j]	TA-33-G-1	N/A[j]

SECTION 10 - STRATOSPHERIC OZONE PROTECTION PROGRAM (Title VI, Clean Air Act Amendments)
Please answer the following questions to determine the applicability of 40 CFR 82, Subparts A through G, to your facility.

1. Does your facility have any air conditioners or refrigeration equipment that uses CFCs, HCFCs or other ozone-depleting substances? ___X___yes _______no

2. Does any air conditioner(s) or any piece(s) of refrigeration equipment contain a refrigeration charge greater than 50 lbs? _____X____yes ________ no (If the answer is yes, describe what type of equipment and how many units are at the facility.)

Refrigerant Type	Number of Units[1]
CFC-11	11
CFC-12	13
HCFC-123	13
HCFC-22	146
HFC-134A	1
R-401A	4
R-401B	1
R-502	4
R-507A	2

[1]These numbers will change due to retrofitting, replacements, and disposals and should be considered estimates.

3. Do your facility personnel maintain, service, repair, or dispose of any motor vehicle air conditioners (MVACs) or appliances ("appliance" and "MVAC" as defined at 82. 152)? ____X______ yes _______no

4. Cite and describe which Title VI requirements are applicable to your facility (i.e. 40CFR Part 82, Subpart A through G.)________________________________

40 CFR Part 82, Subpart A, Production and Consumption Controls
40 CFR Part 82, Subpart B, Servicing of Motor Vehicle Air Conditioners
40 CFR Part 82, Subpart F, Recycling and Emissions Reduction
40 CFR Part 82, Subpart G, Significant New Alternatives Policy Program
40 CFR Part 82, Subpart H, Halon Emissions Reduction

SECTION 11 - CERTIFICATION

I, Ralph E. Erickson and James L. Holt, hereby certify on behalf of Los Alamos National Laboratory, that the information and data submitted in this application package are as complete, true and accurate as possible, to the best of my personal knowledge and professional expertise and experience.

Signed this 26th day of November, 2002, upon my oath of affirmation, before a notary of the State of New Mexico.

______________________________ ____________________

SIGNATURE (Responsible Company Official) DATE

Ralph E. Erickson Director, Office of Los Alamos Site Operations

PRINTED NAME Title

US Department of Energy, National Nuclear Security Administration

Company

______________________________ ____________________

SIGNATURE (Responsible Company Official) DATE

James L. Holt Associate Director for Operations

PRINTED NAME Title

University of California, Los Alamos National Laboratory

Company

Subscribed and sworn to before me on this _____ day of ______________, 20_____.

My authorization as a Notary of the State of ____________________ expires on the _______ day of _____________, 20______.

_________________________ ____________________

NOTARY'S SIGNATURE DATE

_________________________ ____________________

NOTARY'S PRINTED NAME NOTARY SEAL

(a) LANL does not process raw materials. Streams processed are wastes in equipment including the rock crusher, paper shredder, and the air curtain destructors.

(b) LANL is proposing a fuel usage limit of 870 MMscf/yr for all boilers and process heaters described in Chapter 3.4.

(c) These boilers and process heaters are exempted as insignificant activities, but are listed to show that the proposed gas usage limit of 870 MMscf/yr takes into account these units as well as the remaining boilers and heaters from Section 3.4.

(d) Fuel quantity for the asphalt plant heaters have not been included in Section 5 - Fuel Usage and Fuel Data because the emissions from these heaters are factored into the calculations provided in Section 11.1 of AP-42 for Hot Mix Asphalt Plants. Only the BDM Engineering Asphalt Plant is listed because the Barber-Greene Plant is not subject to sulfur limits on the fuel.

(e) Filters are purchased on a 5 year contractual basis. Contracts are awarded using cost and specification considerations. All HEPA filters must have a manufacturer's filtration efficiency rating of 99.97%. Control efficiency for HEPA filtration is 99.95% as measured by particle filter efficiency testing. The discrepancy between manufacturer's filtration efficiency and installed efficiency rating is due to a small amount of leakage around the seal of an installed filter. The following is a list of some of the manufacturers currently providing filters to the Laboratory: Cambridge; Cam-Farr; Flanders; Donaldson; and American Air. Model numbers will vary between manufacturer and change as new models are introduced.

(f) Baghouses are purchased on a 5 year contractual basis. Contracts are awarded using cost and specification considerations. The following is a list of some of the manufacturers currently providing baghouses to the Laboratory: American Wheelabrator Corp.; Carter Day; and Bin-o-matic.

(g) LANL has included emissions limits for these units to ensure continuity with Chapter 3 emissions information. However, LANL is proposing that these emissions not be enforced as a unit-specific limitation, but rather LANL be subject to facility-wide emissions limitations as discussed in Chapter 2.

(h) A heating value for No. 2 Fuel Oil of 137,000 Btu/gal was used in the calculations for the power plant and 138,500 Btu/gal was used in the FGR permit application.

(i) Pound/hr limits vary depending on the fuel used. Refer to Chapter 3, Table 3.10-1 for more detail regarding when each limit applies.

(j) The TA-33 Generator was issued a permit on October 10, 2002. The generator is currently undergoing installation and a kilowatt meter has not yet been installed.

APPENDIX B

Maps and TA Descriptions

Laboratory Maps and TA Descriptions are not available for distribution. For information about the location of the Los Alamos National Laboratory, please visit http://www.lanl.gov/.

APPENDIX C

Source Test Data for Asphalt Plant

File TA-3-73
Facility Records

TSP AND VISIBLE EMISSIONS PERFORMANCE TESTS

BARBER GREENE ASPHALT BATCH PLANT
LOS ALAMOS NATIONAL LABORATORIES
LOS ALAMOS, NEW MEXICO

KRAMER & ASSOCIATES
ALBUQUERQUE, NEW MEXICO

TSP AND VISIBLE EMISSIONS PERFORMANCE TESTS

BARBER GREENE ASPHALT BATCH PLANT
LOS ALAMOS NATIONAL LABORATORIES
LOS ALAMOS, NEW MEXICO

by

Kramer & Associates, Inc.
4501 Bogan NE, Suite A-1
Albuquerque, NM 87109
505-881-0243

June, 1995

CERTIFICATION

The following report has been reviewed and approved to accurately represent the sampling and analyses actually performed. The results reported are accurate to the best of our knowledge.

Gary R. Kramer, PE

TABLE OF CONTENTS

INTRODUCTION

A. **Reason for Test:** Demonstrate compliance of the source's particulate emissions with respect to NM AQCR #501.

B. **Applicable Standards:** This facility is subject to NM AQCR #501 (PM<33 lb/hr)

C. **Process Description:** Aggregate is dried and batch-mixed with oil to produce an asphaltic concrete paving material.

D. **Company:** Los Alamos National Laboratories
P.O. Box 1663
Los Alamos, NM 87545
Dan McReynolds (505-667-6111)

E. **Facility:** Asphalt Plant
TA-3 Construction Yard just North of Steam Plant

F. **Testing Organization:** Kramer & Associates, Inc.
4501 Bogan NE Suite A-1
Albuquerque, NM 87109
Gary R. Kramer, PE
505-881-0243

G. **Individuals Present for Test:**

(1) Kramer & Associates, Inc. - Gary Kramer, Craig Smedley, and Marc Wright

(2) Johnson Controls - Corinne Willison

H. **Date of Test:** August 23, 1993

I. **Description of Unit Tested:** Barber Greene Asphalt Plant Dryer

J. **Control Equipment:** Multiple Cyclone and Wet Scrubber

SUMMARY

TABLE 1

EMISSIONS TEST DATA SUMMARY

Test No.	Exhaust Flow Rate, ACFM	Emissions, Gr./DSCF	Emissions, Lb/Hr.	Isokinetic Ratio, %
1	27012	0.037	5.21	98.9
2	24286	0.037	4.29	102.5
3	25688	0.028	3.41	104.1

Maximum Allowable Emission Rate (AQCR #501) = 33 lb/hr

Discussion:

Particulate emissions were less than AQCR #501 for each of the three tests. Visible emissions were less than 20% opacity.

Stack velocity pressure data indicate zero velocity at several points in the stack cross section. This profile usually accompanies a cyclonic flow condition; however the measured average cyclonic flow angle (11.9 degrees) was within the allowable for testing (20 degrees). Sample was not collected at the "zero" velocity pressure points, however these points were included in the velocity averaging.

The effects of minor deviations from the Method 5 procedures on the test results are discussed in the Test Procedures Section.

TEST PROCEDURES

A. Schematic of Sampling Locations: See Figure 1.

B. Sampling Systems Schematic: See Figure 2.

C. Test Operating Procedures:

Sampling and analyses procedures generally followed Methods 1-5 of the 40 CFR, Part 60 Appendix A. Samples were taken from a 24-point traverse through a 0.251" nozzle.

Probes, nozzles and all glassware upstream from the filter were washed with acetone into a tared beaker on site or at the KAI Laboratory in Albuquerque. The acetone was evaporated and the residue weighed. Filters were dried in a dessicator at least 24 hours prior to reweighing. All samples were in the custody of KAI personnel at all times.

Visible emissions tests were performed according to Method 9.

D. Deviations from EPA Method 5:

1. Hot box temperature were less than that specified in the method (223 Deg. F) during portions of the test. This would bias the results HIGH (if at all). That is, the TRUE emissions would be LOWER than what was measured. This method deviation does NOT affect compliance status because test results were substantially below the allowable.

2. Silica gel outlet (cold box) temperatures were higher than 70 F. Higher temperatures could affect the reported dry gas collected and the isokinetic ratio. This deviation does not significantly affect the results because the silica gel was not spent (i.e. less than 15 grams water collected) at the conclusion of the test.

3. Sample volume for Test #1 was less than the minimum required by NMED (30 DSCF) in part due to the zero velocity portions of the stack. This deviation does not significantly affect the results because: a) the quantity of particulates collected (51 mg) was well above the detection limit (0.5 mg), and b).the results from Test #1 did not significantly vary from Tests #2 and #3.

In summary, the method deviations did not bias the test results or affect the compliance status of the source with respect to NM AQCR 501.

E. Test Instrumentation:

1). MISCO Model 7200 Source Sampler

2). Burrell Industro Model Gas Analyzer (ORSAT)

F. Plant Operating Parameters:

Plant operating data were not recorded during the tests. The plant was operated in a "dry-batch" mode at approximately 60 tons per hour during all tests because of inadequate asphalt product demand. "Dry-batch" operation is identical to normal operation with regard to scrubber emissions because asphalt batch mixing emissions are NOT vented to the scrubber. Only aggregate drying is vented to the scrubber tested.

POINTS ON TRAVERSE

1 1/8"
3 5/8
6 3/8
9 1/2
13 1/2
19 1/8
34 3/8
40 3/8
44 1/4
47 3/8
50 1/8
52 5/8

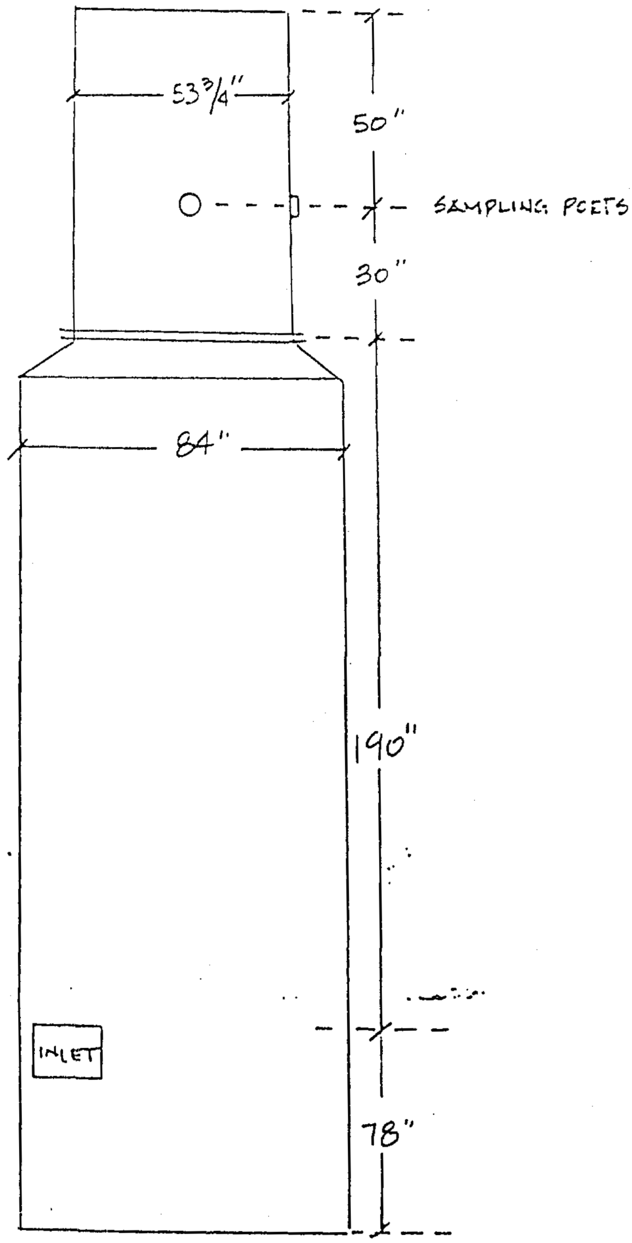


FIGURE 1

SAMPLING LOCATION SCHEMATIC

BARBER-GREENE ASPHALT BATCH PLANT

LOS ALAMOS NATIONAL LABORATORY

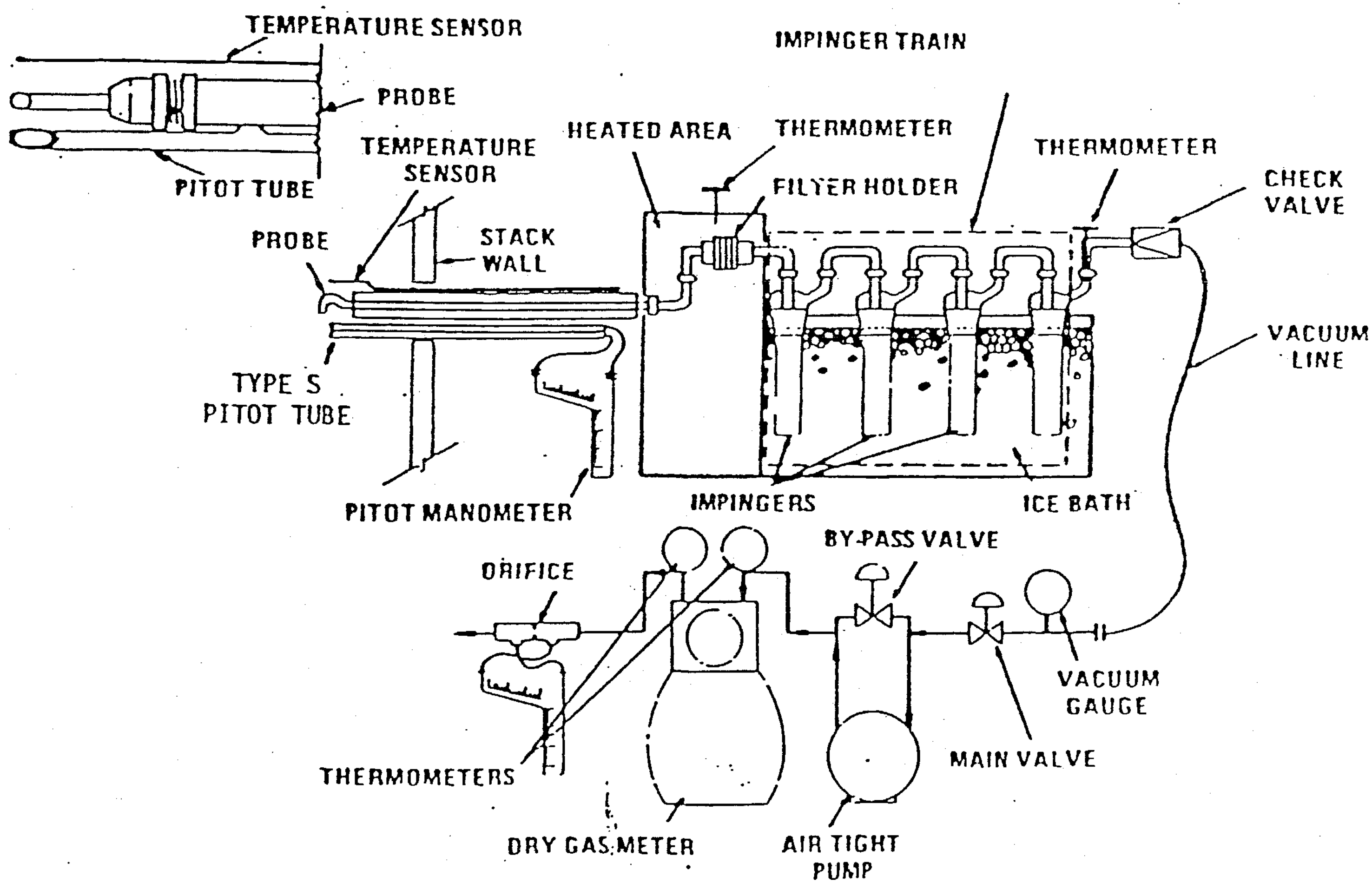


FIGURE 2

METHOD 5 SAMPLING TRAIN SCHEMATIC

DATA AND CALCULATIONS

A. Field Sampling Data and Calculations Summary:

This section contains the following:

1. Computer Analyses Data Summary
2. Field Data including Cyclonic Flow and Opacity
3. Computer Routine Listing (GW Basic)

B. Instrument calibrations: see Appendix 1.

C. Chain of Custody: All samples were in the custody of KAI personnel at all times.

TABLE 1

SOURCE TESTING TSP DATA SUMMARY

BARBER GREENE ASPHALT BATCH PLANT

LOS ALAMOS NATIONAL LABORATORIES

SAMPLING DATA	TEST #1	TEST #2	TEST #3
TEST STARTING TIME	1130	1430	1640
ACTUAL METERED CUBIC FEET	27.3	47.437	40.33
BAROMETRIC PRESSURE, (IN HG)	23.65	23.65	23.65
AVERAGE GAS METER TEMPERATURE (F)	91.79	100.72	98.31
AVERAGE GAS METER COEFFICIENT	1.024	1.024	1.024
MILLILITERS WATER COLLECTED	80.5	201	174
MILLIGRAMS PARTICULATES COLLECTED	51.2	87.1	57.2
CARBON DIOXIDE IN STACK GAS, %	3.1	3.3	3.6
OXYGEN IN STACK GAS, %	15.5	15.1	15.2
STATIC PRESSURE IN STACK (IN HG)	23.65	23.65	23.65
AVERAGE STACK TEMPERATURE, (F)	124.58	135.12	137.37
S-PITOT CORRECTION FACTOR	.76	.85	.85
AVG SQUARE ROOT VEL PRES (IN H2O)	.4642	.3657	.3863
AREA OF STACK, (SQ.FT)	15.76	15.76	15.76
SAMPLING TIME, (MINUTES)	60	120	96
NOZZLE DIAMETER, (INCHES)	.251	.251	.251
AVG ORIFICE DELTA P, (IN H2O)	.785	.686	.749

CALCULATED RESULTS	TEST #1	TEST #2	TEST #3
CORRECTED METER VOLUME (DSCF)	21.19	36.23	30.94
VOLUME H2O COLLECTED (SCF)	3.78	9.46	8.19
PERCENT H2O IN STACK GAS	15.1	20.7	20.9
MOLE WT STACK GAS (WET)	27.53427	26.92125	26.9383
MOLE FRACTION DRY STACK GAS	.849	.793	.791
AVG STACK VELOCITY, (FPM)	1714	1541	1630
AVG STACK FLOW (DSCFM)	16435	13557	14250
AVG STACK FLOW (ACFM)	27012	24286	25688
ISOKINETIC RATIO, %	98.9	102.5	104.1
PARTICULATE EMISSION, (GR/DSCF)	.037	.037	.028
PARTICULATE EMISSION, (LBS/HR)	5.21	4.29	3.41

PARTICULATES SAMPLING AND ANALYSIS DATA

Plant Name and Location: JOHNSON CONTROLS - LOS Alamos

Run No. 1 Date 8/25/93 Start Time 1130 Ambient Temp. °F 80

Bar. Press., in. Hg. 23.65 Stack Location scrubber dschg.

Stack Diameter, in. 53.75 Stack Pressure, in Hg 23.65

Plant Operator ______ P_s/P_m 1.0

Processing Rate ______

Test Equipment I.D. MISCO. 7249 Y=1.024

Filter No. 4 Acetone Jar No. 5 Acetone Bkr No. 1

Probe Tip Diameter, in. 0.251 Assumed Moisture, % 15

Probe Length, Ft. 7½' SS = Cp 0.76 ΔH@ 1.80

Calculator Setting ΔP=1.0 ΔH=2.45

36.8
14.0
51.2 mg

Orsat Analysis Data

CO_2	3.4	3.2	3.0	3.0
$CO_2 + O_2$	18.8	18.6	19.2	18.5
$CO_2 + O_2 + CO$				

Moisture Content

Impinger #1	156
Impinger #2	114
Impinger #3	—
Total initial H_2O	200
Net Impinger H_2O	70
Net H_2O in Silica Gel	10.5
Total H_2O Collected	80.5

Leak Test

Initial 0.01 cfm @ 10" Hg

Final 0.01 cfm @ 10" Hg

PARTICULATES SAMPLING DATA

Plant Name and Location Los Alamos Asphalt Plant JCF Run No. 1

Point	Time	Gas Meter Rdg. Ft^3	ΔP Pitot Rdg. "H_2O	Orifice ΔH "H_2O Desired	Orifice ΔH "H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Vacuum "Hg. gauge	Hot Box Temp. °F	Impinger Temp. °F	Stack Temp. °F	ΔP "H_2O
1	0	569.610	0.66	1.60	1.60	82	81	3	145	75	118	
2	2.5	71.575	0.64	1.55	1.55	86	82	3	135	66	119	
3	5	73.44	0.61	1.50	1.50	84	84	3	140	68	115	
4	7.5	75.37	0.53	1.30	1.30	91	85	2	145	61	115	
5	10	77.02	0.39	0.98	0.98	91	85	1	141	67	115	
6	12.5	78.55	0.23	0.56	0.56	93	86	<1	147	64	120	
7	15	79.72	0.08	0.20	0.20	90	86	<1	150	68	119	
8		80.48	0									
9			0									
10			0									
11	17.5	80.48	0.23	0.56	0.56	89	88	1	170	57	124	
12	20	81.79	0.40	1.0	1.0	91	89	2	173	60	124	
	22.5	83.32										
13	0	83.32	0.45	1.10	1.10	93	93	2	170	70	126	
14	2.5	85.03	0.23	0.56	0.56	96	94	1	173	59	130	
15	5	86.2	0									
16			0									
7			0									
8			0									
9	.5	86.2'	0.40	1.0	1.0	95	94	2	180	60	128	

PARTICULATES SAMPLING DATA

Plant Name and Location Los Alamos Asph Plt JCT Run No. 1

Point	Time	Gas Meter Rdg. Ft^3	ΔP Pitot Rdg. "H_2O	Orifice ΔH "H_2O Desired	Orifice ΔH "H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Vacuum "Hg. gauge	Hot Box Temp. °F	Impinger Temp. °F	Stack Temp. °F	ΔP "H_2O
20	5	87.7	0.45	1.1	1.1	95	94	2	180	72	127	
21	7.5	89.4	0.50	1.25	1.25	97	95	2	175	105	129	
22	10	91.2	0.60	1.50	1.50	100	95	3	177	70	132	
23	12.5	93.15	0.61	1.50	1.50	101	96	3	178	73	136	
24	15	95.08	0.65	1.60	1.60	103	96	4	175	74	129	
	17.5	96.970										
		27.3										

PARTICULATES SAMPLING AND ANALYSIS DATA

Plant Name and Location Los Alamos Asphalt Plant

Run No. 2 Date 8/5/93 Start Time 1430 Ambient Temp. °F ____

Bar. Press.,in. Hg. 23.65 Stack Location Scrubber Dschg

Stack Diameter, in. 53.75 Stack Pressure, in Hg 23.65

Plant Operator ____ P_s/P_m 1.0

Processing Rate ____

Test Equipment I.D. MISCO Y= 1.024

Filter No. 151 Acetone Jar No. 6 Acetone Bkr No. 2

Probe Tip Diameter, in. 0.251 Assumed Moisture, % 15

Probe Length, Ft. 7' glass Cp 0.85 Δ H@ 0.8

Calculator Setting ΔP= 1.0 ΔH= 3.1

65.6
21.5
87.1

Orsat Analysis Data

CO_2	3.0	3.4	3.4	3.3
CO_2+ O_2	18.0	18.4	18.6	15.1
CO_2+ O_2+ CO				

Moisture Content

Impinger #1	254
Impinger #2	134
Impinger #3	—
Total initial H_2O	200
Net Impinger H_2O	188
Net H_2O in Silica Gel	13
Total H_2O Collected	201

Leak Test

Initial 0.008 cfm @ 8" Hg

Final 0.002 cfm @ 6" Hg

PARTICULATES SAMPLING DATA

Plant Name and Location Los Alamos Run No. 2

Point	Time	Gas Meter Rdg. Ft^3	ΔP Pitot Rdg. "H_2O	Orifice ΔH "H_2O Desired	Orifice ΔH "H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Vacuum "Hg. gauge	Hot Box Temp. °F	Impinger Temp. °F	Stack Temp. °F	ΔP "H_2O
1	0	601.40	0.59	1.80	1.80	93	92	5	197	69	129	
2	5	5.5	0.52	1.75	1.75	96	92	6	173	67	135	
3	10	9.5	0.50	1.55	1.55	100	92	6	180	70	134	
4	15	13.35	0.45	1.35	1.35	99	92	5	181	68	131	
5	20	16.93	0.32	1.0	1.0	102	94	2	185	65	132	
6	25	20.07	0.10	0.32	0.32	103	96	<1	170	68	135	
7-11		—	0	0	0							
12	30	21.845	0.20	0.62	0.62	100	100	<1	180	68	134	
	35	24.415										
13	0	24.415	0.55	1.65	1.65	99	101	<1	201	69	140	
14	5	28.135	0.50	1.40	1.40	106	99	5	250	69	137	
15	10	32.0	0.52	1.45	1.45	110	100	5	224	70	134	
16	15	35.75	0.45	1.30	1.30	108	100	4	231	73	133	
17	20	39.21	0.35	1.0	1.0	110	101	4	234	70	134	
18	25	42.30	0.14	0.40	0.40	107	101	<1	243	75	130	
-10	30	44.43	0	0	0							
1	30	44.43	0.15	0.44	0.44	105	103	<1	201	78	140	
2	35	46.8	0.15	0.44	0.44	102	102	<1	170	76	133	
	40	48.837										

47.437

PARTICULATES SAMPLING AND ANALYSIS DATA

Plant Name and Location Los Alamos Asphalt Plant - JCI

Run No. 3 Date 8/25/93 Start Time 1640 Ambient Temp. °F 80

Bar. Press., in. Hg. ~~26~~ 23.65 Stack Location Scrubber Dschg

Stack Diameter, in. 53.75 Stack Pressure, in Hg 23.65

Plant Operator Lenny P_s/P_m 1.00

Processing Rate

Test Equipment I.D. KUSCO Y=1.024

Filter No. WA 4 Acetone Jar No. 8 Acetone Bkr No. 7

Probe Tip Diameter, in. 0.251 Assumed Moisture, % 16

Probe Length, Ft. 7' Glass Cp 0.85 Δ H@ 1.8

Calculator Setting ΔP=1.0 ΔH=3.1

41.9
15.3
57.2

Orsat Analysis Data

CO_2	3.4	3.8	3.8	3.6
$CO_2 + O_2$	18.8	19.0	18.8	15.2
$CO_2 + O_2 + CO$				

Moisture Content

Impinger #1	229
Impinger #2	131
Impinger #3	—
Total initial H_2O	200
Net Impinger H_2O	160
Net H_2O in Silica Gel	13.8
Total H_2O Collected	173.8

Leak Test

Initial 0.02 cfm@6"Hg

Final 0.006 cfm@6"Hg

PARTICULATES SAMPLING DATA

Plant Name and Location Los Alamos Asphalt Plt. JCI Run No. 3

Point	Time	Gas Meter Rdg. Ft^3	ΔP Pitot Rdg. "H_2O	Orifice ΔH "H_2O Desired	Orifice ΔH "H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Vacuum "Hg. gauge	Hot Box Temp. °F	Impinger Temp. °F	Stack Temp. °F	ΔP "H_2O (CYCLONIC ANGLE OF ROTATION)
1	0	649.00	0.57	1.8	1.8	96	95	6	176	70	132	5
2	4	52.2	0.57	1.8	1.8	100	96	6	192	68	132	5
3	8	55.42	0.50	1.55	1.55	104	95	5	212	74	134	15
4	12	58.44	0.40	1.25	1.25	104	95	5	235	75	139	13
5	16	61.25	0.27	0.84	0.84	106	95	2	227	76	137	20
6	20	63.6	0.13	0.40	0.40	100	95	<1	197	81	138	15
7-10	24		0									0
11	24	65.135	0.08	0.25	0.25	98	95	<1	205	84	139	20
12	28	66.40	0.35	1.10	1.10	98	95	3	208	80	138	25
	32	68.945										
13	0	68.945	0.52	1.60	1.60	98	99	5	217	81	142	10
14	4	72.01	0.52	1.60	1.60	101	98	5	209	79	137	10
15	8	75.17	0.50	1.55	1.55	104	98	5	227	74	139	10
16	12	78.05	0.40	1.25	1.25	107	98	5	227	73	139	14
17	16	81 —	0.35	1.10	1.1	109	99	3	232	71	135	18
18	20	83.6	0.10	0.32	0.32	103	98	<1	234	77	136	21
19-22	24	85.03	0									0
23	24	85.03	0.15	0.47	0.47	97	95	<1	207	76	140	4
24	28	86.78	0.35	1.1	1.10	92	92	3	213	73	137	10
	32	89.331										

AVE = 11.9°

ACETONE WASH AND FILTER WEIGHT RECORDS

Facility Barber - Greene Batch Plant

Testing Dates 8/25/93

Date of Tare Weighing 8/19/93 Weighed By MRW

Date of Final Weighing 8/26/93 Weighed by MRW

I.D. No.	Tare Wt.	Final Wt (1)	Final Wt (2)	Net Wt., mg
US 4	.7776	.8144	0.8145	36.8
WA 1	.7873			
US 3	.7877			
US 1	.7832	.8488	0.8488	65.6
WA 4	.7863	.8282	0.8280	41.9
Beaker 1	65.9875	66.0019	66.0020	14.4
Beaker 2	65.6446	65.6661	66.6662	21.5
Beaker 3	83.1226	83.1379	83.1378	15.3

KRAMER & ASSOCIATES

engineers/environmental consultants

RECORD OF VISUAL DETERMINATION OF OPACITY

Company: Barber-Greene Asphalt Batch Plant - Johnson Controls

Location: Los Alamos Observer: Craig Smedley

Test Number: 1 Observer Certification Date: 4-93

Date: 8-25-93 Observer Affiliation: Kramer + Associates

Type of Facility: Asphalt Point of Emission: Top of stack

Control Device: Cyclones Height of Discharge Point: 35'

	Initial	Final
Clock Time	5:11	5:21
Observer Location		
Distance to Discharge	70'	70'
Direction from Discharge	W	W
Height of Observation Pt.	Ground	Ground
Background Description	Blue Sky	Blue Sky
Weather Conditions		
Wind Direction	N	N
Wind Speed	0-3 mph	0-3 mph
Ambient Temperature	86°	86°
Sky Condition (clear, overcast, % clouds, etc.)	Clear	Clear
Plume Description		
Color	white	white
Distance Visible	10-40'	10'-40'
Other Information		

Record Opacity in %
5% Smallest Division

min \ sec	.0	15	30	45
1	5	5	5	0
2	5	5	5	5
3	5	5	5	5
4	5	5	0	0
5	0	5	5	5
6	5	0	5	5
7	0	5	5	5
8	0	5	5	5
9	5	0	5	5
10	0	0	0	0

OPACITY AVERAGE

Sum of No. Recorded: 145

Sum No. of Readings: 40

Average Opacity: 3.6%

Opacity Range: 0 % to 5 %

Comments: Steam Plume

Craig A Smedley
Observer's Signature

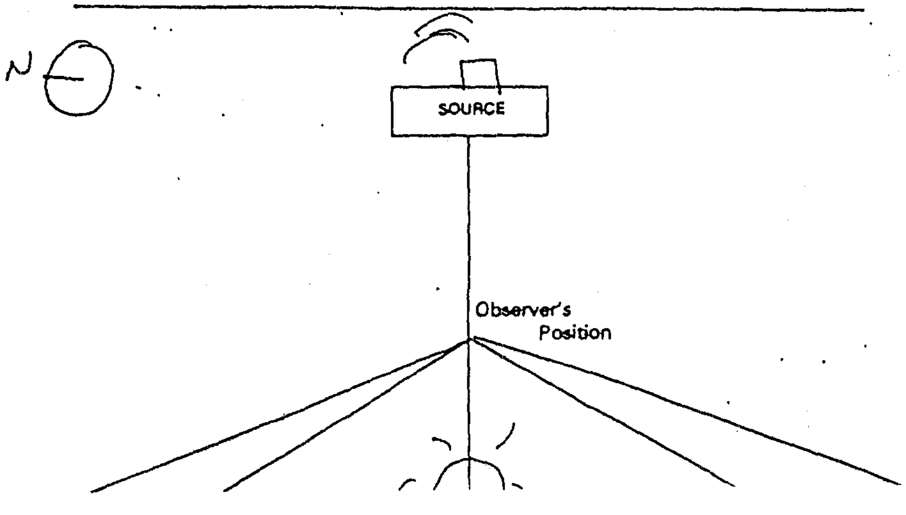
Owner or Manager of Operation

IMPORTANT: Please indicate the following by sketch:

Plume Direction

Sun

North



```
2 REM
3 REM ********  K R A M E R   &   A S S O C I A T E S  ***********
4 REM
; REM *** PARTICULATES SAMPLING DATA ANALYSIS PROGRAM ***
8 REM
12 REM ***NOMENCLATURE: RN(I) = RUN NUMBER                            *
14 REM                   H2O(I) = ML OF WATER COLLECTED               *
16 REM                  CUFT(I) = CUBIC FEET OF GAS SAMPLE            *
18 REM                   CO2(I) = % CARBON DIOXIDE IN STACK GAS       *
20 REM                    O2(I) = % OXYGEN IN STACK GAS               *
22 REM                    MG(I) = MILLIGRAMS PARTICULATE COLLECTED    *
24 REM                     Y(I) = DRY GAS METER CALIBRATION COEFF.    *
26 REM ------------------------------------------------------------------
28 REM
30 FOR I = 1 TO 3  STEP 1
32 READ RN(I), H2O(I), CUFT(I), MG(I), CO2(I), O2(I), Y(I)
34 REM
36 REM --------------------------------------------------------------
38 REM ** NOMENCLATURE: PTS(I) = TOTAL NUMBER OF SAMPLING POINTS   *
40 REM                   BP(I) = BAROMETRIC PRESSURE, IN. HG      *
42 REM                   SP(I) = STACK STATIC PRESSURE, IN. HG    *
44 REM                   CP(I) = ORIFICE COEFFICIENT              *
46 REM                 AREA(I) = STACK CROSS SECTIONAL AREA, SQ FT *
48 REM                  TPD(I) = NOZZLE DIAMETER, INCHES          *
50 REM                 TIME(I) = SAMPLING TIME, MINUTES           *
52 REM --------------------------------------------------------------
54 REM
56 REM
58 READ PTS(I), BP(I), SP(I), CP(I), AREA(I), TPD(I), TIME(I)
 0 REM
62 REM *********** CALCULATE AVERAGES OF SAMPLING DATA **************
64 REM
66 A=0:B=0:C=0:D=0:E=0
68 FOR Z=1 TO PTS(I)
70 REM
72 REM ----------------------------------------------------------------------
74 REM ** NOMENCLATURE: DELP = VELOCITY PRESSURE AT A SAMPLING POINT, IN H2O *
76 REM                  DELH = ORIFICE DELTA P, IN. H20                      *
78 REM                   TMI = DRY GAS METER INLET TEMP. F:  (AVG. IS ATM)   *
80 REM                   TMO = DRY GAS METER OUTLET TEMPERATURE, F           *
82 REM                  STKT = STACK TEMPERATURE, DEG. F                     *
84 REM ----------------------------------------------------------------------
86 READ DELP, DELH, TMI, TMO, STKT
90 REM
92 A=A+SQR(DELP): B=B+DELH: C=C+TMI: D=D+TMO: E=E+STKT
94 NEXT Z
96 REM
98 REM *** A( ) REFERS TO "AVERAGE" PARAMETER IN 74-82 ABOVE ****
100 ADELP(I) = INT(10000*A/PTS(I))/10000
105 ADELH(I) = INT(1000*B/PTS(I))/1000
110 ATM(I) = INT(100*(C+D)/(2*PTS(I)))/100
115 ASTKT(I) = INT(100*E/PTS(I))/100
120 REM
122 REM
'24 REM ---------------------------------------------------------------------
 26 REM ** NOMENCLATURE: VMSTD = DRY STD CUBIC FEET OF GAS SAMPLE              *
128 REM                     VW = STD CUBIC FEET OF WATER VAPOR COLLECTED      *
130 REM                    BWO = PERCENT WATER VAPOR IN STACK GAS             *
132 REM                     N2 = PERCENT NITROGEN IN STACK GAS                *
134 REM                     MW = MOLECULAR WEIGHT OF STACK GAS                *
```

```
136 REM                       DMW = DRY MOLECULAR WEIGHT OF STACK GAS         *
138 REM                       VSA = AVERAGE STACK GAS VELOCITY, FPM           *
140 REM                       QSA = AVERAGE STACK GAS FLOW, DSCFM             *
142 REM                       ISO = ISOKINETIC RATIO, %                       *
144 REM ------------------------------------------------------------------
146 REM
148 VMSTD(I) = INT(Y(I)*1764.7*CUFT(I)*(BP(I)+ADELH(I)/13.6)/(ATM(I)+460))/100
150 REM
155 VW(I) = INT(4.707*H2O(I))/100
157 REM
160 BWO(I) = INT(1000*VW(I)/(VW(I)+VMSTD(I)))/10
161 REM
162 REM *** IF STACK GASES ARE SUPERSATURED WITH WATER, SATURATION VALUES AS
            LISTED IN STATEMENT 163 ARE USED IN THE CALCULATIONS. ***
164 REM
165 N2(I) = 99 - CO2(I) - O2(I)
168 REM
172 REM
175 DMW(I) = INT(44*CO2(I)+40+32*O2(I)+28*N2(I))/100
176 MW(I) = DMW(I)*(1-BWO(I)/100)+18*BWO(I)/100
177 REM
180 VSA(I) = INT(60*85.49*CP(I)*ADELP(I)*(SQR((ASTKT(I)+460)/(MW(I)*SP(I)))))
182 REM
185 QSA(I) = INT(10.6283*VSA(I)*(100-BWO(I))*AREA(I)*SP(I)/(60*(ASTKT(I)+460)))
187 REM --------------------------------------------------------------
188 REM  ** NOMENCLATURE: F = MOLE FRACTION DRY STACK GASES              *
190 REM                  CS = PARTICULATE EMISSIONS IN GRAINS PER DSCF  *
192 REM                   G = PARTICULATE EMISSIONS IN LBS PER HOUR     *
194 REM                ACTQ = ACTUAL STACK FLOW, CFM                    *
195 REM                  FS = FRACTION OF POINTS SAMPLED (NON ZERO DELP)*
196 REM --------------------------------------------------------------
197 REM
200 REM
202 REM
205 F(I) = 1 - BWO(I)/100
207 REM
210 NUM(I) = 17.316*VMSTD(I)*(ASTKT(I)+460)*60
215 DEN(I) = VSA(I)*(100-BWO(I))*.01*SP(I)*TPD(I)*TPD(I)*TIME(I)
225 ISO(I) = INT(10*NUM(I)/DEN(I))/10
230 ACTQ(I) = INT(VSA(I)*AREA(I))
232 CS(I) =INT(1000*.0154*MG(I)/VMSTD(I))/1000
234 G(I) = INT(100*CS(I)*QSA(I)*.0001428*60)/100
235 REM
240 NEXT I
999 DATA 1,80.5,27.30 ,51.2,3.1 ,15.5, 1.024
1000 DATA 24,23.65,23.65,0.76,15.760 ,.251,60
1001 DATA 0.66,1.60,82,81,118
1002 DATA 0.64,1.55,86,82,119
1003 DATA 0.61,1.50,84,84,115
1004 DATA 0.53,1.30,91,85,115
1005 DATA 0.39,0.98,91,85,115
1006 DATA 0.23,0.56,93,86,120
1007 DATA 0.08,0.20,90,86,119
1008 DATA 0.00,0.00,89,88,124
1009 DATA 0.00,0.00,91,89,124
1010 DATA 0.00,0.00,90,90,124
1011 DATA 0.23,0.56,96,94,124
1012 DATA 0.40,1.00,91,89,124
1013 DATA 0.45,1.10,93,93,126
1014 DATA 0.23,0.56,96,94,130
```

```
1015 DATA 0.00,0.00,95,94,130
1016 DATA 0.00,0.00,95,94,130
1017 DATA 0.00,0.00,95,94,130
1018 DATA 0.00,0.00,95,94,128
1019 DATA 0.40,1.00,95,94,128
1020 DATA 0.45,1.10,95,94,127
1021 DATA 0.50,1.25,97,95,129
1022 DATA 0.60,1.50,100,95,132
1023 DATA 0.61,1.50,101,96,130
1024 DATA 0.65,1.60,103,96,129
1500 REM ******************* END OF RUN #1 DATA ********************
1501 REM
1550 REM
1590 REM ******** RUN #2 DATA ********
1999 DATA 2,201   ,47.437,87.1,3.3,15.1 ,1.024
2000 DATA 24,23.65,23.65,0.85 ,15.76 ,.251,120
2001 DATA 0.59,1.80,93,92,129
2002 DATA 0.52,1.75,96,92,135
2003 DATA 0.50,1.55,100,92,134
2004 DATA 0.45,1.35,99,92,131
2005 DATA 0.32,1.00,102,94,132
2006 DATA 0.10,0.32,103,96,135
2007 DATA 0.00,0.00,103,97, 135
2008 DATA 0.00,0.00,102,98 ,135
2009 DATA 0.00,0.00,101,99 ,135
2010 DATA 0.00,0.00,100,100,135
2011 DATA 0.00,0.00,100,100,134
2012 DATA 0.20,0.62,100,100,134
2013 DATA 0.55,1.65,99,101,140
2014 DATA 0.50,1.40,106,99,137
2015 DATA 0.52,1.45,110,100,134
2016 DATA 0.45,1.30,108,100,133
2017 DATA 0.35,1.00,110,101,134
2018 DATA 0.14,0.40,107,101,136
2019 DATA 0.00,0.00,107,101,136
2020 DATA 0.00,0.00,106,101,140
2021 DATA 0.00,0.00,106,101,138
2022 DATA 0.00,0.00,106,102,138
2023 DATA 0.15,0.44,105,103,140
2024 DATA 0.15,0.44,102,102,133
2500 REM ******************* END OF RUN #2 DATA ********************
2501 REM
2550 REM
2590 REM ******** RUN #3 DATA ********
2999 DATA 3,174   ,40.33 ,57.2, 3.6,15.2,1.024
3000 DATA 24,23.65,23.65,0.85 ,15.760,.251,96
3001 DATA 0.57,1.80,96,95,132
3002 DATA 0.57,1.80,100,96,132
3003 DATA 0.50,1.55,104,95,134
3004 DATA 0.40,1.25,104,95,139
3005 DATA 0.27,0.84,106,95,137
3006 DATA 0.13,0.40,100,95,138
3007 DATA 0.00,0.00,100,95,138
3008 DATA 0.00,0.00,100,95,138
3009 DATA 0.00,0.00,100,95,138
3010 DATA 0.00,0.00,100,95,138
3011 DATA 0.08,0.25,98,95,138
3012 DATA 0.35,1.10,98,95,138
3013 DATA 0.52,1.60,98,99,142
3014 DATA 0.52,1.60,101,98,137
```

```
3015 DATA 0.50,1.55,104,98,139
3016 DATA 0.40,1.25,107,98,139
3017 DATA 0.35,1.10,109,99,135
3018 DATA 0.10,0.32,103,98,136
3019 DATA 0.00,0.00,102,97,138
3020 DATA 0.00,0.00,101,96,138
3021 DATA 0.00,0.00,100,95,138
3022 DATA 0.00,0.00,98,95,138
3023 DATA 0.15,0.47,97,95,140
3024 DATA 0.35,1.10,92,92,137
3500 REM ****************** END OF RUN #3 DATA *******************
3525 REM
3535 PRINT ISO(1),ISO(2),ISO(3) :STOP
3550 REM
3575 REM ********  PRINTING COMMANDS  ********
3585 REM
3600 LPRINT         CHR$(14)"                                   TABLE    1
    "
3605 LPRINT CHR$(10)CHR$(14)"                          SOURCE TESTING TSP DATA SUMMA
RY"
3610 LPRINT CHR$(10)CHR$(14)"                         BARBER GREENE ASPHALT BATCH PL
ANT"
3615 LPRINT CHR$(10)CHR$(14)"                          LOS ALAMOS NATIONAL LABORATOR
IES"
3620 LPRINT CHR$(10)
3623 LPRINT CHR$(10)
3625 LPRINT CHR$(10);TAB(7)"SAMPLING DATA";TAB(36)"TEST #1       TEST #2
 TEST #3"
3627 LPRINT TAB(7)"--------------";TAB(36)"-------       -------       -------

3630 LPRINT CHR$(10)
3632 LPRINT "TEST STARTING TIME                       ";1130;TAB(50);1430;TAB(66);1640
3635 LPRINT "ACTUAL METERED CUBIC FEET                ";CUFT(1);TAB(50);CUFT(2);TAB(66
);CUFT(3)
3640 LPRINT "BAROMETRIC PRESSURE, (IN HG)             ";BP(1);TAB(50);BP(2);TAB(66);BP
(3)
3645 LPRINT "AVERAGE GAS METER TEMPERATURE (F)        ";ATM(1);TAB(50);ATM(2);TAB(66);
ATM(3)
3647 LPRINT "AVERAGE GAS METER COEFFICIENT            ";Y(1);TAB(50);Y(2);TAB(66);Y(3)
3650 LPRINT "MILLILITERS WATER COLLECTED              ";H2O(1);TAB(50);H2O(2);TAB(66);
H2O(3)
3655 LPRINT "MILLIGRAMS PARTICULATES COLLECTED        ";MG(1);TAB(50);MG(2);TAB(66);MG
(3)
3660 LPRINT "CARBON DIOXIDE IN STACK GAS, %           ";CO2(1);TAB(50);CO2(2);TAB(66);
CO2(3)
3665 LPRINT "OXYGEN IN STACK GAS,  %                  "; O2(1);TAB(50); O2(2);TAB(66);
 O2(3)
3675 LPRINT "STATIC PRESSURE IN STACK  (IN HG)        ";SP(1);TAB(50);SP(2);TAB(66);SP
(3)
3680 LPRINT "AVERAGE STACK TEMPERATURE, (F)           ";ASTKT(1);TAB(50);ASTKT(2);TAB(
66);ASTKT(3)
3685 LPRINT "S-PITOT CORRECTION FACTOR                ";CP(1);TAB(50);CP(2);TAB(66);CP
(3)
3690 LPRINT "AVG SQUARE ROOT VEL PRES (IN H2O)        ";ADELP(1);TAB(50);ADELP(2);TAB(
66);ADELP(3)
3695 LPRINT "AREA OF STACK, (SQ.FT)                   ";AREA(1);TAB(50);AREA(2);TAB(66
);AREA(3)
3700 LPRINT "SAMPLING TIME, (MINUTES)                 ";TIME(1);TAB(50);TIME(2);TAB(66
);TIME(3)
3705 LPRINT "NOZZLE DIAMETER, (INCHES)                ";TPD(1);TAB(50);TPD(2);TAB(66);
```

```
TPD(3)
3710 LPRINT "AVG ORIFICE DELTA P, (IN H2O)      ";ADELH(1);TAB(50);ADELH(2);TAB(
 6);ADELH(3)
3715 LPRINT CHR$(10)CHR$(10);TAB(3)"CALCULATED RESULTS"
3720 LPRINT TAB(3)"------------------" ;CHR$(10)
3725 LPRINT "CORRECTED METER VOLUME (DSCF)      ";VMSTD(1);TAB(50);VMSTD(2);TAB(
66);VMSTD(3)
3730 LPRINT "VOLUME H2O COLLECTED (SCF)         ";VW(1);TAB(50);VW(2);TAB(66);VW
(3)
3735 LPRINT "PERCENT H2O IN STACK GAS           ";BWO(1);TAB(50);BWO(2);TAB(66);
BWO(3)
3740 LPRINT "MOLE WT STACK GAS (WET)            ";MW(1);TAB(50);MW(2);TAB(66);MW
(3)
3750 LPRINT "MOLE FRACTION DRY STACK GAS        ";F(1);TAB(50);F(2);TAB(66);F(3)
3755 LPRINT "AVG STACK VELOCITY, (FPM)          ";VSA(1);TAB(50);VSA(2);TAB(66);
VSA(3)
3760 LPRINT "AVG STACK FLOW (DSCFM)             ";QSA(1);TAB(50);QSA(2);TAB(66);
QSA(3)
3765 LPRINT "AVG STACK FLOW (ACFM)              ";ACTQ(1);TAB(50);ACTQ(2);TAB(66
);ACTQ(3)
3770 LPRINT "ISOKINETIC RATIO, %                ";ISO(1);TAB(50);ISO(2);TAB(66);
ISO(3)
3775 LPRINT "PARTICULATE EMISSION, (GR/DSCF)    ";INT(1000*CS(1))/1000;TAB(50);C
S(2);TAB(66);CS(3)
3780 LPRINT "PARTICULATE EMISSION, (LBS/HR)     ";G(1);TAB(50);G(2);TAB(66);G(3)
3800 FOR Y=1 TO 5
3810 LPRINT CHR$(10)
3820 NEXT Y
4000 REM
4010 REM
4020 REM
4030 REM
4040 REM -----------------------------------------------------------------------
         -----------------------------------------------------------------------
4050 REM ****************** PROCEDURE TO RUN ANALYSIS  ************************
4060 REM      RUN #1: ENTER DATA FOR READ STATEMENT #32 IN DATA STATEMENT #999.
                      ENTER DATA FOR READ STATEMENT #58 IN DATA STATEMENT #1000.
                      ENTER DATA FOR READ STATEMENT #86 IN DATA STATEMENTS #1001
4070 REM
4080 REM      RUN #2: ENTER DATA FOR READ STATEMENT #32 IN DATA STATEMENT #1999.
                      ENTER DATA FOR READ STATEMENT #58 IN DATA STATEMENT #2000.
                      ENTER DATA FOR READ STATEMENT #86 IN DATA STATEMENTS #2001
4090 REM
4100 REM      RUN #3: ENTER DATA FOR READ STATEMENT #32 IN DATA STATEMENT #2999.
                      ENTER DATA FOR READ STATEMENT #58 IN DATA STATEMENT #3000.
                      ENTER DATA FOR READ STATEMENT #86 IN DATA STATEMENTS #3001
4200 REM -----------------------------------------------------------------------
         -----------------------------------------------------------------------
4500 END
6001 DATA 0.66,1.60,82,81,118
```

APPENDIX 1

Sampling Equipment Calibrations
Opacity Certifications

Air Care

Clean Air
For Quality Living

THIS CERTIFIES THAT

Craig Smedley

has successfully completed the requirements of

VISIBLE EMISSION SCHOOL

and is therefore certified to read visible emissions
in the State of New Mexico.

Course Location: Albuquerque
Course Date: April 14-16, 1993
Expiration Date: October 16, 1993

Mike Baca
Course Instructor
City of Albuquerque

DRY METER AND ORIFICE CALIBRATION DATA

Date 5/27/93 Location Santa Fe -EID Barometric Pressure, P_b 23.44 in Hg

Control Module Serial No. MISCO #7700 Dry Gas Meter No. ______

Orifice Setting ΔH	Metered Gas Volume, Ft^3 Wet Test V_w	Dry V_d	Meter Temperature, ^oF Wet Test T_w	Dry(ave) T_d	Metering Time Minutes t	Accuracy Ratio G *	Orifice Coefficient $\Delta H_@$ *
.25	3.335	3.271	79°	90°	10'	1.039	1.605
.50	3.239	3.213	79°	92.25	7'	1.031	1.652
.75	2.810	2.798	79°	93.75	5'	1.029	1.684
1.0	3.181	3.190	79°	95.25	5'	1.024	1.748
1.5	3.800	3.819	79°	96.5	5'	1.022	1.833
2.0	4.328	4.353	79°	97.25	5'	1.021	1.882

Max diff=0.018

$$* \ G = \frac{V_w P_b (T_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(T_w + 460)}$$

$$H_@ = \frac{0.0317 \Delta H}{P_b (T_d + 460)} \left(\frac{(T_w + 460) t}{V_w} \right)^2$$

G = ratio of accuracy of wet test meter to dry test meter

$\Delta H_@$ = orifice pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches Hg

KRAMER & ASSOCIATES, INC.
engineers / environmental consultants

4501 bogan northeast, suite a-1
albuquerque, new mexico 87109

(505) 881-0243

NOZZLE SIZING CALIBRATION SHEET

NOZZLE #	MEASURED DIAMETER, INCHES 1	2	3	4	5	6	7	8	9	10	AVERAG
1	.120	.120	.120	.120	.122	.119	.120	.121	.120	.118	.120
2	.123	.120	.121	.122	.120	.124	.120	.122	.122	.122	.122
3	.173	.172	.174	.173	.177	.173	.173	.175	.174	.173	.174
4	.207	.211	.206	.212	.212	.211	.211	.213	.212	.209	.210
5	.230	.229	.228	.226	.228	.223	.230	.228	.228	.228	.228
6	.230	.232	.232	.231	.229	.228	.229	.229	.233	.229	.230
7	.241	.239	.242	.241	.241	.241	.240	.240	.242	.238	.241
8	.250	.252	.251	.251	.251	.252	.251	.251	.250	.252	.251
9	.310	.311	.310	.310	.312	.310	.310	.311	.314	.311	.311
10	.315	.312	.313	.313	.310	.311	.313	.313	.314	.314	.313
11	.364	.365	.364	.363	.363	.366	.365	.365	.366	.363	.364
12	.369	.367	.368	.367	.367	.367	.368	.367	.367	.367	.367
13	.372	.372	.369	.370	.371	.369	.370	.370	.373	.370	.371
14	.377	.374	.368	.375	.375	.374	.372	.371	.372	.375	.373
15	.376	.374	.375	.377	.376	.376	.376	.376	.377	.377	.376
16	.478	.475	.480	.480	.475	.479	.479	.480	.476	.478	.478
17	.480	.479	.479	.478	.483	.484	.485	.479	.480	.485	.481
18	.492	.491	.491	.492	.493	.491	.491	.491	.492	.491	.492
19	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500
20	.500	.503	.497	.502	.498	.500	.500	.500	.500	.501	.500

TYPE S PITOT CALIBRATION DATA

Reference: CFR-40 Pt. 60, AA. A, Method 2

Calibration Date: March 21,1991 by Marv McIntyre

Nozzle Used 0.031 inches

Probe Length	Usable Length	Degrees *				Length in Inches		
		alpha1	alpha2	beta1	beta2	z**	w***	PT-T
14" SS	12'2"	<1	<1	<1	<1	<0.001	0.025	.76
8'6" SS	7'3	<1	<1	<1	<1	<0.001	<0.001	.79
8'1" Glass	6'4"	<1	<1	<1	<1	<0.001	0.029	.99
6'1" SS	4'3"	<1	<1	<1	<1	0.073	<0.001	.88
6'1" Glass	4'3"	<1	<1	<1	<1	<0.001	<0.001	.94

Pitot Tube-Thermocouple Spacing Requirement is 0.75-1.0 inches

* Requirement for alpha is < 10 degrees
Requirement for beta is < 5 Degrees

** Requirement is <0.125 inches

*** Requirement is <0.0313 inches

CBS INC.

CERTIFIED BALANCE SERVICE, INC.

DATE: October 2, 1992 DATE OF SERVICE: September 25, 1992

This Certificate verifies that the following balances belonging to KRAMER AND ASSOCIATES have been serviced by Bruce Houpt an authorized service representative of Certified Balance Service, and found to be within manufacturers specifications. They were checked by weight set K-2 Certified by the Colorado Bureau of Weights and Measures, on 8/10/92 and found to be within specification and TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS, WASHINGTON, D.C.

Dept.	Wt. Set	Model	Serial #	Other I.D. #	Manufacturer	Recert. Date
	K-2		702036		SARTORIUS	9/25/93

APPENDIX D

Source Test Data for FGR/Power Plant

EMISSIONS TEST REPORT

BOILER UNIT NO. 3 : TECH AREA 3
at

LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO

by

Kramer & Associates, Inc.
4501 Bogan NE, Suite A-1
Albuquerque, NM 87109
505-881-0243

August, 1995

<u>CERTIFICATION</u>

The following report has been reviewed and approved to accurately represent the sampling and analyses actually performed. The results reported are accurate to the best of our knowledge.

Gary R. Kramer, PE

TABLE OF CONTENTS

INTRODUCTION

A. **Reason for Tests:** EPA Title 5 Permit estimation purposes

B. **Regulations:** None Apply

C. **Equipment Use:** Unit #3 at TA-3 is used to provide facility heat and electricity the LANL facility.

D. **Company:** Los Alamos National Laboratory
Tech Area 3
Los Alamos, NM
Contact: Mr. Pat Binkley Radian Corp. (505-672-2109)

E. **Facility :** Unit #3 TA-3 Steam Plant
Los Alamos National Laboratories
Los Alamos, New Mexico

F. **Testing Organization:** Kramer & Associates, Inc.
4501 Bogan NE Suite A-1
Albuquerque, NM 87109
Gary R. Kramer, PE (505-881-0243)

G. **Individuals Present for Tests:**

1) Kramer & Associates, Inc. - Rick Stallings, RickTrujillo and Buster Wright
2) Radian Corp. - Mark Ludwiczak
3) NMED - Arun Dhawan

H. **Dates of Tests:** August 29, 1995

I. **Description of Units Tested:**

Unit #3 TA-3 Steam Plant

J. **Emissions Control Equipment:**

None

TABLE 1

TEST RESULTS SUMMARY

Boiler Load Condition	100%	70%	50%
Test Time of Day -Start	1223	1643	1904
-Stop	1547	1819	2119
Steam Load: lb/hr x10^3	106	72.2	57.3
Gas Firing Rate, ft^3/hr x10^3	188	130	101
Oxygen in Stack Gas, %	5.3	5.4	6.3
Nitrogen Oxides, ppmv *	97	94	75
lb/MMBTU	0.136	0.132	0.112
lb/1000 ft^3	0.136	0.132	0.112
lb/hr	25.5	17.2	11.3
Carbon Monoxide, ppmv *	8.2	15	30
lb/MMBTU	0.006	0.013	0.027
lb/1000 ft3	0.006	0.013	0.027
lb/hr	1.1	1.7	2.7
* Based on Method 19 Analyses			

Calculations in Table:

NOx, lb/MMBTU (Method 19) = ppmv x 1.194×10^{-7} x 8710 x (20.9/20.9-O_2)
CO, lb/MMBTU (Method 19) = ppmv x 0.727×10^{-7} x 8710 x (20.9/20.9-O_2)
Lb/hr = lb/MMBTU x Gas Firing Rate x 1000 BTU/Ft^3 gas

Reference: Equation 19-1 of the 40CFR Part 60 Appendix A

Discussion:

A traverse of the stack (24 points) revealed that significant gas stratification did not exist at the sampling location (see Part 1 - 100% load), and the average cyclonic flow angle was 17 degrees. Exhaust gas flow rate data were collected during the the 100% and 50% load conditions (see Data and Calculations - Part 1) according to Methods 1 and 2. NOx and CO emission rates calculated from flow rate data were in agreement (i.e. within 15%) with the emission rates calculated by Method 19. Flow rate measurements were not made at the 70% load condition.

Quality Assurance:

A rain storm interrupted Test #1 (100% Load) for a one hour and fourteen minute period. Test #2 (70% load) was extended a few minutes due to an automatic shutoff of the circular chart recorder during the test period. A clogged filter in the sampling system resulted in a 15-minute delay during Test #3 (50% Load).

Sampling system response time measurements were made in the field. Actual sampling time at each point (3 minutes) was six times the system response time (25 seconds) and exceeded the requirement of the test methods.

CO and NOx analyser calibrations were conducted at the beginning and end of each test. Calibration drift was determined to be within 2% allowable for all calibration ranges on each analyser except one 3.6% drift of the span gas (223.6 ppm NOx) on the NOx analyser at the 70% load. However, the NOx reading for the 70% load was about 94 ppm which was nearer the mid-range calibration gas (87.4 ppm) for which the drift was only 0.8%. All calibration drift and bias data are found in Appendix 1. All analyser bias checks were within the 5% maximum allowed by the method.

Pitot assemblies and orsat analyser were leak-checked before and after sampling.

Unit Operating Parameters: See Table 1

Control Equipment Operaring Parameters: N/A

TEST PROCEDURES

A. Schematic of Sampling Locations: See Figure 1

B. Sampling Systems Schematics: See Figure 2

C. Operating Procedures:

Moisture, Velocity: Stack gas sample was sampled and analysed for moisture according to Method 4 of the 40CFR, Part 60 App A. Stack velocity measurements were made according to Methods 1, and 2 of the 40CFR using an S-Type pitot on a 24-point traverse.

NOx-CO : Methods 7E and 10: Exhaust gas sample was drawn from the stack through a heated stainless steel probe and filter box into a cold trap where the gas is cooled and the moisture removed. Cool dry gas sample is conveyed by teflon sample lines to the NOx - CO analysers which are calibrated with EPA Protocol I Gas Mixtures.

D. Deviations from EPA Methods: None

E. Test Instrumentation:

1). Honeywell Truline Circular Chart Recorder (NOx-CO)
2). MISCO Model 7200 Source Sampler (Method 5 System)
3). TECO Model 10 Chemiluminescence NOx Analyser
4). Rosemount Model 880 Non-Dispersive Infrared CO Analyser

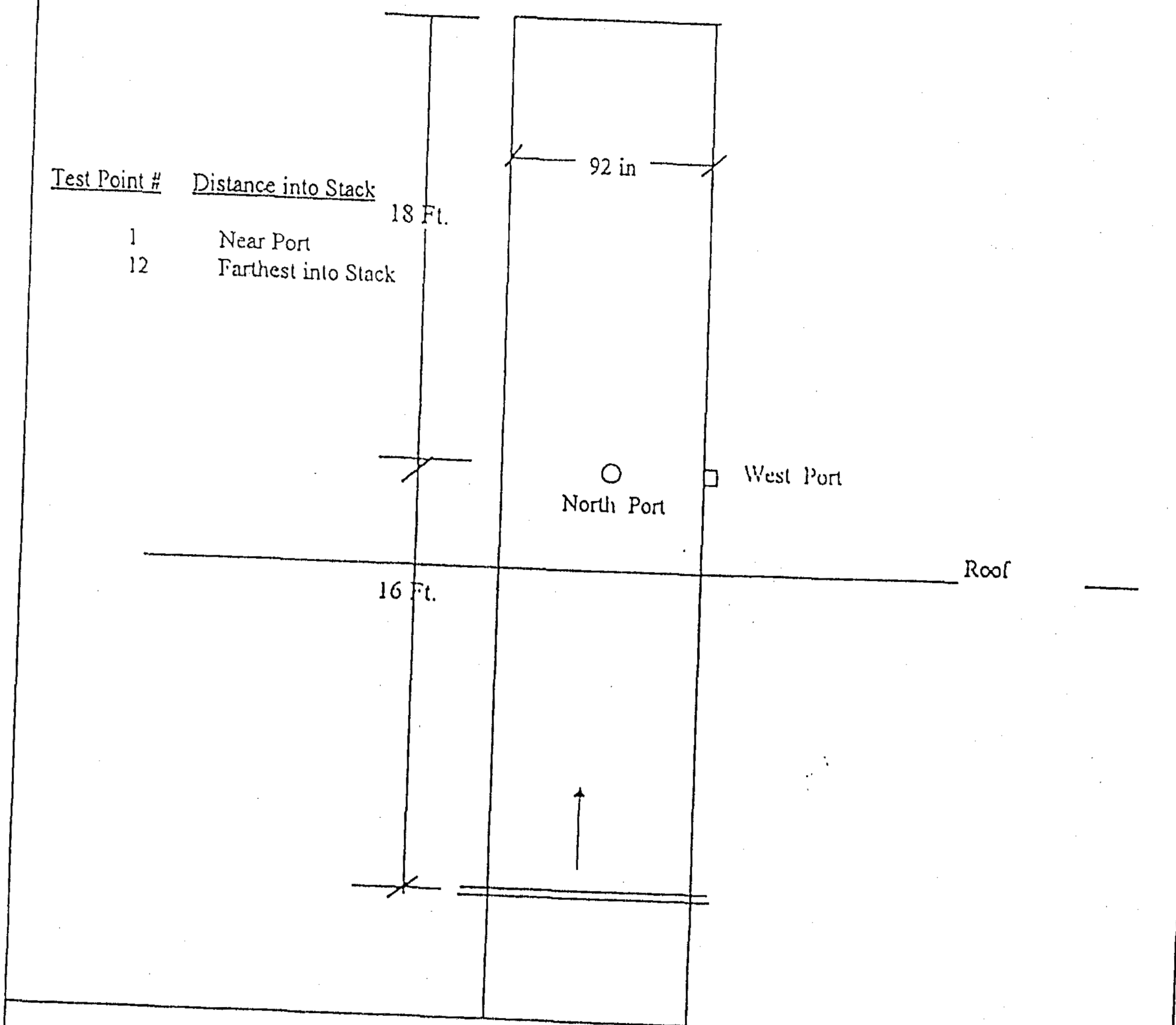


FIGURE 1

Boiler Unit No. 3 Sampling Location Schematic

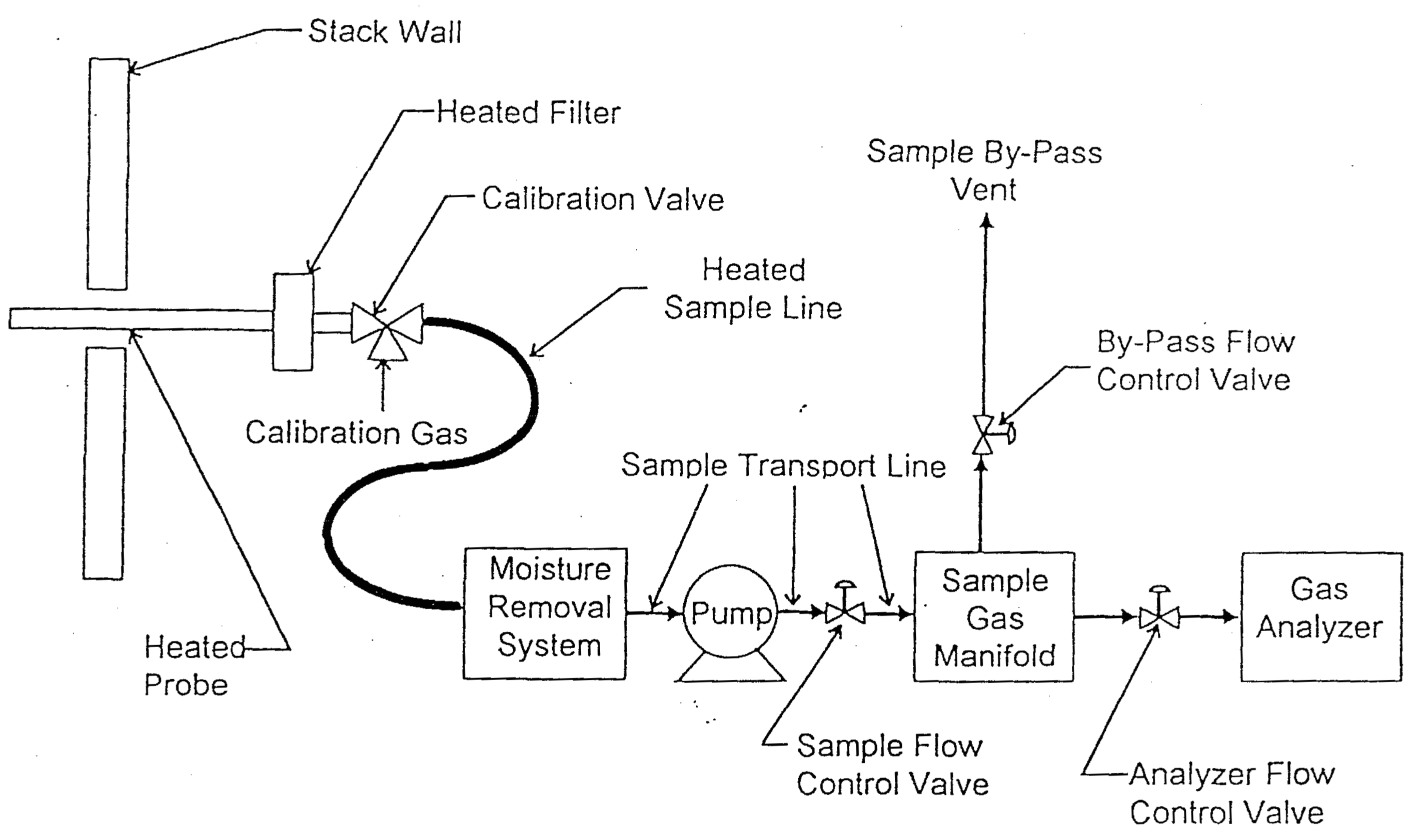


Figure 2. NO_x and CO Sampling System Schematic.

DATA AND CALCULATIONS

A. Field Sampling Data and Calculations Summaries:

Parts 1-3 contain the following:

1. Calculations, Field Data and Computer Routine: NOx, CO, Flow
2. Response Time, Zero and Calibration Field Data: NOx and CO
3. Boiler Operating Data

B. Calibrations: Protocol 1 gas certifications and other instrument calibrations are in Appendix 2.

C. Chain of Custody: All samples were in the possession of Kramer & Associates Inc. personnel at all times.

EMISSIONS TEST REPORT

for

Boiler No. 3

Los Alamos National Laboratories

Permit Pending

KRAMER & ASSOCIATES

ALBUQUERQUE, NEW MEXICO

EMISSIONS TEST REPORT
for
Boiler No. 3
at
Los Alamos National Laboratory

Permit Pending

by

Kramer & Associates, Inc.
4501 Bogan NE Suite A-1
Albuquerque, New Mexico 87109
505-881-0243

February, 2000

Table of Contents

CERTIFICATION

The following report has been reviewed and approved to accurately represent the sampling and analyses actually performed. The results reported are accurate to the best of our knowledge.

Gary R. Kramer, PE

Introduction:

A. **Reason for Tests:**
   Boiler No. 3 emissions tests were conducted to provide data to be used in air quality permitting.

B. **Applicable Standards:**
   None

C. **Process:**
   Boiler No.3 is one of two operational units which provide space heating and power at Los Alamos National Laboratories (TA-3)

D. **Company:**
   Los Alamos National Laboratories
   Tech Area 3 Steam Plant
   Los Alamos, New Mexico
   Contact Person: Ms. Margie Stockton (Radian – (505) 667-9359)
   (505-665-8858)-FAX

E. **Facility Location:**
   Tech Area 3d Steam Plant
   Los Alamos National Laboratories

F. **Testing Firm:**
   Kramer & Associates, Inc.
   4501 Bogan NE, Suite A-1
   Albuquerque, NM 87109
   Gary R. Kramer (505 881-0243)

G. **Individuals Present at Test:**
   1. LANL – Paul Parker, Plant Engineer
   2. Kramer & Associates, Inc. – Bill Ristau, Buster Wright, Gary Kramer

H. **Date of Test:**
   February 16, 2000

I. **Description of Units Tested:**
   Boiler Unit No. 3 - $1x10^6$ lb/hr steam rate

J. **Emissions Control Equipment:**
   none

Table 1

Boiler No. 3 Data Summary

Test Parameter (Ave.)	25% Load	50% Load	75% Load	100% Load
% Carbon Dioxide	6.7	9.2	9.1	9.5
% Oxygen	10.2	5.3	5.6	5
Burner Fuel Rate, MMBTU/hr	46.4	82.3	122.6	160.2
NOx Emission				
ppm	53	75	95	117
lb/hr (Method 19)	5.0	8.6	16.6	25.6
lb/hr (Methods 1-4)	5.7	12.7	19.7	30
lb/MMBTU	0.123	0.154	0.161	0.187
CO Emission				
ppm	15	60	18	10
lb/hr (Methods 1-4)	0.91	5.5	2.0	1.4
lb/hr (Method 19)	0.80	3.79	1.73	1.20
lb/MMBTU	0.020	0.067	0.017	0.009
Exhaust Flow Rate, ACFM	30545	48167	61093	79887

Discussion:

Comparisons of the lb/hr emission rates as measured (40CFR Part60 Methods 1-4) and as calculated from fuel rate data (Method 19) do not agree as well as they should. The measured flow rates may be in error because of the skewed velocity profile in the stack (see pitot measurements in Data and Calculations Section). It is recommended that for any future emissions testing accurate fuel flow readings be used with Method 19 rather than stack velocity measurements as the primary method for computing mass emission rates.

Test Procedures:

A. **Source Sampling Locations:** See Figure 1.
B. **Sampling Systems Schematics:** See Figure 2.
C. **Test Operating Procedures:**

NOx and CO sampling and analysis procedures followed Methods 7E and 10 respectively of the 40CFR, Part 60 - Appendix A. Boiler exhaust samples were drawn through a stainless steel probe and filter into a moisture trap and then through Teflon sample lines to the pollutant analyzers. At least one 30-minute test run was conducted at each of four loads (25%, 50%, 75%, and 100%).

Oxygen and carbon dioxide concentrations in the exhaust were determined according to Method 3a of the 40CFR Part 60, App. A. Gas sample was drawn through the NOx-CO sampling conditioning system.

Stack flow rates (and emission rates) were determined according to Methods 1-4 of the 40CFR Part 60 App. A. An "s-type" pitot assembly was used with a low range (0.005" H_2O sensitivity) Dwyer Magnehelix to measure velocity pressure in a vertical section of exhaust. In addition, emission rates were calculated using fuel flow and BTU value, and stack oxygen concentrations (O_2 "F" Factor = 8710).

NOx, CO, O2, and CO2 analyzers were calibrated before and after each test with EPA Protocol 1 reference gas mixtures (see certificates in Appendix 1).

D. **Deviations from EPA Methods:**

None

E. **Test Instrumentation:**

See descriptions in Table 2.

F. **Turbine Operating Parameters:**

The boiler parameters monitored included fuel rate and staeam production (see Table 1 and Parts 1-4 of the Data and Calculations Section).

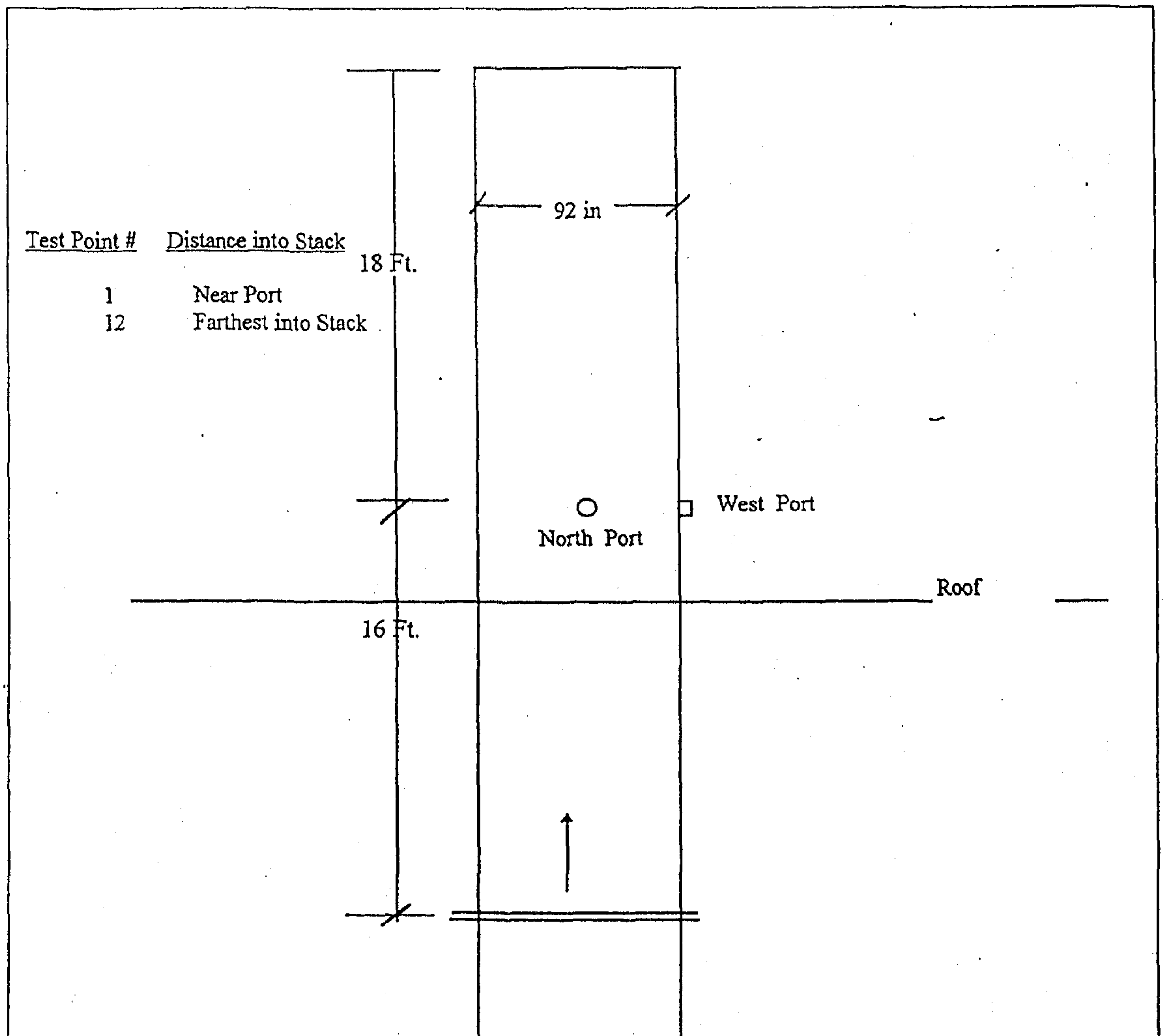


FIGURE 1

Boiler Unit No. 3 Sampling Location Schematic

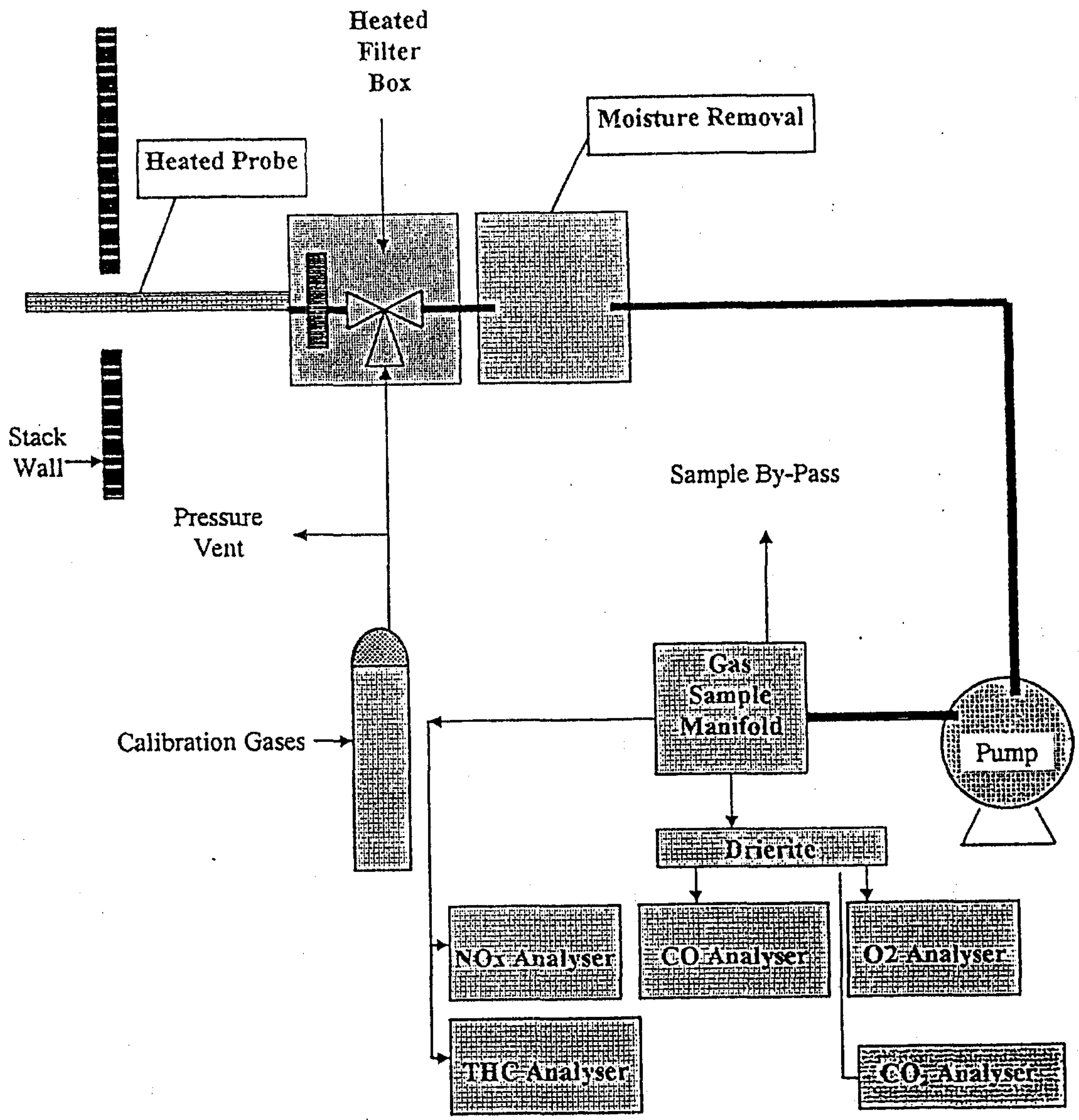


Figure 2

NOx-CO-CO_2-HC-O_2 System Schematic Diagram

Methods 3A, 7E, 10, 20, 25A

Table 2

Analytical Instrumentation

Parameter	Instrument Model	Ranges	Sensitivity	Response Time	Operating Principle
NOx	TECO Model 10AR	0-25 ppm 0-100 ppm 0-250 ppm 0-1000 ppm	1 ppm	15 - 30 sec.	Thermal Reduction NO_2 to NO Chemiluminecence - Linear
CO	Rosemount 880A	0-200 ppm 0-1000 ppm	1 ppm	45 - 75 sec.	non-dispersive infrared abs microproc'r linearization
O_2	Servomex 1440	0-5% 0-25%	0.1%	15 - 30 sec.	Paramagnetic cell Linear
THC	TECO Model 51HT	0-10 0-100	0.2 ppm	15 - 30 sec.	Flame Ionization Detector Linear
CO2	Servomex 1440	0-30 0-50	0.1 %	30-45 sec	Infrared

Data and Calculations:

This section contains the following:

Part 1 – 25% Load:

1. Computer generated (EXCEL) emissions data analyses summaries
2. Field test data
3. NOx, CO, O_2, and CO_2 analyzers pre and post test calibrations

Part 2 – 50% Load:

1. Computer generated (EXCEL) emissions data analyses summaries;
2. Field test data
3. NOx, CO, CO_2, and O_2 analyzers pre and post test calibrations;

Part 3 – 75% Load:

1. Computer generated (EXCEL) emissions data analyses summaries;
2. Field test data
3. NOx, CO, CO_2, and O_2 analyzers pre and post test calibrations;

Part 4 – 100% Load:

1. Computer generated (EXCEL) emissions data analyses summaries;
2. Field test data
3. NOx, CO, CO_2, and O_2 analyzers pre and post test calibrations;
4. Chart Records – All Loadings

Part 5 – Boiler Operating Data

Boiler Emissions Compliance Test Report for Technical Area 03-22 Power Plant Los Alamos National Laboratory

Submitted to:

Los Alamos National Laboratory
P.O. Box 1663, MS J978
Los Alamos, NM 87567

Submitted by:

URS Group, Inc.
9400 Amberglen Boulevard (78729)
P.O. Box 201088
Austin, TX 78720-1088

October 2002

Table of Contents

List of Tables

Page

List of Figures

Executive Summary

Los Alamos National Laboratory (LANL) generates electrical power and steam in 3 boilers located in Technical Area 03-22 (TA-03-22). These boilers have recently been fitted with a flue gas recirculation (FGR) system as a measure to control nitrogen oxides (NO_x) emissions. These boilers are operated under Air Quality Permit No. 2195B, which requires testing for NO_x and carbon monoxide (CO) within 60 days of the startup of the FGR systems. This stack test report documents the compliance stack testing conducted on September 25, 26, and 27, 2002. The results of the testing show that:

- For Boiler 3, emissions of NO_x exceed the pounds per hour (lbs/hr) emission permit limits, but by less than 10%. For boilers 1 and 2, emissions of nitrogen oxide comply with the lbs/hr emission limits.
- Emissions of NO_x are well within the pounds per million Btu (lbs/mmBtu) emission limits specified in 20.2.33 NMAC.
- Emissions of CO are well within the permit limits.

The results of the compliance stack test are summarized in Table 1.

Table 1. Summary of Emission Test Results

	NO_x Emission Rate				CO Emission Rate	
	(lbs/hr)		(lbs/mmBtu)		(lbs/hr)	
	Measured	Permit	Measured	Permit	Measured	Permit
Boiler 1	8.61	9.0	0.057	0.3	0.65	7.4
Boiler 2	8.12	9.0	0.052	0.3	0.04	7.4
Boiler 3	9.61	9.0	0.060	0.3	1.53	7.4

I. Introduction

This section of this test protocol presents background information pertinent to the test. This includes the permit requirements, and references to the applicable regulations and statutes are presented in this section, as well as a brief description of the operating processes.

A. Test Purpose

Los Alamos National Laboratory (LANL) operates a power plant at Technical Area 03-22 (TA-03-22). The three natural gas and #2 fuel oil fired boilers located in TA-03-22 provide space heating and power generation at LANL. This test was conducted to demonstrate compliance with permit and regulatory requirements.

B. Concise statement of applicable regulations and permits, including permit numbers and issuance dates.

This facility is operated under permit number 2195-B, issued by New Mexico Environment Department (NMED) on September 27, 2000. As addressed in this permit, this facility is subject to the requirements of the 20 NMAC 2.33 (Gas Burning Equipment – Nitrogen Dioxide), 2.34 (Oil Burning Equipment – Nitrogen Dioxide), and 2.61(Smoke and Visible Emissions). Permit 2195B requires compliance testing for NO_x and CO. Emissions from the boilers were tested while burning natural gas, at nominal maximum rates. Because #2 fuel oil is a back-up fuel and only used occasionally, NMED agreed that the boilers did not need to be tested while burning fuel oil (see attached letter, Appendix F).

C. Test date(s).

Emissions testing was conducted on September 25, 26 and 27, 2002

D. Startup date, and maximum production rate date for the source being tested.

Preliminary operation and testing of the FGR system began approximately two weeks prior to the test date. The official startup for continuous operation of the system is October 1, 2002. Installation of the FGR system did not change the normal or maximum production rate of the power plant.

E. If the test is not done within 60 days after achieving the maximum production rate at which the source will operate or within 180 days after the initial startup of the source (if maximum production rate was not achieved), then explain why not.

The stack test was conducted within the time frames listed.

F. Description of Plant Process and Pollutant Points Being Sampled

Three different power boilers (B-1, B-2, and B-3) were tested during the planned test effort. B-1 (serial number 4008) and B-2 (serial number 4009) were manufactured by Egdemoor Iron Works in 1950. Boiler B-3 (serial number 11804) was manufactured by Union Iron Works in 1952. All three boilers are rated at a capacity of 178.5 mmBtu/hr (derated for altitude).

Flue gas recirculation (FGR) fans (F-1, F-2, and F-3) were installed on the three boilers. The FGR fans were manufactured by Robinson Industries, and all are rated at 1800 RPM. The FGR fans were installed to reduce NO_x emissions from the boilers. The designers of the system have estimated that the FGR fans will achieve 70% reduction in NO_x by weight.

G. Company name, contact person, mailing address, and telephone number.

University of California
Los Alamos National Laboratory
P.O. Box 1663, MS J978
Los Alamos, NM 87567

Technical Contact: Bill Blankenship
Phone Number: 505-665-0823

H. Site name, location, map, and directions to the facility.

Los Alamos National Laboratory

I. Name of testing organization, contact person, mailing address, and telephone number.

Testing was performed by URS Group, Inc. Experienced stack testing personnel were brought in from the URS Austin, Texas office.

Contact Person: Eugene Youngerman, Ph.D.
URS Group, Inc.
P.O. Box 201088,
Austin, Texas 78720-1088
512-419-5992

Physical Address: URS Group, Inc.
9500 Amberglen Boulevard
Austin, Texas 78729

J. Name of each person present at the test and each person's affiliation.

1. Eugene Youngerman – URS, Austin, Texas - Source Tester
2. Gary Hall – URS, Albuquerque, New Mexico - Source Tester
3. Bill Blankenship – LANL, Air Quality Group
4. Jerome Gonzales – LANL, FWO-Utilities Group
5. Paul Parker – JCNNM, TA-3 Power/Steam Plant Engineer
6. Bob Simpson – NMED Air Quality Bureau

K. Equipment and Procedures

1. A brief description of the unit/source to be tested, make and model number, and design/nameplate capacity. List any original process equipment that has been replaced in the last 3 years.
2. A brief description of the control equipment on the units being tested, including the make and model number.

The boilers and the control equipment are described in Section F, above.

II. Summary

This section summarizes in tabular form the test results for each unit tested.

A. For each run, show velocities (stack velocity in feet/second), flows (stack exhaust flow in actual cubic feet/minute and dry standard cubic feet/minute), concentrations, emission rates including the average of the emission rates from all runs, allowable emission limits, stack temperature and pressure, sampling times, pitot tube average results, etc. Include opacity reading if applicable. (A minimum of one visible emission reading per run is required every time a Method 5 test is done.) Also show the results of cyclonic flow determination.

All data for this test effort were collected using a URS-furnished continuous emission monitoring system. Velocities and flow rates were determined according to EPA Method 19. (This is a deviation from the test plan, but was agreed upon by NMED in a telephone conversation during the week of testing, see email, Appendix F).

Table 2 summarizes the values measured by the continuous emissions monitors for nitrogen oxides, carbon monoxide and carbon dioxide. Note that these data are "as-recorded" and are not corrected for drift or system bias, according to Equation 6C-1 (from EPA Method 6C).

Table 2. Summary of Continuous Emission Monitoring

			Time	Nitrogen Oxides (ppmv)	Carbon Monoxide (ppmv)	Carbon Dioxide (%)
Boiler 3	Run 1	9/25/02	1715-1815	47.4 (43.0-51.2)	10.9 (1.6-34.5)	9.2 (9.0-9.5)
	Run 2	9/25/02	1835-1935	46.9 (40.1-49.9)	13.8 (3.0-56.7)	9.2 (9.0-9.5)
	Run 3	9/25/02	1955-2055	46.2 (39.3-50.4)	16.3 (2.0-110.5)	9.2 (9.0-9.6)
Boiler 1	Run 1	9/26/02	0807-0907	46.7 (36.1-62.4)	7.2 (0.8-28.5)	9.0 (8.8-9.3)
	Run 2	9/26/02	0923-1023	40.9 (35.8-44.8)	6.9 (0.6-24.4)	9.1 (8.7-9.4)
	Run 3	9/26/02	1043-1143	40.3 (36.8-45.8)	8.8 (3.2-16.7)	9.0 (8.7-9.3)
Boiler 2	Run 1	9/27/02	0818-0918	28.8 (27.6-30.4)	3.9 (3.5-4.2)	6.7 (6.3-7.0)
	Run 2	9/27/02	0938-1038	28.5 (26.9-29.9)	4.6 (4.3-5.1)	6.7 (6.5-7.0)
	Run 3	9/27/02	1058-1158	28.4 (27.0-30.0)	4.7 (4.2-5.2)	6.7 (6.4-6.9)

Note: The results in each cell represent the average, with the range shown in parentheses.

The correction of the average results of the continuous emission monitoring for drift and system bias according to Equation 6C-1 from EPA Method 6 is presented in Tables 3, 4, and 5 for nitrogen oxides, carbon monoxide and carbon dioxide, respectively. Equation 6C-1 is:

$$C_{gas} = (C_{avg} - C_o)\frac{C_{ma}}{C_m - C_o}$$

Where:

C_{gas} = Effluent gas concentration, dry basis
C_{avg} = Average gas concentration indicated by gas analyzer, dry basis
C_o = Average of initial and final system calibration bias check responses for the zero gas
C_{ma} = Average of initial and final system calibration bias check responses for the upscale calibration gas
C_m = Actual concentration of the upscale calibration gas

Table 3. Correction of Nitrogen Oxide for Drift and System Bias

		Span Bias Check				Zero Bias Check			NO_x Concentration	
		Actual (C_m)	Initial	Final	Average (C_{ma})	Initial	Final	Average (C_o)	Analyzer Response (C_{avg})	Corrected (C_{gas})
Boiler 3	Run 1	44.82	48.37	47.78	48.1	0.51	0.62	0.6	47.43	44.2
	Run 2	44.82	47.78	47.27	47.5	0.62	0.38	0.5	46.92	44.2
	Run 3	44.82	47.27	46.88	47.1	0.38	0.00	0.2	46.23	44.0
Boiler 1	Run 1	44.82	45.50	46.50	46.0	0.01	0.77	0.4	46.73	45.5
	Run 2	44.82	46.50	45.38	45.9	0.77	0.67	0.7	40.88	39.8
	Run 3	44.82	45.38	45.70	45.5	0.67	0.00	0.3	40.34	39.7
Boiler 2	Run 1	44.82	45.66	45.47	45.6	0.11	0.65	0.4	28.80	28.2
	Run 2	44.82	45.47	44.73	45.1	0.65	0.46	0.6	28.48	28.1
	Run 3	44.82	44.73	45.12	44.9	0.46	0.00	0.2	28.45	28.3

Table 4. Correction of Carbon Monoxide for Drift and System Bias

		Span Bias Check				Zero Bias Check			CO Concentration	
		Actual (C_m)	Initial	Final	Average (C_{ma})	Initial	Final	Average (C_o)	Analyzer Response (C_{avg})	Corrected (C_{gas})
Boiler 3	Run 1	59.30	63.04	61.62	62.3	1.99	2.92	2.5	10.87	8.3
	Run 2	59.30	61.62	61.90	61.8	2.92	1.77	2.3	13.84	11.5
	Run 3	59.30	61.90	63.79	62.8	1.77	0.00	0.9	16.33	14.8
Boiler 1	Run 1	59.30	61.92	64.24	63.1	2.21	2.45	2.3	7.22	4.8
	Run 2	59.30	64.24	62.45	63.3	2.45	3.24	2.8	6.90	4.0
	Run 3	59.30	62.45	63.67	63.1	3.24	0.00	1.6	8.84	7.0
Boiler 2	Run 1	59.30	61.08	60.92	60.9	3.66	3.97	3.8	3.88	0.1
	Run 2	59.30	60.92	61.59	61.6	3.97	4.69	4.3	4.62	0.3
	Run 3	59.30	61.59	61.22	61.2	4.69	4.05	4.4	4.71	0.4

Table 5. Correction of Carbon Dioxide for Drift and System Bias

		Span Bias Check				Zero Bias Check			CO_2 Concentration	
		Actual (C_m)	Initial	Final	Average (C_{ma})	Initial	Final	Average (C_o)	Analyzer Response (C_{avg})	Corrected (C_{gas})
Boiler 3	Run 1	9.96	10.11	9.99	10.0	0.21	0.09	0.2	9.20	9.1
	Run 2	9.96	9.99	10.07	10.0	0.09	0.24	0.2	9.22	9.1
	Run 3	9.96	10.07	10.07	10.1	0.24	0.00	0.1	9.21	9.1
Boiler 1	Run 1	9.96	10.00	9.99	10.0	0.19	0.16	0.2	9.03	9.0
	Run 2	9.96	9.99	9.99	10.0	0.16	0.10	0.1	9.07	9.0
	Run 3	9.96	9.99	9.94	10.0	0.10	0.00	0.1	9.05	9.0
Boiler 2	Run 1	9.96	9.90	9.95	9.9	0.08	0.11	0.1	6.73	6.7
	Run 2	9.96	9.95	9.97	10.0	0.11	0.09	0.1	6.71	6.7
	Run 3	9.96	9.97	9.90	9.9	0.09	0.00	0.0	6.66	6.7

Emission rates for nitrogen oxides and carbon monoxide were developed using Equation 19-6 from EPA Method 19. This equation is:

$$E = C_d F_c \frac{100}{\%CO_{2d}}$$

Where:

E	=	Pollutant emission rate (lbs/million Btu)
C_d	=	Pollutant concentration, dry basis, (lbs/scf)
F_c	=	Volume of carbon dioxide per unit of heat content (scf/million Btu) (This is 1040 for natural gas, taken from Table 19-2 in EPA Method 19)
$\%CO_{2d}$	=	Concentration of carbon dioxide on a dry basis, percent

The development of these data is shown in Table 6.

B. Unit Operating Parameters at Time of Test

During the emission testing, the boilers were running at approximately 90% of capacity. This is documented in the process summary found in Appendix A.

C. Control Equipment Operating Parameters at Time of Test

The FGR system was in operation during the test. This is documented in the process summary found in Appendix A.

D. Comparison of Measured and Modeled Parameters (see Table 1)

For each unit tested, make a copy of Table 1 (page 8) and enter the required stack data. This table compares the measured emission parameters (stack height and diameter, stack gas exit velocity, and stack gas temperature) with the parameters used in the atmospheric dispersion modeling. Disregard this section if the Bureau did not require atmospheric dispersion modeling for this source.

Not applicable. No direct measurements of stack parameters were conducted. Emission rates were based on stack composition, fuel flow rate, and calculations.

Table 6. Emission Rates for Nitrogen Oxides and Carbon Monoxide

		Natural Gas		CO_2 Concentration (%) (% CO_{2d})	Volume of CO_2 per unit heat (scf/mmBtu) (F_c)	Nitrogen Oxides				Carbon Monoxide			
		Flow Rate (scfh)	Heat Value (Btu/scf)			Concentration		Emission Rate		Concentration		Emission Rate	
						(ppmv)	lbs/scf (C_d)	lbs/million Btu (E)	(lbs/hr)	(ppmv)	lbs/scf (C_d)	lbs/million Btu (E)	(lbs/hr)
Boiler 3	Run 1	152390	1037.924	9.1	1040	44.2	5.3E-06	0.060	9.54	8.3	6.1E-07	6.9E-03	1.09
	Run 2	154650	1037.924	9.1	1040	44.2	5.3E-06	0.060	9.65	11.5	8.3E-07	9.5E-03	1.52
	Run 3	154410	1037.924	9.1	1040	44.0	5.3E-06	0.060	9.63	14.8	1.1E-06	1.2E-02	1.97
	Average							0.060	9.61				1.53
Boiler 1	Run 1	149860	1038.438	9.0	1040	45.5	5.4E-06	0.063	9.81	4.8	3.5E-07	4.0E-03	0.63
	Run 2	144570	1038.438	9.0	1040	39.8	4.8E-06	0.055	8.22	4.0	2.9E-07	3.3E-03	0.50
	Run 3	137980	1038.438	9.0	1040	39.7	4.7E-06	0.055	7.81	7.0	5.1E-07	5.8E-03	0.84
	Average							0.057	8.61				0.65
Boiler 2	Run 1	146980	1044.098	6.7	1040	28.2	3.4E-06	0.052	7.99	0.1	4.7E-09	7.2E-05	0.04
	Run 2	147680	1044.098	6.7	1040	28.1	3.4E-06	0.052	8.06	0.3	2.2E-08	3.4E-04	0.05
	Run 3	150650	1044.098	6.7	1040	28.3	3.4E-06	0.053	8.30	0.4	2.6E-08	4.0E-04	0.06
	Average							0.052	8.12				0.04

III. Test Procedures

This section describes the test procedures, including any variations from EPA test methods. This section includes, but is not limited to:

A. Schematic drawing of the process being tested showing emission points, sampling sites, and stack cross section. The sampling points are labeled and dimensions indicated.

   Figure 1 presents a simple schematic of the power plant and boilers 1, 2, and 3. Figure 2 presents a simple schematic of the boiler emission locations. Samples were collected from a single point in the stack.

B. Schematic drawing of the sampling device/train used. Each component is labeled and explained in a legend.

   Figure 3 presents a schematic drawing of the CEM system.

C. A brief description of the EPA reference methods used to operate the sampling train and the procedures used to recover and analyze the samples. Include sampling durations, number of test runs, calibration procedures, leak checks, cyclonic flow checks, etc.

   The emissions from the boiler stacks were monitored for nitrogen oxides, carbon monoxide and carbon dioxide. Each of these is discussed briefly below:

   - Nitrogen oxides were monitored according to EPA Method 7E. This was done using a TECO Model 10 analyzer. This analyzer works on the principle of chemiluminescence.
   - Carbon monoxide was monitored according to EPA Method 10. This was done using a TECO Model 48 analyzer. This analyzer works on the principle of non-dispersive infrared spectroscopy.
   - Carbon dioxide was monitored according to EPA Method 3A. This was done using a Siemens Ultramat analyzer. This analyzer works on the principle of non-dispersive infrared spectroscopy.

   For this test program, emissions from each boiler were monitored over three independent 60-minute periods.

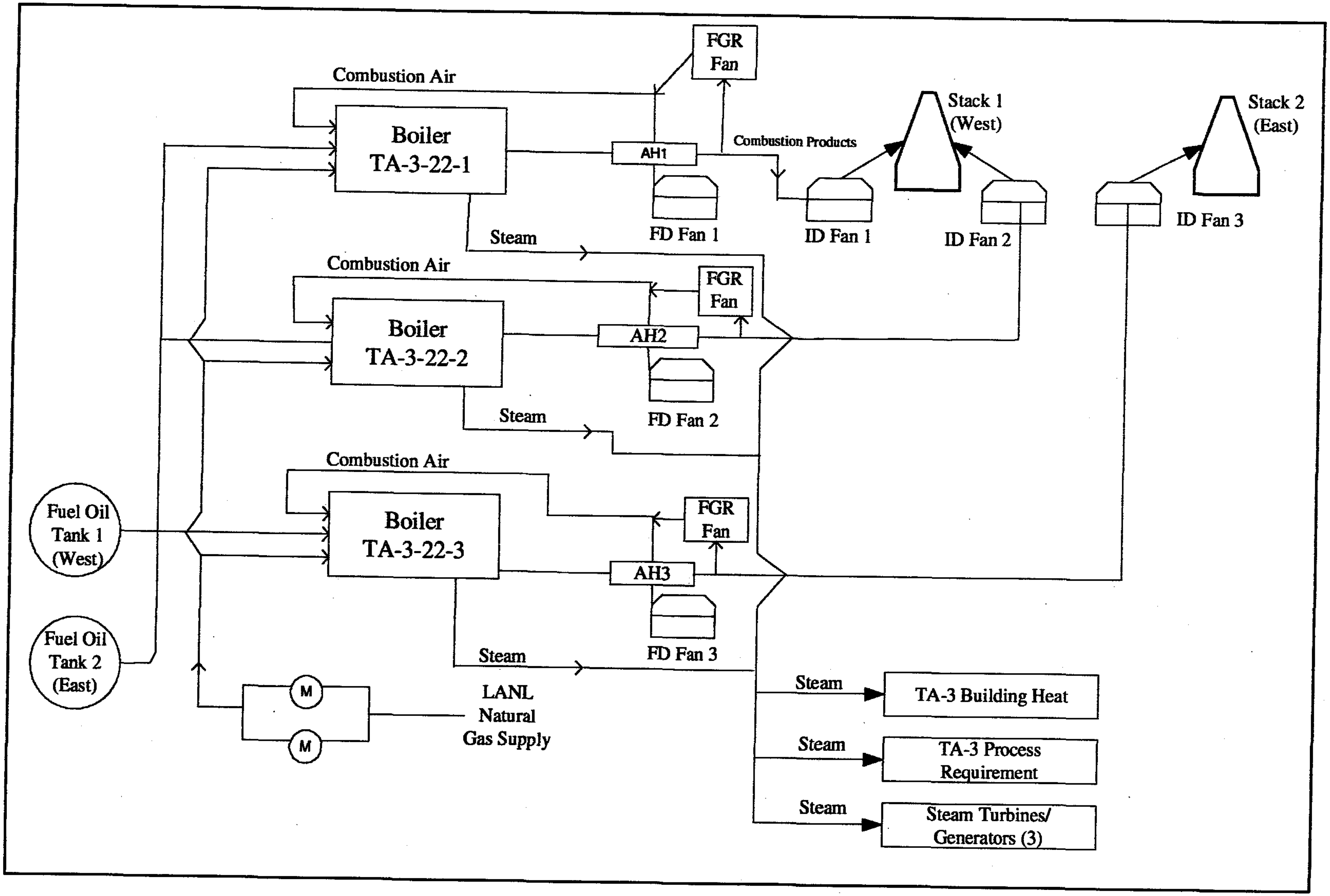
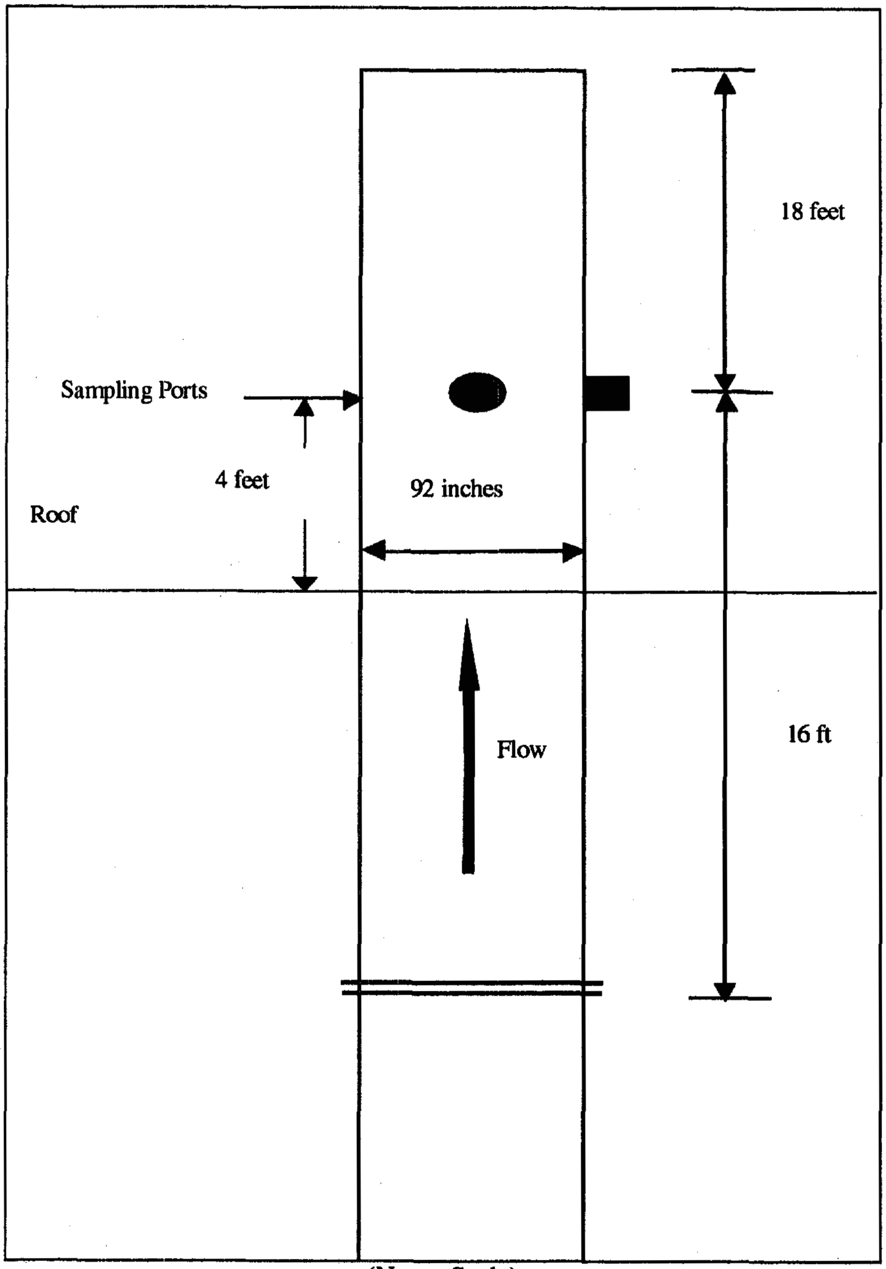


Figure 1. Power Plant and Boilers 1, 2, and 3 Schematic



(Not to Scale)

Figure 2. Schematic Drawing of Stack

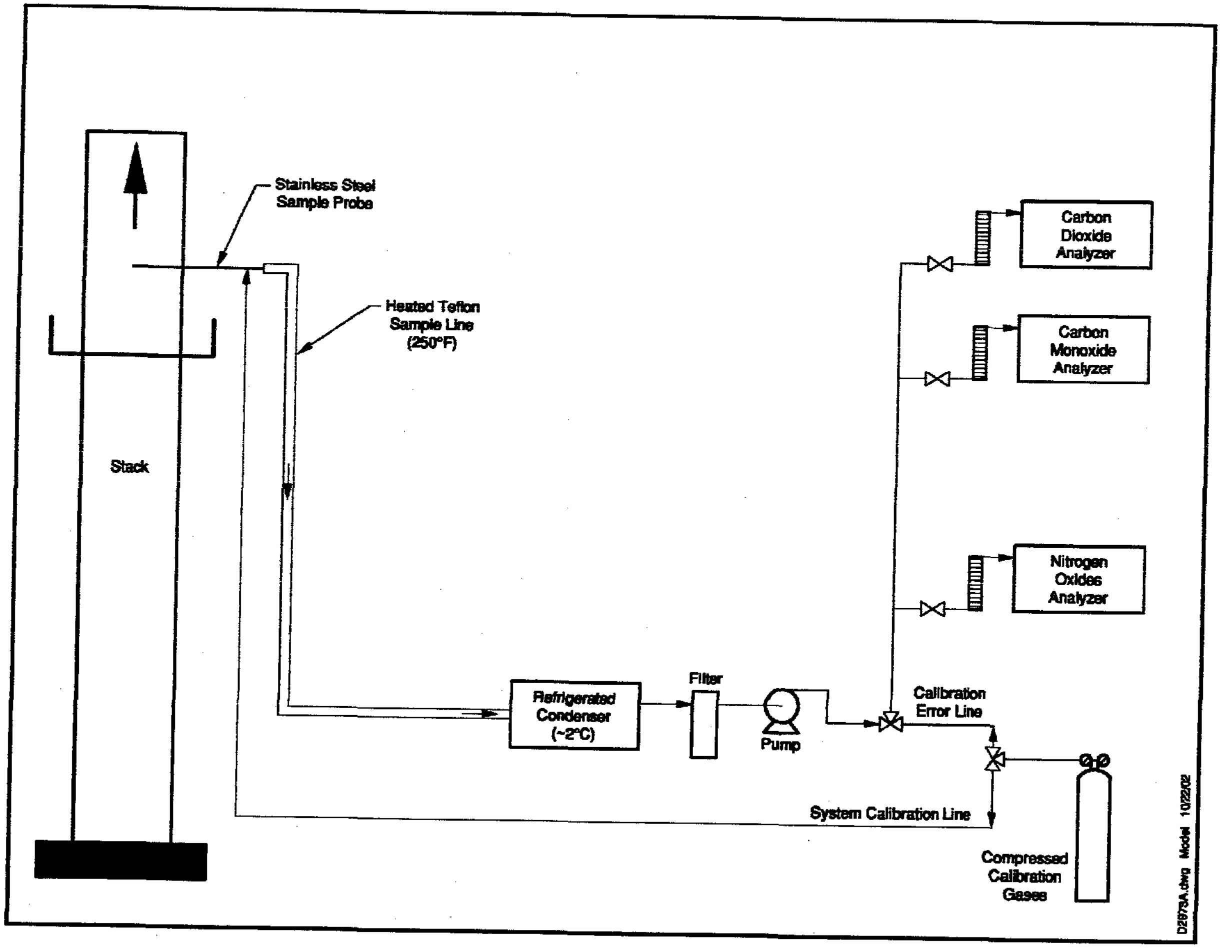


Figure 3. Schematic Drawing of CEM System

Quality Control – QC activities associated with the collection of samples included:

- Use of calibration gas standards of documented and appropriate quality (The documentation of calibration gas certification is presented in Appendix B.);
- Performance of instrument calibration (This is documented on the field notes presented in Appendix C and on the raw instrument data presented in Appendix D.);
- Performance of calibration error check (This is documented on the field notes presented in Appendix C and on the raw instrument data presented in Appendix D. Calibration error is summarized in Table 7.);
- Performance of system bias checks (This is documented on the field notes presented in Appendix C and on the raw instrument data presented in Appendix D. Bias and drift are summarized in Tables 8, 9, and 10.);
- Performance of zero and span bias and drift checks (This is documented on the field notes presented in Appendix C and on the raw instrument data presented in Appendix D. Bias and drift are summarized in Tables 8, 9, and 10.);
- Performance of NO_x converter efficiency check (This is documented in Appendix C); and
- Collection of data on field log sheets and on the computer data acquisition system (These are presented in Appendices C and D.).

D. Any deviation from EPA reference methods or from the original protocol and who at the Air Quality Bureau approved the deviation.

The original protocol specified that stack flow rate would be measured using EPA Method 2 (and methods referenced therein). Method 19 was used for the determination of stack flow rate.

This deviation was approved by John Volkerding at the Air Quality Bureau with the provision that gas flow rate be measured with a certified flow meter, and that the heat value of the fuel be determined by analysis (see email, Appendix F).

The plant was operated using only one boiler at a time, so that the fuel flow rate through the facility's calibrated flow meter represented fuel flow to each boiler, in turn. The heat value of the fuel was analyzed on the day of testing. Results of the analysis are included in Appendix A.

E. Make and model of test instrumentation and specifications including sensitivity, interferences, response time, linearity, span and range, calibration dates/method.

Table 7. Results of Calibration Error Determination

		Cylinder Value (ppm)	Analyzer Response (ppm)	Absolute Difference (ppm)	Difference (% of Span)
9/25/02	NO_x	0	0.39	0.39	0.39
		44.82	45.48	0.66	0.66
		85.63	85.66	0.03	0.03
	CO	0	0.81	0.81	0.81
		30.6	30.85	0.25	0.25
		59.3	59.26	0.04	0.04
		87.7	85.72	1.98	1.98
	CO_2	0	0.13	0.13	0.52
		9.96	9.88	0.09	0.34
		18.10	18.21	0.11	0.45
9/26/02	NO_x	0	0.11	0.11	0.11
		44.82	45.92	1.10	1.10
		85.63	84.57	1.06	1.06
	CO	0	0.75	0.75	0.75
		30.6	32.34	1.74	1.74
		59.3	58.59	0.71	0.71
		87.7	90.36	2.66	2.66
	CO_2	0	0.07	0.07	0.27
		9.96	9.96	0.00	0.02
		18.10	18.03	0.07	0.26
9/27/02	NO_x	0	0.11	0.11	0.11
		44.82	46.11	1.29	1.29
		85.63	84.06	1.57	1.57
	CO	0	0.07	0.07	0.07
		30.6	31.04	0.44	0.44
		59.3	57.92	1.38	1.38
		87.7	87.33	0.37	0.37
	CO_2	0	0.07	0.07	0.26
		9.96	9.87	0.09	0.35
		18.10	18.02	0.08	0.31

Table 8. System Bias and Drift for Determination of NO_x

Date	Mid-Range Gas					Zero Gas				
	Time	Actual Value (ppm)	Analyzer Response (ppmv)	Bias (% of span)	Drift (% of span)	Time	Actual Value (ppm)	Analyzer Response (ppmv)	Bias (% of span)	Drift (% of span)
9/25/02	16:57	44.82	48.37	3.5		17:00	0	0.51	0.5	
	18:29	44.82	47.78	3.0	-0.6	18:32	0	0.616	0.6	0.1
	19:45	44.82	47.27	2.5	-0.5	19:50	0	0.38	0.4	-0.2
	21:10	44.82	46.88	2.1	-0.4	21:13	0	0.56	0.6	0.2
9/26/02	8:03	44.82	45.50	0.7		8:01	0	0.01	0.0	
	9:17	44.82	46.50	1.7	1.0	9:20	0	0.77	0.8	0.8
	10:37	44.82	45.38	0.6	-1.1	10:39	0	0.67	0.7	-0.1
	12:03	44.82	45.70	0.9	0.3	12:05	0	0.68	0.7	0.0
9/27/02	7:46	44.82	45.66	0.8		7:15	0	0.11	0.1	
	9:31	44.82	45.47	0.7	-0.2	9:35	0	0.65	0.6	0.5
	10:50	44.82	44.73	-0.1	-0.7	10:54	0	0.46	0.5	-0.2
	12:12	44.82	45.12	0.3	0.4	12:15	0	0.65	0.6	0.2

Table 9. System Bias and Drift for CO Determination

Date	Mid-Range Gas					Zero Gas				
	Time	Actual Value (ppm)	Analyzer Response (ppmv)	Bias (% of span)	Drift (% of span)	Time	Actual Value (ppm)	Analyzer Response (ppmv)	Bias (% of span)	Drift (% of span)
9/25/02	17:06	59.3	63.04	3.7		17:00	0	1.99	2.0	
	18:18	59.3	61.62	2.3	-1.4	18:29	0	2.92	2.9	0.9
	19:40	59.3	61.90	2.6	0.3	19:48	0	1.77	1.8	-1.2
	21:01	59.3	63.79	4.5	1.9	21:13	0	2.46	2.5	0.7
9/26/02	7:52	59.3	61.92	2.6		8:01	0	2.21	2.2	
	9:11	59.3	64.24	4.9	2.3	9:18	0	2.45	2.4	0.2
	10:31	59.3	62.45	3.1	-1.8	10:40	0	3.24	3.2	0.8
	11:55	59.3	63.67	4.4	1.2	12:05	0	3.42	3.4	0.2
9/27/02	8:05	59.3	61.08	1.8		8:12	0	3.66	3.7	
	9:27	59.3	60.92	1.6	-0.2	9:33	0	3.97	4.0	0.3
	10:42	59.3	61.59	2.3	0.7	10:54	0	4.69	4.7	0.7
	12:03	59.3	61.22	1.9	-0.4	12:15	0	4.05	4.1	-0.6

Table 10. System Bias and Drift for CO_2 Determination

Date	Mid-Range Gas					Zero Gas				
	Time	Actual Value (ppm)	Analyzer Response (ppmv)	Bias (% of span)	Drift (% of span)	Time	Actual Value (ppm)	Analyzer Response (ppmv)	Bias (% of span)	Drift (% of span)
9/25/02	17:01	9.96	10.11	0.6		17:02	0	0.21	0.9	
	18:32	9.96	9.99	0.1	-0.4	18:28	0	0.09	0.4	-0.5
	19:47	9.96	10.07	0.4	0.3	19:49	0	0.24	0.9	0.6
	21:07	9.96	10.07	0.4	0.0	21:14	0	0.10	0.4	-0.5
9/26/02	8:01	9.96	10.00	0.2		8:04	0	0.19	0.8	
	9:16	9.96	9.99	0.1	0.0	9:20	0	0.16	0.6	-0.1
	10:34	9.96	9.99	0.1	0.0	10:40	0	0.10	0.4	-0.2
	12:00	9.96	9.94	-0.1	-0.2	12:05	0	0.10	0.4	0.0
9/27/02	7:50	9.96	9.90	-0.2		8:11	0	0.08	0.3	
	9:29	9.96	9.95	0.0	0.2	9:35	0	0.11	0.4	0.1
	10:46	9.96	9.97	0.1	0.1	10:54	0	0.09	0.4	0.0
	12:08	9.96	9.90	-0.2	-0.3	12:15	0	0.11	0.4	0.0

The models of the instruments used during this testing are specified in Table 11.

Table 11. Continuous Monitoring Instrument Specifications

	Nitrogen Oxides	Carbon Monoxide	Carbon Dioxide
Manufacturer	TECO	TECO	Siemens
Model	10	48	Ultramat
Principle of Operation	Chemiluminescence	NDIR	NDIR
Span	100 ppmv	100 ppmv	25%
Calibration	Daily, per method specifications	Daily, per method specifications	Daily, per method specifications
Linearity (Calibration Error)	Per method specifications	Per method specifications	Per method specifications
Response Time (observed during system bias check	40 seconds	90 seconds	30 seconds
Interferences	Acceptable response (zero) to all upscale standards from other calibration gases		
Method	EPA Method 7E	EPA Method 10	EPA Method 3A
Sensitivity	Threshold sensitivity reported as 2% of full scale; 2 ppmv for NO_x and CO; 0.5 % for CO_2		

F. A brief description of the methods used to obtain plant or unit operating parameters/ conditions. Measured parameters must be clearly distinguished from derived parameters.

Operating data for fuel flow and steam flow were obtained from flow transmitters electronically to the control system. The data on fuel flow and steam flow during the time of the testing were retrieved from the control room computer system and downloaded to an Excel spreadsheet.

IV. Data and Calculations

This section includes copies of all raw data and at least one example calculation for every derived number showing all equations used. This section includes, but is not limited to:

A. All raw data used in the emissions calculations:

1. Plant operating parameters. The power plant was operated in a nominal maximum operating conditions. This is documented in Appendix A.

2. Unit operating parameters. Each of the boilers was operated in a normal maximum operating condition. Boiler operation is documented in Appendix A.

3. Stack parameters (including cyclonic flow data). No stack parameters were measured. Velocities and emission rates were calculated using EPA Method 19.

4. Control equipment operating parameters. The control equipment is the FGR. Documentation of FGR operation is presented in Appendix A.

5. Isokinetic calculations, if applicable.

   Not Applicable.

C. Laboratory data, including blanks, tare weights, and results of analysis.

Not applicable.

D. Labeled copies of strip charts.

Not applicable. CEM data was collected on a computerized data acquisition system. Raw CEM data is presented in Appendix C.

E. An example calculation for every calculated result showing how the result was derived from the raw data.

Show all equations used on any approximations. Carry out to completion the calculations for at least one test run.

Detailed calculations for Run 1 are presented in Appendix E.

E. Analysis and certification documents for calibration gases. List expiration dates. (Warning: transferring the gas to a secondary container voids the certification).

Documentation for calibration gases is presented in Appendix B.

F. Audit sample results (if applicable).

Not applicable.

G. Visible emissions field sheets (Method 5 or where applicable).

Not applicable.

H. Sample chain of custody, if applicable. Show names of custodians, method of transportation, departure and arrival times/locations.

Not applicable.

V. Appendices

Place any additional information in this section, including but not limited to:

A. Any complications during the tests or with plant operations and how these might have biased the results.

Not applicable.

B. Any special information that might be helpful for performing future tests at this site.

Not applicable.

C. Brief resumes including experience of test personnel.

Resumes of stack testing personnel were provided in the Stack Test Plan submitted in September 2002.

APPENDIX E

AP-42 and Emissions Data

Air Curtain Destructors

Table 3.3-1. EMISSION FACTORS FOR UNCONTROLLED GASOLINE AND DIESEL INDUSTRIAL ENGINES[a]

Pollutant	Gasoline Fuel (SCC 2-02-003-01, 2-03-003-01)		Diesel Fuel (SCC 2-02-001-02, 2-03-001-01)		EMISSION FACTOR RATING
	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	
NO_x	0.011	1.63	0.031	4.41	D
CO	0.439	62.7	6.68 E-03	0.95	D
SO_x	5.91 E-04	0.084	2.05 E-03	0.29	D
PM-10[b]	7.21 E-04	0.10	2.20 E-03	0.31	D
CO_2[c]	1.08	154	1.15	164	B
Aldehydes	4.85 E-04	0.07	4.63 E-04	0.07	D
TOC					
Exhaust	0.015	2.10	2.47 E-03	0.35	D
Evaporative	6.61 E-04	0.09	0.00	0.00	E
Crankcase	4.85 E-03	0.69	4.41 E-05	0.01	E
Refueling	1.08 E-03	0.15	0.00	0.00	E

[a] References 2,5-6,9-14. When necessary, an average brake-specific fuel consumption (BSFC) of 7,000 Btu/hp-hr was used to convert from lb/MMBtu to lb/hp-hr. To convert from lb/hp-hr to kg/kw-hr, multiply by 0.608. To convert from lb/MMBtu to ng/J, multiply by 430. SCC = Source Classification Code. TOC = total organic compounds.

[b] PM-10 = particulate matter less than or equal to 10 μm aerodynamic diameter. All particulate is assumed to be ≤ 1 μm in size.

[c] Assumes 99% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, 86 weight % carbon in gasoline, average BSFC of 7,000 Btu/hp-hr, diesel heating value of 19,300 Btu/lb, and gasoline heating value of 20,300 Btu/lb.

Table 3.3-2. SPECIATED ORGANIC COMPOUND EMISSION FACTORS FOR UNCONTROLLED DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

Pollutant	Emission Factor (Fuel Input) (lb/MMBtu)
Benzene[b]	9.33 E-04
Toluene[b]	4.09 E-04
Xylenes[b]	2.85 E-04
Propylene[b]	2.58 E-03
1,3-Butadiene[b,c]	<3.91 E-05
Formaldehyde[b]	1.18 E-03
Acetaldehyde[b]	7.67 E-04
Acrolein[b]	<9.25 E-05
Polycyclic aromatic hydrocarbons (PAH)	
Naphthalene[b]	8.48 E-05
Acenaphthylene	<5.06 E-06
Acenaphthene	<1.42 E-06
Fluorene	2.92 E-05
Phenanthrene	2.94 E-05
Anthracene	1.87 E-06
Fluoranthene	7.61 E-06
Pyrene	4.78 E-06
Benzo(a)anthracene	1.68 E-06
Chrysene	3.53 E-07
Benzo(b)fluoranthene	<9.91 E-08
Benzo(k)fluoranthene	<1.55 E-07
Benzo(a)pyrene	<1.88 E-07
Indeno(1,2,3-cd)pyrene	<3.75 E-07
Dibenz(a,h)anthracene	<5.83 E-07
Benzo(g,h,l)perylene	<4.89 E-07
TOTAL PAH	1.68 E-04

[a] Based on the uncontrolled levels of 2 diesel engines from References 6-7. Source Classification Codes 2-02-001-02, 2-03-001-01. To convert from lb/MMBtu to ng/J, multiply by 430.
[b] Hazardous air pollutant listed in the *Clean Air Act*.
[c] Based on data from 1 engine.

Total 0.0064536 lb/MMBtu

$$0.0065 \frac{lb}{MMBtu} \times \frac{7000\ Btu}{hp\text{-}hr} \times \frac{MM}{1 \times 10^6} = 4.6 \times 10^{-5} \frac{lb}{hp\text{-}hr}$$

↑ from footnote in Table 3.3-1

1.6 Wood Residue Combustion In Boilers

1.6.1 General[1-6]

The burning of wood residue in boilers is mostly confined to those industries where it is available as a byproduct. It is burned both to obtain heat energy and to alleviate possible solid residue disposal problems. In boilers, wood residue is normally burned in the form of hogged wood, bark, sawdust, shavings, chips, mill rejects, sanderdust, or wood trim. Heating values for this residue range from about 4,500 British thermal units/pound (Btu/lb) of fuel on a wet, as-fired basis, to about 8,000 Btu/lb for dry wood. The moisture content of as-fired wood is typically near 50 weight percent for the pulp, paper and lumber industries and is typically 10 to 15 percent for the furniture industry. However, moisture contents may vary from 5 to 75 weight percent depending on the residue type and storage operations. Generally, bark is the major type of residue burned in pulp mills; either a mixture of wood and bark residue or wood residue alone is burned most frequently in the lumber, furniture, and plywood industries.

1.6.2 Firing Practices[5, 7, 8]

Various boiler firing configurations are used for burning wood residue. One common type of boiler used in smaller operations is the Dutch oven. This unit is widely used because it can burn fuels with very high moisture content. Fuel is fed into the oven through an opening in the top of a refractory-lined furnace. The fuel accumulates in a cone-shaped pile on a flat or sloping grate. Combustion is accomplished in two stages: (1) drying and gasification, and (2) combustion of gaseous products. The first stage takes place in the primary furnace, which is separated from the secondary furnace chamber by a bridge wall. Combustion is completed in the secondary chamber before gases enter the boiler section. The large mass of refractory helps to stabilize combustion rates but also causes a slow response to fluctuating steam demand.

In another boiler type, the fuel cell oven, fuel is dropped onto suspended fixed grates and is fired in a pile. Unlike the Dutch oven, the refractory-lined fuel cell also uses combustion air preheating and positioning of secondary and tertiary air injection ports to improve boiler efficiency. Because of their overall design and operating similarities, however, fuel cell and Dutch oven boilers have many comparable emission characteristics.

The firing method most commonly employed for wood-fired boilers with a steam generation rate larger than 100,000 lb/hr is the spreader stoker. In this boiler type, wood enters the furnace through a fuel chute and is spread either pneumatically or mechanically across the furnace, where small pieces of the fuel burn while in suspension. Simultaneously, larger pieces of fuel are spread in a thin, even bed on a stationary or moving grate. The burning is accomplished in three stages in a single chamber: (1) moisture evaporation; (2) distillation and burning of volatile matter; and (3) burning of fixed carbon. This type of boiler has a fast response to load changes, has improved combustion control, and can be operated with multiple fuels. Natural gas, oil, and/or coal, are often fired in spreader stoker boilers as auxiliary fuels. The fossil fuels are fired to maintain constant steam production when the wood residue moisture content or mass rate fluctuates and/or to provide more steam than can be generated from the residue supply alone. Although spreader stokers are the most common stokers among larger wood-fired boilers, overfeed and underfeed stokers are also utilized for smaller units.

Table 1.6-2. EMISSION FACTORS FOR NO_x, SO_2, AND CO FROM WOOD RESIDUE COMBUSTION[a]

Source Category[c]	NO_x[b]		SO_2[b]		CO[b]	
	Emission Factor (lb/MMbtu)	EMISSION FACTOR RATING	Emission Factor (lb/MMBtu)	EMISSION FACTOR RATING	Emission Factor (lb/MMbtu)	EMISSION FACTOR RATING
Bark/bark and wet wood/wet wood-fired boiler	0.22[d]	A	0.025[e]	A	0.60[f,g,i,j]	A
Dry wood-fired boilers	0.49[h]	C	0.025[e]	A	0.60[f,g,i,j]	A

[a] Units of lb of pollutant/million Btu (MMBtu) of heat input. To convert from lb/MMBtu to lb/ton, multiply by (HHV * 2000), where HHV is the higher heating value of the fuel, MMBtu/lb. To convert lb/MMBtu to kg/J, multiply by 4.3E-10. NO_x = Nitrogen oxides, SO_2 = Sulfur dioxide, CO = Carbon monoxide.
[b] Factors represent boilers with no controls or with particulate matter controls.
[c] These factors apply to Source Classification Codes (SCC) 1-0X-009-YY, where X = 1 for utilities, 2 for industrial, and 3 for commercial/institutional, and where Y = 01 for bark-fired boiler, 02 for bark and wet wood-fired boiler, 03 for wet wood-fired boiler, and 08 for dry wood-fired boiler.
[d] References 19, 33, 34, 39, 40, 41, 55, 62-64, 67, 70, 72, 78, 79, 88-89.
[e] References 26, 45, 50, 72, 88-89.
[f] References 26, 59, 88-89.
[g] References 19, 26, 39-41, 60-64, 67, 68, 70, 75, 79, 88-89.
[h] References 30, 34, 45, 50, 80, 81, 88-89.
[i] References 26, 30, 45-51, 80-82, 88-89.
[j] Emission factor is for stokers and dutch ovens/fuel cells. References 26, 34, 36, 55, 60, 65, 71, 72, 75. **CO Factor for fluidized bed combustors is 0.17 lb/MMbtu.** References 26, 72, 88-89.

$$0.22\ \frac{lb}{mmBtu} \times 0.0045\ \frac{mmBtu}{lb} \times 2000\ \frac{lb}{ton} = 2.0\ \frac{lb}{ton}$$

FOUNTAINHEAD
ENGINEERING
LIMITED

Final Report Describing Particulate and Carbon Monoxide Emissions From the Whitton S-127 Air Curtain Destructor

December 26, 2000

Prepared for:
WHITTON TECHNOLOGY, INC.
Air Burners Products Division
4390 Cargo Way
Palm City, Florida 34990

Prepared by:
FOUNTAINHEAD ENGINEERING
134 N. LaSalle Street, Suite 720
Chicago, Illinois 60602
And
DERUITER ENVIRONMENTAL, INC.
P.O. Box 1702
Tallahassee, FL 32302

In association with:
GENESIS AIR, INC.
8412 Kreuter NE
Rockford, Michigan 49341

Project #00-21

FOUNTAINHEAD
ENGINEERING
LIMITED

December 26, 2000

Mr. Brian O'Connor
Managing Director
Whitton Technology Ltd.
4390 Cargo Way
Palm City, Florida 34990

RE: Transmittal of Final Emissions Report for the Whitton S-127 Air Curtain Destructor

Dear Mr. O'Connor:

Fountainhead Engineering, Ltd. (FOUNTAINHEAD) is pleased to submit the enclosed final report for the emissions testing performed on the Whitton S-127 refractory lined air curtain destructor conducted on October 10 and October 11, 2000 in Clarkston, Michigan. FOUNTAINHEAD performed three emission test runs with the S-Series technology and averaged the results. Methodologies and approaches are contained in the attached report.

The design of the Whitton S-Series air curtain destruction (ACD) incineration technology presents several challenges to representative emissions sampling. The largest obstacle to representative sampling is the lack of a single, measurable emission point due to its open combustion chamber or "box" design. The turbulence created by the operation of the air curtain, the make up air provided by the air curtain, the temperature of combustion and the resulting rising air creates an extremely turbulent flow over the operating ACD.

Traditional stack testing methods are not designed for sampling from a turbulent gas stream. However, with modifications the quantification or measurement of emissions from the ACD was documented for submittal to State regulators. To our knowledge this is the first time that the S-Series refractory lined incineration units have been subjected to this type of testing. The testing approach utilized can be reproduced following our initial testing methods described in the documentation report. The ability of others to reproduce the results by utilizing the testing protocol was an important factor considered when determining the test method(s). The project team did consider other approaches as well.

We assessed the performance of an ambient air quality testing approach, which would employ ambient air sampling techniques at a point downwind of the operating ACD to quantify particulate

134 N.LaSalle Street, Suite 720 • Chicago, Illinois 60602 • Phone: 312-332-4434 • Fax: 312-346-2968
530 S. Whittaker, No. 378 • New Buffalo, Michigan, 49117 • Phone: 616-469-5014 • Fax: 616 469-5937
P.O. Box 2502 • Ann Arbor, Michigan 48106 • Phone: 734-663-0883 • Fax: 734-663-1882
P.O. Box 67 • Zenda, Wisconsin 53195 • Phone: 262-249-0936 • Fax: 262-249-0937

emissions. This approach would give an indication of the "impact" of potential contaminants (particulates), but could not be correlated back to a point source emission rate. In addition with the active loading of the unit by either a front-end loader or track backhoe (possibly configured with a grapple attachment) there could be additional particulate readings associated with the rolling stock which could not necessarily be differentiated from particulate emissions from the combusted wood waste incinerated by the ACD. Furthermore measurements may be influenced by the rolling stock feeding fuel into the ACD since the "downwind side" of the ACD would be opposite of the manifold and this happens to be the "loading side" of the ACD. This approach would not illustrate what's happening "above the box". This brings us to our next consideration, a "Canopy Hood Approach".

The initial sampling strategy consisted of assessing the temporary placement of a canopy hood to fully capture any emissions and direct them towards a single exhaust port. The directed emissions would then be sampled using USEPA Methods 1-5 and USEPA Method 10 for Carbon Monoxide. Although this would be a more traditional approach as it relates to "methods" testing the logistical difficulties appeared to be substantial.

The primary "logistical" difficulty is fueling the ACD unit. Fuel is added from the top of the ACD via a front loader or similar "rolling stock" as described previously which is opposite of the manifold. The canopy hood would block efficient fueling of the ACD. Although initially attractive from a simplistic point of view the data collected would be flawed when truly assessing normal operating conditions of the ACD.

The effects of the air curtain and its flow dynamic would be disrupted by the flow interference caused by the collection hood. The likely scenario would be a loss of flow balance, resulting in emissions escaping from the bottom of the canopy hood and would cause a decrease of combustion efficiency resulting from insufficient oxygen supply. The effect on measured emissions rates associated with decreased combustion efficiency from combustion units are well documented and for the ACD the results would probably include increased carbon monoxide readings and increased particulate capture due to the hood. This is not representative of actual operation or "in-field" conditions.

There are many problems associated with the "hood" approach. The initial attractiveness of trying to "force" the flow to one isolated sample point should be weighed against the quality of the data obtained. The data collected in this testing approach would not be able to be reliably reproduced under normal operating conditions associated with this technology in the field and would overestimate emission rates. This approach may be appropriate for "methods applications" but biased for data collection and interpretation. In addition the hood would not allow for normal feeding or loading of the wood waste and would therefore once again not be representative of an actual operating installation under normal operating conditions. The hood approach could not be judged adequate since it changes the operations of the entire system and has many logistical interruptions to the normal operating ACD system.

The next option assessed was "total enclosure". This approach would pace the ACD inside of a temporary enclosure, similar to that of a metal building with a single emission point (or stack) located at the top of the building. Special sliding doors would need to be fabricated and installed in this approach which would allow a front loader to fuel the unit from opposite the manifold. The obvious drawbacks to this approach are safety and health risks for personnel performing the test and operating the unit. As with the canopy approach the entire system dynamics would be altered in order to make the "methods" application more traditional. This would sacrifice an understanding of how the system would actually perform in the field and it would be difficult to replicate under normal operating conditions. In addition it be difficult to evaluate the quality of the data since the building or enclosure would impact the thermal dynamics of the ACD.

From a practical standpoint the heat generated by the accelerated combustion process would be significant and very dangerous to sampling personnel on the roof of the structure. There is a possibility of an oxygen deficient atmosphere inside the building from lack of sufficient makeup air, which could jeopardize the health of the operators and fueling team. In addition to the human factors, a building that would be large and high enough to effectively house the ACD unit operating at maximum efficiency without taking structural damage would not be effective in collecting and concentrating emissions to a single point as intended. Therefore, this approach may be appropriates from a "methods application" but biased from a data quality standpoint.

The goal of any testing should be to accurately confirm how the air curtain technology will perform once installed in the field and operating normally. None of these approaches accomplish this nor do any of these proposed compliance-testing approaches allow for any reliable Method 9 assessment. Method 9 in most regulatory schemes is the primary "method" associated with air curtain incineration devices. Other testing consistent with traditional incineration methods, as we have illustrated would result in significant data collection errors or comprise the quality of the data as it relates to normal operating conditions in the field.

All of the" enclosure" strategies suggested by various regulatory personnel have severe limitations and will not provide consistency with "approved methods". The Whitton S-Series technology for untreated waste wood streams should be subjected to Method 9 testing. If Method 9 illustrates or reveals inconsistency with permit conditions then other testing may be appropriate. USEPA Method 9 is recognized as reliable by the USEPA and is used widely for compliance and used by state and federal agencies throughout the United States not only for compliance but for enforcement as well. Method 9 seems a simple and likely Method to assess this technology and it has been codified as well so consistency with federal regulation is not a problem if one chooses to use this Method for compliance purposes.

Regulatory agencies fail to address the fact that the enclosure testing approaches will:

- Cause an applicant to actually alter the technology for compliance testing only;
- Construct enclosures that if not impossible to build are extremely dangerous and would only be used for some sort of compliance testing that really isn't recognized;
- Place the applicants (or applicants staff) in dangerous conditions to collect unreliable data;
- Cause the fuel loading system to be altered from normal operating conditions and would make it impossible to fuel the S-Series efficiently or consistent with the manufactures specifications; and,
- Enclosure testing approaches will disrupt the flow and combustion characteristics of the ACD, resulting in conditions that are not reflective of actual operating conditions, which would place the results in the un-useable category.

The general goal was to provide a reproducible testing protocol that would not adversely interfere with the normal operating conditions of the ACD and allow the owner-operator to follow the manufactures guidance for safe and effective operation of the ACD. Since enclosures would not allow the ACD to operate as designed, a sampling method had to be devised that would allow the ACD to operate normally and still give a representative emission rate.

The solution devised was to use USEPA Method 5 for particulates (which encompasses Methods 1-4), USEPA Method 10 for Carbon Monoxide, and USEPA Method 9 for Opacity. These Methods were used as written in 40 CFR Part 60, Appendix A, with noted exceptions. These are explained in the documentation report and are summarized below.

The most significant deviation results with the use of USEPA Method 1. This method is used to determine the acceptable location for the sample point locations. This method was designed specifically for sampling *confined* sources of emissions, specifically stacks. The average stack has significant lengths of straight runs and gas flows at a consistent velocity when a blower or fan is incorporated into the system. Air flow in a confined stack follows predictable patterns, and the Reynolds number generally significantly decreases the further you get from any disturbances (fans, bends, changes in diameter). This results in an even, non-turbulent, easily sampled flow stream. Method 1 spells out sampling port locations in respect to upstream and downstream disturbances, and provides recommendations as to the number of sample points required in order to obtain a representative sample. This method is the root, the cornerstone, of all stack sampling.

An ideal sampling point, according to Method 1, is a point 7 to 8 stack diameters downstream from a disturbance, and 2 stack diameters from any upstream disturbance. The absolute minimum allowed is 2-stack diameters downstream, and 1 stack diameter upstream. This is the exact dimensions of the stack structure constructed (in accordance to USEPA Method 5D for lengthening short stacks) used to sample the ACD.

Unfortunately, the ACD does not produce a predictable gas stream source. The combustion chamber of the ACD is chaotic in its operation, with cross drafts, up drafts, and down drafts. To apply traditional stack testing methods to accurately quantify emissions of this source will leave considerable room for interpretation. But since it is classified as an incinerator, it has to be assigned some sort of emission specific to its actual point of emission. This implies to most regulators that do not have a separate category for air curtain incinerators that an applicant is somehow required to apply "traditional" stack testing methods. For the purposes of this discussion, the actual point will have to be classified as *"emissions past all emission control devices"*. The air curtain, along with its air supply properties that simultaneously aid with efficient combustion is also functioning as an emission control device. Therefore, point source emissions are classified as *emissions above the air curtain*.

The air curtain is invisible to the naked eye while in operation. It cannot be seen other than as a disturbance of the flame tips or a particularly intense area of combustion. The digital images included with the documentation report illustrate the clarity or minimal opacity of the operating ACD. However, the air curtain is quite noticeable from a velocity pressure standpoint.

When the stack structure is lowered into the air curtain, the air curtain actually creates a zone of negative pressure within the stack, drawing air from above the stack backwards down to the air curtain for re-circulation into the ACD. When the stack structure is raised above the air curtain, velocity pressure (which is used to calculate the volumetric flow rate) drops to zero. As the stack structure is raised slightly higher, velocity pressure becomes positive, very slightly positive (.010 to .050 inches of water displaced). If the stack is raised higher yet, velocity pressure drops off and becomes almost completely undetectable.

This indicated to the emission testing team that the most representative area to sample the Whitton S-Series unit is at the point of highest velocity pressure. This is what the field team did during the test. The point of negative pressure was identified and the sampling apparatus was raised to the point where velocity pressure was maximized. Our check was that we had a point in between the positive and negative pressures where the flow was zero. This demonstrates that the airflow from the exit manifold was not being funneled into the sampling apparatus (which would dilute the sample and give artificially low results). We were consistently able to reproduce this result during repeated trails before actual testing with the same results and therefore provided evidence that we were sampling the actual emissions of the ACD directly above the emission control device. By sampling at the point of highest velocity pressure, we were attempting to capture the most particulates and sample gas that we could for the ACD. We felt that this approach when compared to all other potential approaches described previously was reasonable, the most cost effective and did not interfere with the manufacturers operating instructions of the ACD and were exactly representative of in field normal operating conditions. The testing has yielded reasonable results, especially for run number 3, which yielded the lowest carbon monoxide numbers (this was the third run of the day, when the ACD was sufficiently heated and loading of the unit during this testing was near continuous).

Given similar conditions with another Whitton S-Series ACD in another location using slightly different waste wood feedstock with equal or greater fueling parameters and with at least 4 hours of peak operating efficiency prior to sampling we could reproduce the results within a reasonable degree of error. Therefore the general goal of reproducible data that reflects normal operating conditions can be achieved. In addition the Method 9 testing performed during testing should provide additional evidence of good combustion and good particulate capture and control.

FOUNTAINHEAD believes that the emission testing methods performed on the ACD provide accurate data that can be reproduced. The test methods also provide emissions data that reflects actual field conditions under normal operating conditions without altering the manufactures specification of the combustion or control technology.

If you have any questions please contact Bruce Bawkon P.E. (734) 663-0883 or Milan Kluko at (312) 332-4434.

Sincerely,

Fountainhead Engineering, Ltd.

Milan Kluko

Fountainhead Engineering, Ltd.

Bruce W. Bawkon, P.E.

Cc: Dave DeRuiter, CHMM, DeRuiter Environmental, Inc.
Amy L. Miller CHMM, Fountainhead Engineering, Ltd.

Table of Contents

Appendices

Appendix A: Method Calculations and Test Data
Method 5 Calculation Sheet, Run Summary
Method 5 Calculation Sheets
Method 10 Sample Calculation

Appendix B: Field Data Sheets, Per Run
Method 5 Particulate Field Data Sheets
Method 10 Carbon Monoxide Data Sheets
ECOM Data Sheets
Method 9 Opacity Data Sheets
Weather Data

Appendix C: Process and Sampling Schematics
Diagram of Sampling Train
Diagram of Sampling Points

Appendix D: Calibration Data
Method 5 Impinger Data
Meter Box Calibration
Orifice Calibration Spreadsheet
Type S Pitot Tube Inspection Data Sheet
Probe Nozzle Diameter Calibration Data Sheet
Temperature Sensor Calibration Data Sheet
NDIR Calibration
ECOM Calibration
Method 9 Certification, David DeRuiter

Appendix E: Digital Images (from Emissions Testing)

1.0 SUMMARY OF TEST RESULTS

The results of the emissions testing on the Air Curtain Destructor are as follows:

Run Number	Particulate (lbs/hr)	Carbon Monoxide (lbs/hr)	Opacity (%)
Run 1 (Startup)	0.81	4.67	1.5
Run 2	3.08	27.62	6.3
Run 3	1.54	7.06	3.8
Run 4	1.81	26.27	6.1
Averages*=	2.14	19.98	5.4

* Averages of Runs 2, Run 3 and Run 4 only. Run 1 was an engineering test to quantify emissions during start up and collect initial flow data from the mobile stack test unit.

** omitted run # 3 to be conservative

1.1 DESCRIPTION OF PROCESS

This mechanical combustion unit or MCU is a departure from typical combustion equipment upon which most air quality regulations have historically been developed. The S-Series MCU has a patented manifold design and it is engineered specifically to the dimensions of the combustion chamber. It has a specialized ceramic refractory lining that surrounds the combustion chamber. *Therefore it is quite different from other air curtain devices and incineration technologies*. This combustion system does not utilize a stack to transport combustion gases out of the primary or secondary furnace or boiler, which in turn passes into particulate and/or other air pollution control devices such as electric static precipitators (ESP's), bag houses or acid gas scrubbing systems. The primary combustion chamber is also not totally enclosed on four sides like most furnaces or boilers. These primary differences present some unique situations with the typical "air quality" approval process. This will be discussed in greater detail in Section 6 of this Technical Memorandum.

The engineering aspects of this unit rely on the fact that it is completely self-contained and the unit functions in a fashion that does not rely solely on an air delivery system blowing air across the unit for optimum emission control or combustion performance. The S-Series MCU relies on several systems with integrated supporting functions that enhance the operation of the MCU. This approach has refined the "air curtain concept". We will refer periodically to the S-127 series MCU but the technology for the other S-Series MCU are identical.

There are several variations of the S-Series MCU manufactured by Whitton Technology. The S-127 MCU is 37'4" long, 11'9' wide and 10'3" in height. The S-121 model is 32'2" long, 11'9" wide and 10'3" in height. The S-127 weighs approximately 50,000 lbs. and the S-121 weighs 41,000 lbs. Whitton also manufactures an S-116 model, which is 27' long, 7' 5" wide, and 7' 5" in height and weighs 24,500 lbs. The majority of the

VOLUME II: CHAPTER 14

UNCONTROLLED EMISSION FACTOR LISTING FOR CRITERIA AIR POLLUTANTS

July 2001

Prepared by:
Eastern Research Group, Inc.

Prepared for:
Point Sources Committee
Emission Inventory Improvement Program

[1]SCC	[2]PROCESS NAME	[3]PM, filt. Lbs/Unit	[4]PM-10 Lbs/Unit	[5]PM, cond. Lbs/Unit	[6]SOx Lbs/Unit	[7]NOx Lbs/Unit	[8]VOC Lbs/Unit	[9]CO Lbs/Unit	[10]Lead Lbs/Unit	[11]UNITS
Landfill Dump - 4953										
5-01-004-22	Waste Gas Recovery: Other	—	—	—	—	—	—	—	—	Million Cubic Feet Processed
5-01-004-23	Waste Gas Recovery: Boiler	—	—	—	—	33	—	5.7	—	Million Dry Standard Cubic Feet Generated
5-01-004-30	Waste Gas Purification: Absorption	—	—	—	—	—	—	—	—	Million Cubic Feet Processed
5-01-004-31	Waste Gas Purification: Adsorption	—	—	—	—	—	—	—	—	Million Cubic Feet Processed
5-01-004-32	Waste Gas Purification: Membranes	—	—	—	—	—	—	—	—	Million Cubic Feet Processed
5-01-004-33	Waste Purification: Other	—	—	—	—	—	—	—	—	Million Cubic Feet Processed
Other Incineration - 4953										
5-01-005-05	Medical Waste Incinerator, unspecified type, Infectious wastes only	—	—	—	—	—	—	—	—	Tons Burned
5-01-005-06	Sludge	—	—	—	—	[27] 1.04	—	[27] 7.73	—	Tons Burned
5-01-005-07	Conical Design (Tee Pee) Municipal Refuse	20	11	—	2	5	20	60	—	Tons Burned
5-01-005-08	Conical Design (Tee Pee) Wood Refuse	See App. C	3.85	—	0.1	1	11	130	—	Tons Burned
5-01-005-10	Trench Burner: Wood	13	4.94	—	0.1	4	19	—	—	Tons Burned
5-01-005-11	Trench Burner: Tires	138	52.4	—	—	—	6	—	—	Tons Burned
5-01-005-12	Trench Burner: Refuse	37	14.1	—	2.5	—	13	—	—	Tons Burned
5-01-005-15	Sludge: Multiple Hearth	100	8.2	—	20	5	1.7	31	0.1	Tons Fed
5-01-005-16	Sludge: Fluidized Bed	460	—	—	[21] 0.3	1.7	—	2.1	0.04	Tons Fed
5-01-005-17	Sludge: Electric Infrared	7.4	6	—	20	8.6	—	—	—	Tons Fed
5-01-005-18	Sewage Sludge Incinerator: Single Hearth Cyclone	—	—	—	—	—	—	—	—	Tons Fed
5-01-005-19	Sewage Sludge Incinerator: Rotary Kiln	—	—	—	—	—	—	—	—	Tons Fed
5-01-005-20	Sewage Sludge Incinerator: High Pressure, Wet Oxidation	—	—	—	—	—	—	—	—	Tons Fed
Fire Fighting - 9224										
5-01-006-01	Structure: Jet Fuel	—	—	—	—	—	—	—	—	1000 Gallons Burned
5-01-006-02	Structure: Distillate Oil	—	—	—	—	—	—	—	—	1000 Gallons Burned
5-01-006-03	Structure: Kerosene	—	—	—	—	—	—	—	—	1000 Gallons Burned
5-01-006-04	Structure: Wood Pallets	—	—	—	—	—	—	—	—	Tons Burned
Sewage Treatment - 4952										
5-01-007-01	Entire Plant	—	—	—	—	—	8.9	—	—	Million Gallons Processed

Air Burners LLC

Air Burners, LLC
4390 Cargo Way,
Palm City, Florida 34990
PH (772) 220-7303
Fax (772) 220-7302
E-Mail: nfuhrmann@airburners.com
www.airburners.com

FAX MESSAGE

Date: June 25, 2002
Pages: 1+1
To: Adrienne L. Nash, LANL
FAX: 505-665-8858
From: Norbert Fuhrmann, Marketing & Sales Manager
Mobile Phone: 561-622-9626
Subject: Florida Department of Environmental Regulation
Interoffice Memo of June 5, 1986

Ms. Nash,

Attached is a copy of our file copy of the referenced memorandum. It consist of only one (1) page.

Sincerely,

Norbert Fuhrmann

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

INTEROFFICE MEMORANDUM

For Routing To District Offices
And/Or To Other Than The Addressee

To:		Loctn.:			
To:		Loctn.:			
To:		Loctn.:			
From:		Date:			
Reply Optional [ ]		Reply Required [ ]		Info. Only [ ]	
Date Due		Date Due			

RECEIVED
JUN -9 1986
NORTHWEST FLORIDA DER

TO: District Managers
District Air Engineers
District Air Permitting Engineers
Local Program Air Directors

THRU: Bill Buzick

FROM: Clair Fancy

DATE: June 5, 1986

SUBJ: Interim Policy on Air Curtain Incinerators

Emission Factor

The permitting of air curtain incinerators has become a major air pollution permitting issue in the State of Florida during the past year. On May 16, 1986, the Bureau of Air Quality Management received permission from the Rule Development Committee to hold a workshop on June 17 on a number of air permitting issues, among them air curtain incinerators. It will be the responsibility of the district offices to permit these as minor sources using the explicit guidelines as outlined in this memo. The language of these guidelines will be the rule language proposed at this workshop.

According to AP-42, the emission factor for trench burning is 13 lbs particulate matter per ton of material burned. From discussions with EPA people, it is believed that these devices reduce particulate matter by between 80-90%. Consequently, 13 lb/ton x 15% = 1.95 lbs per ton. The bureau has determined that particulate emissions from these devices is 2 lbs per ton of clean wood charged in a well operated air curtain incinerator. Using this emission factor, one could burn the following amounts, for the following times, without the source being major for particulate.

Tons Burned/day	Days Per Year	Tons Particulate Per Year
500	200	100
390	256	100
385	260	100
274	365	100

Table 13.1-3 (Metric Units). EMISSION FACTORS FOR PRESCRIBED BURNING[a]

Fire/Fuel Configuration	Phase	Pollutant (g/kg)						Fuel Mix (%)	EMISSION FACTOR RATING
		Particulate			Carbon Monoxide	Volatile Organics			
		PM-2.5	PM-10	Total		Methane	Nonmethane		
Broadcast logging slash									
Hardwood	F	6	7[b]	13	44	2.1	3.8	33	A
	S	13	14[b]	20	146	8.0	7.7	67	A
	Fire	11	12[b]	18	112	6.1	6.4		A
Conifer									
Short needle	F	7	8[c]	12	72	2.3	2.1	33	A
	S	14	15[c]	19	226	7.2	4.2	67	A
	Fire	12	13[c]	17	175	5.6	3.5		A
Long needle	F	6	6[d]	9	45	1.5	1.7	33	B
	S	16	17[d]	25	166	7.7	5.4	67	B
	Fire	13	13[d]	20	126	5.7	4.2		B
Logging slash debris									
Dozer piled conifer									
No mineral soil[d]	F	4	4	5	28	1.0	ND	90	B
	S	6	7	14	116	8.7	ND	10	B
	Fire	4	4	6	37	1.8	ND		B

2.1 + 1.7 = 1.9 g/kg x .002205 lb/g x kg/.001102 ton

= 3.8 lb/ton

Table 1.6-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS, TOC, VOC, NITROUS OXIDE, AND CARBON DIOXIDE FROM WOOD RESIDUE COMBUSTION[a]

Organic Compound	Average Emission Factor[b] (lb/MMBtu)	EMISSION FACTOR RATING
Acenaphthene	**9.1 E-07**[c]	B
Acenaphthylene	**5.0 E-06**[d]	A
Acetaldehyde	**8.3 E-04**[e]	A
Acetone	**1.9 E-04**[f]	D
Acetophenone	**3.2 E-09**[g]	D
Acrolein	**4.0 E-03**[h]	C
Anthracene	**3.0 E-06**[i]	A
Benzaldehyde	**<8.5 E-07**[j]	D
Benzene	**4.2 E-03**[k]	A
Benzo(a)anthracene	**6.5 E-08**[l]	B
Benzo(a)pyrene	**2.6 E-06**[m]	A
Benzo(b)fluoranthene	**1.0 E-07**[l]	B
Benzo(e)pyrene	**2.6 E-09**[f]	D
Benzo(g,h,i)perylene	**9.3 E-08**[n]	B
Benzo(j,k)fluoranthene	**1.6 E-07**[o]	D
Benzo(k)fluoranthene	**3.6 E-08**[p]	B
Benzoic acid	**4.7 E-08**[q]	D
bis(2-Ethylhexyl)phthalate	**4.7 E-08**[g]	D
Bromomethane	**1.5 E-05**[f]	D
2-Butanone (MEK)	**5.4 E-06**[f]	D
Carbazole	**1.8 E-06**[f]	D
Carbon tetrachloride	**4.5 E-05**[r]	D
Chlorine	**7.9 E-04**[s]	D
Chlorobenzene	**3.3 E-05**[f]	D
Chloroform	**2.8 E-05**[f]	D
Chloromethane	**2.3 E-05**[f]	D
2-Chloronaphthalene	**2.4 E-09**[f]	D
2-Chlorophenol	**2.4 E-08**[u]	C
Chrysene	**3.8 E-08**[c]	B
Crotonaldehyde	**9.9 E-06**[j]	D
Decachlorobiphenyl	**2.7 E-10**[r]	D
Dibenzo(a,h)anthracene	**9.1 E-09**[l]	B
1,2-Dibromoethene	**5.5 E-05**[f]	D
Dichlorobiphenyl	**7.4 E-10**[r]	C
1,2-Dichloroethane	**2.9 E-05**[r]	D
Dichloromethane	**2.9 E-04**[v]	D
1,2-Dichloropropane	**3.3 E-05**[f]	D
2,4-Dinitrophenol	**1.8 E-07**[w]	C
Ethylbenzene	**3.1 E-05**[f]	D
Fluoranthene	**1.6 E-06**[x]	B
Fluorene	**3.4 E-06**[i]	A
Formaldehyde	**4.4 E-03**[y]	A
Heptachlorobiphenyl	**6.6E-11**[r]	D

Table 1.6-3. (cont.)

Organic Compound	Average Emission Factor[b] (lb/MMBtu)	EMISSION FACTOR RATING
Hexachlorobiphenyl	**5.5 E-10[r]**	D
Hexanal	**7.0 E-06[z]**	D
Heptachlorodibenzo-p-dioxins	**2.0 E-09[aa]**	C
Heptachlorodibenzo-p-furans	**2.4 E-10[aa]**	C
Hexachlorodibenzo-p-dioxins	**1.6 E-06[aa]**	C
Hexachlorodibenzo-p-furans	**2.8 E-10[aa]**	C
Hydrogen chloride	**1.9 E-02[j]**	C
Indeno(1,2,3,c,d)pyrene	**8.7 E-08[l]**	B
Isobutyraldehyde	**1.2 E-05[z]**	D
Methane	**2.1 E-02[f]**	C
2-Methylnaphthalene	**1.6 E-07[z]**	D
Monochlorobiphenyl	**2.2 E-10[r]**	D
Naphthalene	**9.7 E-05[ab]**	A
2-Nitrophenol	**2.4 E-07[w]**	C
4-Nitrophenol	**1.1 E-07[w]**	C
Octachlorodibenzo-p-dioxins	**6.6 E-08[aa]**	B
Octachlorodibenzo-p-furans	**8.8 E-11[aa]**	C
Pentachlorodibenzo-p-dioxins	**1.5 E-09[aa]**	B
Pentachlorodibenzo-p-furans	**4.2 E-10[aa]**	C
Pentachlorobiphenyl	**1.2 E-09[r]**	D
Pentachlorophenol	**5.1 E-08[ac]**	C
Perylene	**5.2 E-10[f]**	D
Phenanthrene	**7.0 E-06[ad]**	B
Phenol	**5.1 E-05[ae]**	C
Propanal	**3.2 E-06[z]**	D
Propionaldehyde	**6.1 E-05[f]**	D
Pyrene	**3.7 E-06[af]**	A
Styrene	**1.9 E-03[f]**	D
2,3,7,8-Tetrachlorodibenzo-p-dioxins	**8.6 E-12[aa]**	C
Tetrachlorodibenzo-p-dioxins	**4.7 E-10[ag]**	C
2,3,7,8-Tetrachlorodibenzo-p-furans	**9.0 E-11[aa]**	C
Tetrachlorodibenzo-p-furans	**7.5 E-10[aa]**	C
Tetrachlorobiphenyl	**2.5 E-09[r]**	D
Tetrachloroethene	**3.8 E-05[t]**	D
o-Tolualdehyde	**7.2 E-06[j]**	D
p-Tolualdehyde	**1.1 E-05[z]**	D
Toluene	**9.2 E-04[v]**	C
Trichlorobiphenyl	**2.6 E-09[r]**	C
1,1,1-Trichloroethane	**3.1 E-05[t]**	D
Trichloroethene	**3.0 E-05[t]**	D
Trichlorofluoromethane	**4.1 E-05**	D
2,4,6-Trichlorophenol	**<2.2 E-08[ak]**	C

Table 1.6-3. (cont.)

Organic Compound	Average Emission Factor[b] (lb/MMBtu)	EMISSION FACTOR RATING
Vinyl Chloride	**1.8 E-05**[r]	D
o-Xylene	**2.5 E-05**[v]	D
Total organic compounds (TOC)	**0.039**[ai]	D
Volatile organic compounds (VOC)	**0.013**[aj]	D
Nitrous Oxide (N_2O)	**0.013**[ak]	D
Carbon Dioxide (CO_2)	**195**[al]	A

[a] Units of lb of pollutant/million Btu (MMBtu) of heat input. To convert from lb/MMBtu to lb/ton, multiply by (HHV * 2000), where HHV is the higher heating value of the fuel, MMBtu/lb. To convert lb/MMBtu to kg/J, multiply by 4.3E-10. These factors apply to Source Classification Codes (SCC) 1-0X-009-YY, where X = 1 for utilities, 2 for industrial, and 3 for commercial/institutional, and where Y = 01 for bark-fired boiler, 02 for bark and wet wood-fired boiler, 03 for wet wood-fired boiler, and 08 for dry wood-fired boiler.

[b] Factors are for boilers with no controls or with particulate matter controls.

[c] References 26, 34, 36, 59, 60, 65, 71-73, 75.

[d] References 26, 33, 34, 36, 59, 60, 65, 71-73, 75.

[e] References, 26, 35, 36, 46, 50, 59, 60, 65, 71-75.

[f] Reference 26.

[g] Reference 33.

[h] Reference 26, 50, 83.

[i] References 26, 34, 36, 59, 60, 65, 71-73, 75.

[j] References 26, 50.

[k] References 26, 35, 36, 46, 59, 60, 65, 70, 71-75.

[l] References 26, 36, 59, 60, 65, 70-75.

[m] References 26, 33, 36, 59, 60, 65, 70-73, 75.

[n] References 26, 33, 36, 59, 60, 65, 71-73, 75.

[o] Reference 34.

[p] References 26, 36, 60, 65, 71-75.

[q] References 26, 33.

[r] References 26.

[s] Reference 83.

[t] References 26, 72.

[u] References 35, 60, 65, 71, 72.

[v] References 26, 72.

[w] References 35, 60, 65, 71, 72.

[x] References 26, 33, 34, 59, 60, 65, 71-75.

[y] References 26, 28, 35, 36, 46 - 51, 59, 60, 65, 70, 71-75, 79, 81, 82.

[z] Reference 50.

[aa] Reference 26, 45.

[ab] References 26, 33, 34, 36, 59, 60, 65, 71-75, 83.

[ac] References 26, 35, 60, 65, 71, 72.

[ad] References 26, 33, 34, 36, 59, 60, 65, 71 - 73.

[ae] References 26, 33, 34, 35, 60, 65, 70, 71, 72.

[af] References 26, 33, 34, 36, 59, 60, 65, 71 - 73, 83.

[ag] References 26, 45.

[ah] References 26, 35, 60, 65, 71.

[ai] TOC = total organic compounds. Factor is the sum of all factors in table except nitrous oxide and carbon dioxide.

[aj] VOC volatile organic compounds. Factor is the sum of all factors in table except hydrogen chloride, chlorine, formaldehyde, tetrachloroethene, 1,1,1,-trichloroethane, dichloromethane, acetone, nitrous oxide, methane, and carbon dioxide.

[ak] Reference 83.

[al] References 19 - 26, 33 - 49, 51- 57, 77, 79 - 82, 84 - 86.

Table 1.6-4. EMISSION FACTORS FOR TRACE ELEMENTS FROM WOOD RESIDUE COMBUSTION[a]

Trace Element	Average Emission Factor (lb/MMBtu)[b]	EMISSION FACTOR RATING
Antimony	**7.9 E-06[c]**	C
Arsenic	**2.2 E-05[d]**	A
Barium	**1.7 E-04[c]**	C
Beryllium	**1.1 E-06[e]**	B
Cadmium	**4.1 E-06[f]**	A
Chromium, total	**2.1 E-05[g]**	A
Chromium, hexavalent	**3.5 E-06[h]**	C
Cobalt	**6.5 E-06[i]**	C
Copper	**4.9 E-05[g]**	A
Iron	**9.9 E-04[k]**	C
Lead	**4.8 E-05[l]**	A
Manganese	**1.6 E-03[d]**	A
Mercury	**3.5 E-06[m]**	A
Molybdenum	**2.1 E-06[c]**	D
Nickel	**3.3 E-05[n]**	A
Phosphorus	**2.7 E-05[c]**	D
Potassium	**3.9 E-02[c]**	D
Selenium	**2.8 E-06[o]**	A
Silver	**1.7 E-03[p]**	D
Sodium	**3.6 E-04[c]**	D
Strontium	**1.0 E-05[c]**	D
Tin	**2.3 E-05[c]**	D
Titanium	**2.0 E-05[c]**	D
Vanadium	**9.8 E-07[c]**	D
Yttrium	**3.0 E-07[c]**	D
Zinc	**4.2 E-04[o]**	A

[a] Units of lb of pollutant/million Btu (MMBtu) of heat input. To convert from lb/MMBtu to lb/ton, multiply by (HHV * 2000), where HHV is the higher heating value of the fuel, MMBtu/lb. To convert lb/MMBtu to kg/J, multiply by 4.3E-10. These factors apply to Source Classification Codes (SCC) 1-0X-009-YY, where X = 1 for utilities, 2 for industrial, and 3 for commercial/institutional, and where Y = 01 for bark-fired boiler, 02 for bark and wet wood-fired boiler, 03 for wet wood-fired boiler, and 08 for dry wood-fired boiler.
[b] Factors are for boilers with no controls or with particulate matter controls.
[c] Reference 26.
[d] References 26, 33, 36, 46, 59, 60, 65, 71-73, 75, 81.
[e] References 26, 35, 36, 46, 59, 60, 65, 71-73, 75.
[f] References 26, 35, 36, 42, 46, 59, 60, 65, 71-73, 75, 81.
[g] References 26, 34, 35, 36, 42, 59, 60, 65, 71-73, 75, 81.
[h] References 26, 36, 46, 59, 60, 71, 72, 73, 75.
[i] References 26, 34, 83.
[j] References 26, 33-36, 46, 59, 60, 65, 71-73, 75, 81.
[k] References 26, 71, 72, 81.
[l] References 26, 33-36, 46, 59, 60, 65, 71-73, 75.
[m] References 26, 35, 36, 46, 59, 60, 65, 71-73, 75, 81.
[n] References 26, 33 - 36, 46, 59, 60, 65, 71-73, 75, 81.
[o] References 26, 33, 35, 46, 59, 60, 65, 71-73, 75, 81.
[p] Reference 34.

Asphalt Production

Table 11.1-1. PARTICULATE MATTER EMISSION FACTORS FOR BATCH MIX HOT MIX ASPHALT PLANTS[a]

Process	Filterable PM				Condensable PM[b]				Total PM			
	PM[c]	EMISSION FACTOR RATING	PM-10[d]	EMISSION FACTOR RATING	Inorganic	EMISSION FACTOR RATING	Organic	EMISSION FACTOR RATING	PM[e]	EMISSION FACTOR RATING	PM-10[f]	EMISSION FACTOR RATING
Dryer, hot screens, mixer[g] (SCC 3-05-002-45, -46, -47)												
Uncontrolled	32[h]	E	4.5	E	0.013[j]	E	0.0041[j]	E	32	E	4.5	E
Venturi or wet scrubber	0.12[k]	C	ND	NA	0.013[m]	B	0.0041[n]	B	0.14	C	ND	NA
Fabric filter	0.025[p]	A	0.0098	C	0.013[m]	A	0.0041[n]	A	0.042	B	0.027	C

a Factors are lb/ton of product. SCC = Source Classification Code. ND = no data. NA = not applicable. To convert from lb/ton to kg/Mg, multiply by 0.5.

b *Condensable PM is that PM collected using an EPA Method 202, Method 5 (analysis of "back-half" or impingers), or equivalent sampling train.*

c Filterable PM is that PM collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.

d Particle size data from Reference 23 were used in conjunction with the filterable PM emission factors shown.

e Total PM is the sum of filterable PM, condensable inorganic PM, and condensable organic PM.

f Total PM-10 is the sum of filterable PM-10, condensable inorganic PM, and condensable organic PM.

g Batch mix dryer fired with natural gas, propane, fuel oil, waste oil, and coal. The data indicate that fuel type does not significantly effect PM emissions.

h Reference 5.

j Although no data are available for uncontrolled condensable PM, values are assumed to be equal to the controlled value measured.

k Reference 1, Table 4-19. Average of data from 16 facilities. Range: 0.047 to 0.40 lb/ton. Median: 0.049 lb/ton. Standard deviation: 0.11 lb/ton.

m Reference 1, Table 4-19. Average of data from 35 facilities. Range: 0.00073 to 0.12 lb/ton. Median: 0.0042 lb/ton. Standard deviation: 0.024 lb/ton.

n Reference 1, Table 4-19. Average of data from 24 facilities. Range: 0.000012 to 0.018 lb/ton. Median: 0.0026 lb/ton. Standard deviation: 0.0042 lb/ton.

p Reference 1, Table 4-19. Average of data from 89 facilities. Range: 0.0023 to 0.18 lb/ton. Median: 0.012 lb/ton. Standard deviation: 0.033 lb/ton.

Table 11.1-5. EMISSION FACTORS FOR CO, CO_2, NO_x, AND SO_2 FROM BATCH MIX HOT MIX ASPHALT PLANTS[a]

Process	CO[b]	EMISSION FACTOR RATING	CO_2[c]	EMISSION FACTOR RATING	NO_x	EMISSION FACTOR RATING	SO_2[c]	EMISSION FACTOR RATING
Natural gas-fired dryer, hot screens, and mixer (SCC 3-05-002-45)	0.40	C	37[d]	A	0.025[e]	D	0.0046[f]	E
No. 2 fuel oil-fired dryer, hot screens, and mixer (SCC 3-05-002-46)	0.40	C	37[d]	A	0.12[g]	E	0.088[h]	E
Waste oil-fired dryer, hot screens, and mixer (SCC 3-05-002-47)	0.40	C	37[d]	A	0.12[g]	E	0.088[h]	E
Coal-fired dryer, hot screens, and mixer[j] (SCC 3-05-002-98)	ND	NA	37[d]	A	ND	NA	0.043[k]	E

a Emission factor units are lb per ton of HMA produced. SCC = Source Classification Code. ND = no data available. NA = not applicable. To convert from lb/ton to kg/Mg, multiply by 0.5.

b References 24, 34, 46-47, 49, 161, 204, 215-217, 282, 370, 378, 381. The CO emission factors represent normal plant operations without scrutiny of the burner design, operation, and maintenance. Information is available that indicates that attention to burner design, periodic evaluation of burner operation, and appropriate maintenance can reduce CO emissions. Data for dryers firing natural gas, No. 2 fuel oil, and No. 6 fuel oil were combined to develop a single emission factor because the magnitude of emissions was similar for dryers fired with these fuels.

c Emissions of CO_2 and SO_2 can also be estimated based on fuel usage and the fuel combustion emission factors (for the appropriate fuel) presented in AP-42 Chapter 1. The CO_2 emission factors are an average of all available data, regardless of the dryer fuel (emissions were similar from dryers firing any of the various fuels). Based on data for drum mix facilities, 50 percent of the fuel-bound sulfur, up to a maximum (as SO_2) of 0.1 lb/ton of product, is expected to be retained in the product, with the remainder emitted as SO_2.

d Reference 1, Table 4-20. Average of data from 115 facilities. Range: 6.9 to 160 lb/ton. Median: 32 lb/ton. Standard deviation: 22 lb/ton.

e References 24, 34, 46-47.

f References 46-47.

g References 49, 226.

h References 49, 226, 228, 385.

j Dryer fired with coal and supplemental natural gas or fuel oil.

k Reference 126.

Table 11.1-6. EMISSION FACTORS FOR TOC, METHANE, AND VOC FROM BATCH MIX HOT MIX ASPHALT PLANTS[a]

Process	TOC[b]	EMISSION FACTOR RATING	CH_4[c]	EMISSION FACTOR RATING	VOC[d]	EMISSION FACTOR RATING
Natural gas-fired dryer, hot screens, and mixer (SCC 3-05-002-45)	0.015[e]	D	0.0074	D	0.0082	D
No. 2 fuel oil-fired dryer, hot screens, and mixer (SCC 3-05-002-46)	0.015[e]	D	0.0074	D	0.0082	D
No. 6 fuel oil-fired dryer, hot screens, and mixer (SCC 3-05-002-47)	0.043[f]	E	0.0074	D	0.036	E

[a] Emission factor units are lb per ton of HMA produced. SCC = Source Classification Code. ND = no data available. NA = not applicable. To convert from lb/ton to kg/Mg, multiply by 0.5.
[b] TOC equals total hydrocarbons as propane, as measured with an EPA Method 25A or equivalent sampling train plus formaldehyde.
[c] References 24, 46-47, 49. Factor includes data from natural gas- and No. 6 fuel oil-fired dryers. Methane measured with an EPA Method 18 or equivalent sampling train.
[d] The VOC emission factors are equal to the TOC factors minus the methane emission factors; differences in values reported are due to rounding.
[e] References 24, 46-47, 155.
[f] Reference 49.

Table 11.1-9. EMISSION FACTORS FOR ORGANIC POLLUTANT EMISSIONS FROM BATCH MIX HOT MIX ASPHALT PLANTS[a]

Process	Pollutant CASRN	Pollutant Name	Emission Factor, lb/ton	Emission Factor Rating	Ref. Nos.
Natural gas- or No. 2 fuel oil-fired dryer, hot screens, and mixer with fabric filter (SCC 3-05-002-45,-46)	Non-PAH Hazardous Air Pollutants[b]				
	75-07-0	Acetaldehyde	0.00032	E	24,34
	71-43-2	Benzene	0.00028	D	24,34,46, 382
	100-41-4	Ethylbenzene	0.0022	D	24,46,47,49
	50-00-0	Formaldehyde	0.00074	D	24,34,46,47,49,226,382
	106-51-4	Quinone	0.00027	E	24
	108-88-3	Toluene	0.0010	D	24,34,46,47
	1330-20-7	Xylene	0.0027	D	24,46,47,49
		Total non-PAH HAPs	0.0075		
	PAH HAPs				
	91-57-6	2-Methylnaphthalene[c]	7.1×10^{-5}	D	24,47,49
	83-32-9	Acenaphthene[c]	9.0×10^{-7}	D	34,46,226
	208-96-8	Acenaphthylene[c]	5.8×10^{-7}	D	34,46,226
	120-12-7	Anthracene[c]	2.1×10^{-7}	D	34,46,226
	56-55-3	Benzo(a)anthracene[c]	4.6×10^{-9}	E	46,226
	50-32-8	Benzo(a)pyrene[c]	3.1×10^{-10}	E	226
	205-99-2	Benzo(b)fluoranthene[c]	9.4×10^{-9}	D	34,46,226
	191-24-2	Benzo(g,h,i)perylene[c]	5.0×10^{-10}	E	226
	207-08-9	Benzo(k)fluoranthene[c]	1.3×10^{-8}	E	34,226
	218-01-9	Chrysene[c]	3.8×10^{-9}	E	46,226
	53-70-3	Dibenz(a,h)anthracene[c]	9.5×10^{-11}	E	226
	206-44-0	Fluoranthene[c]	1.6×10^{-7}	D	34,46,47,226
	86-73-7	Fluorene[c]	1.6×10^{-6}	D	34,46,47,226
	193-39-5	Indeno(1,2,3-cd)pyrene[c]	3.0×10^{-10}	E	226
	91-20-3	Naphthalene	3.6×10^{-5}	D	34,46,47,49,226
	85-01-8	Phenanthrene[c]	2.6×10^{-6}	D	34,46,47,226
	129-00-0	Pyrene[c]	6.2×10^{-8}	D	34,46,226
		Total PAH HAPs	0.00011		
	Total HAPs		0.0076		
	Non-HAP organic compounds				
	100-52-7	Benzaldehyde	0.00013	E	24
	78-84-2	Butyraldehyde/ isobutyraldehyde	3.0×10^{-5}	E	24
	4170-30-3	Crotonaldehyde	2.9×10^{-5}	E	24
	66-25-1	Hexanal	2.4×10^{-5}	E	24
		Total non-HAPs	0.00019		

Table 11.1-9 (cont.)

Process	Pollutant CASRN	Pollutant Name	Emission Factor, lb/ton	Emission Factor Rating	Ref. Nos.
Waste oil-, drain oil-, or No. 6 fuel oil-fired dryer, hot screens, and mixer with fabric filter (SCC 3-05-002-47)	Non-PAH Hazardous Air Pollutants[b]				
	75-07-0	Acetaldehyde	0.00032	E	24,34
	71-43-2	Benzene	0.00028	D	24,34,46, 382
	100-41-4	Ethylbenzene	0.0022	D	24,46,47,49
	50-00-0	Formaldehyde	0.00074	D	24,34,46,47,49,226, 382
	106-51-4	Quinone	0.00027	E	24
	108-88-3	Toluene	0.0010	D	24,34,46,47
	1330-20-7	Xylene	0.0027	D	24,46,47,49
		Total non-PAH HAPs	0.0075		
	PAH HAPs[b]				
	91-57-6	2-Methylnaphthalene[c]	7.1×10^{-5}	D	24,47,49
	83-32-9	Acenaphthene[c]	9.0×10^{-7}	D	34,46,226
	208-96-8	Acenaphthylene[c]	5.8×10^{-7}	D	34,46,226
	120-12-7	Anthracene[c]	2.1×10^{-7}	D	34,46,226
	56-55-3	Benzo(a)anthracene[c]	4.6×10^{-9}	E	46,226
	50-32-8	Benzo(a)pyrene[c]	3.1×10^{-10}	E	226
	205-99-2	Benzo(b)fluoranthene[c]	9.4×10^{-9}	D	34,46,226
	191-24-2	Benzo(g,h,i)perylene[c]	5.0×10^{-10}	E	226
	207-08-9	Benzo(k)fluoranthene[c]	1.3×10^{-8}	E	34,226
	218-01-9	Chrysene[c]	3.8×10^{-9}	E	46,226
	53-70-3	Dibenz(a,h)anthracene[c]	9.5×10^{-11}	E	226
	206-44-0	Fluoranthene[c]	2.4×10^{-5}	E	49
	86-73-7	Fluorene[c]	1.6×10^{-6}	D	34,46,47,226
	193-39-5	Indeno(1,2,3-cd)pyrene[c]	3.0×10^{-10}	E	226
	91-20-3	Naphthalene	3.6×10^{-5}	D	34,46,47,49, 226
	85-01-8	Phenanthrene[c]	3.7×10^{-5}	E	49
	129-00-0	Pyrene[c]	5.5×10^{-5}	E	49
		Total PAH HAPs	0.00023		
	Total HAPs		0.0077		
	Non-HAP organic compounds				
	100-52-7	Benzaldehyde	0.00013	E	24
	78-84-2	Butyraldehyde/ isobutyraldehyde	3.0×10^{-5}	E	24
	4170-30-3	Crotonaldehyde	2.9×10^{-5}	E	24
	66-25-1	Hexanal	2.4×10^{-5}	E	24
		Total non-HAPs	0.00019		

a Emission factor units are lb/ton of hot mix asphalt produced. Factors represent uncontrolled emissions, unless noted. CASRN = Chemical Abstracts Service Registry Number. SCC = Source Classification Code. To convert from lb/ton to kg/Mg, multiply by 0.5.

b Hazardous air pollutants (HAP) as defined in the 1990 Clean Air Act Amendments (CAAA).

c Compound is classified as polycyclic organic matter, as defined in the 1990 CAAA.

File TA-3-73
Facility Records

TSP AND VISIBLE EMISSIONS PERFORMANCE TESTS

BARBER GREENE ASPHALT BATCH PLANT
LOS ALAMOS NATIONAL LABORATORIES
LOS ALAMOS, NEW MEXICO

KRAMER & ASSOCIATES
ALBUQUERQUE, NEW MEXICO

TSP AND VISIBLE EMISSIONS PERFORMANCE TESTS

BARBER GREENE ASPHALT BATCH PLANT
LOS ALAMOS NATIONAL LABORATORIES
LOS ALAMOS, NEW MEXICO

by

Kramer & Associates, Inc.
4501 Bogan NE, Suite A-1
Albuquerque, NM 87109
505-881-0243

June, 1995

SUMMARY

TABLE 1

EMISSIONS TEST DATA SUMMARY

Test No.	Exhaust Flow Rate, ACFM	Emissions, Gr./DSCF	Emissions, Lb/Hr.	Isokinetic Ratio, %
1	27012	0.037	5.21	98.9
2	24286	0.037	4.29	102.5
3	25688	0.028	3.41	104.1

Maximum Allowable Emission Rate (AQCR #501) = 33 lb/hr

$$\frac{5.21 + 4.29 + 3.41}{3} \left(\frac{lb}{hr}\right) \times \frac{hr}{60\ ton} = 0.07\ lb/ton$$

Discussion:

Particulate emissions were less than AQCR #501 for each of the three tests. Visible emissions were less than 20% opacity.

Stack velocity pressure data indicate zero velocity at several points in the stack cross section. This profile usually accompanies a cyclonic flow condition; however the measured average cyclonic flow angle (11.9 degrees) was within the allowable for testing (20 degrees). Sample was not collected at the "zero" velocity pressure points, however these points were included in the velocity averaging.

The effects of minor deviations from the Method 5 procedures on the test results are discussed in the Test Procedures Section.

Boilers and Heaters

Table 1.4-1. EMISSION FACTORS FOR NITROGEN OXIDES (NO_x) AND CARBON MONOXIDE (CO) FROM NATURAL GAS COMBUSTION[a]

Combustor Type (MMBtu/hr Heat Input) [SCC]	NO_x[b]		CO	
	Emission Factor (lb/10^6 scf)	Emission Factor Rating	Emission Factor (lb/10^6 scf)	Emission Factor Rating
Large Wall-Fired Boilers (>100) [1-01-006-01, 1-02-006-01, 1-03-006-01]				
Uncontrolled (Pre-NSPS)[c]	280	A	84	B
Uncontrolled (Post-NSPS)[c]	190	A	84	B
Controlled - Low NO_x burners	140	A	84	B
Controlled - Flue gas recirculation	100	D	84	B
Small Boilers (<100) [1-01-006-02, 1-02-006-02, 1-03-006-02, 1-03-006-03]				
Uncontrolled	100	B	84	B
Controlled - Low NO_x burners	50	D	84	B
Controlled - Low NO_x burners/Flue gas recirculation	32	C	84	B
Tangential-Fired Boilers (All Sizes) [1-01-006-04]				
Uncontrolled	170	A	24	C
Controlled - Flue gas recirculation	76	D	98	D
Residential Furnaces (<0.3) [No SCC]				
Uncontrolled	94	B	40	B

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. To convert from lb/10^6 scf to kg/10^6 m^3, multiply by 16. Emission factors are based on an average natural gas higher heating value of 1,020 Btu/scf. To convert from lb/10^6 scf to lb/MMBtu, divide by 1,020. The emission factors in this table may be converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to this average heating value. SCC = Source Classification Code. ND = no data. NA = not applicable.

[b] Expressed as NO_2. For large and small wall fired boilers with SNCR control, apply a 24 percent reduction to the appropriate NO_x emission factor. For tangential-fired boilers with SNCR control, apply a 13 percent reduction to the appropriate NO_x emission factor.

[c] NSPS=New Source Performance Standard as defined in 40 CFR 60 Subparts D and Db. Post-NSPS units are boilers with greater than 250 MMBtu/hr of heat input that commenced construction modification, or reconstruction after August 17, 1971, and units with heat input capacities between 100 and 250 MMBtu/hr that commenced construction modification, or reconstruction after June 19, 1984.

TABLE 1.4-2. EMISSION FACTORS FOR CRITERIA POLLUTANTS AND GREENHOUSE GASES FROM NATURAL GAS COMBUSTION[a]

Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
CO_2[b]	120,000	A
Lead	0.0005	D
N_2O (Uncontrolled)	2.2	E
N_2O (Controlled-low-NO_X burner)	0.64	E
PM (Total)[c]	7.6	D
PM (Condensable)[c]	5.7	D
PM (Filterable)[c]	1.9	B
SO_2[d]	0.6	A
TOC	11	B
Methane	2.3	B
VOC	5.5	C

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by 16. To convert from $lb/10^6$ scf to 1b/MMBtu, divide by 1,020. The emission factors in this table may be converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to this average heating value. TOC = Total Organic Compounds. VOC = Volatile Organic Compounds.

[b] Based on approximately 100% conversion of fuel carbon to CO_2. CO_2[$lb/10^6$ scf] = (3.67) (CON) (C)(D), where CON = fractional conversion of fuel carbon to CO_2, C = carbon content of fuel by weight (0.76), and D = density of fuel, $4.2x10^4$ $lb/10^6$ scf.

[c] All PM (total, condensible, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the PM emission factors presented here may be used to estimate PM_{10}, $PM_{2.5}$ or PM_1 emissions. Total PM is the sum of the filterable PM and condensible PM. Condensible PM is the particulate matter collected using EPA Method 202 (or equivalent). Filterable PM is the particulate matter collected on, or prior to, the filter of an EPA Method 5 (or equivalent) sampling train.

[d] Based on 100% conversion of fuel sulfur to SO_2.
Assumes sulfur content is natural gas of 2,000 $grains/10^6$ scf. The SO_2 emission factor in this table can be converted to other natural gas sulfur contents by multiplying the SO_2 emission factor by the ratio of the site-specific sulfur content ($grains/10^6$ scf) to 2,000 $grains/10^6$ scf.

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
91-57-6	2-Methylnaphthalene[b, c]	2.4E-05	D
56-49-5	3-Methylchloranthrene[b, c]	<1.8E-06	E
	7,12-Dimethylbenz(a)anthracene[b,c]	<1.6E-05	E
83-32-9	Acenaphthene[b,c]	<1.8E-06	E
203-96-8	Acenaphthylene[b,c]	<1.8E-06	E
120-12-7	Anthracene[b,c]	<2.4E-06	E
56-55-3	Benz(a)anthracene[b,c]	<1.8E-06	E
71-43-2	Benzene[b]	2.1E-03	B
50-32-8	Benzo(a)pyrene[b,c]	<1.2E-06	E
205-99-2	Benzo(b)fluoranthene[b,c]	<1.8E-06	E
191-24-2	Benzo(g,h,i)perylene[b,c]	<1.2E-06	E
205-82-3	Benzo(k)fluoranthene[b,c]	<1.8E-06	E
106-97-8	Butane	2.1E+00	E
218-01-9	Chrysene[b,c]	<1.8E-06	E
53-70-3	Dibenzo(a,h)anthracene[b,c]	<1.2E-06	E
25321-22-6	Dichlorobenzene[b]	1.2E-03	E
74-84-0	Ethane	3.1E+00	E
206-44-0	Fluoranthene[b,c]	3.0E-06	E
86-73-7	Fluorene[b,c]	2.8E-06	E
50-00-0	Formaldehyde[b]	7.5E-02	B
110-54-3	Hexane[b]	1.8E+00	E
193-39-5	Indeno(1,2,3-cd)pyrene[b,c]	<1.8E-06	E
91-20-3	Naphthalene[b]	6.1E-04	E
109-66-0	Pentane	2.6E+00	E
85-01-8	Phenanathrene[b,c]	1.7E-05	D

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION (Continued)

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
74-98-6	Propane	1.6E+00	E
129-00-0	Pyrene[b, c]	5.0E-06	E
108-88-3	Toluene[b]	3.4E-03	C

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by 16. To convert from $lb/10^6$ scf to lb/MMBtu, divide by 1,020. Emission Factors preceeded with a less-than symbol are based on method detection limits.

[b] Hazardous Air Pollutant (HAP) as defined by Section 112(b) of the Clean Air Act.

[c] HAP because it is Polycyclic Organic Matter (POM). POM is a HAP as defined by Section 112(b) of the Clean Air Act.

[d] The sum of individual organic compounds may exceed the VOC and TOC emission factors due to differences in test methods and the availability of test data for each pollutant.

TABLE 1.4-4. EMISSION FACTORS FOR METALS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor (lb/10^6 scf)	Emission Factor Rating
7440-38-2	Arsenic[b]	2.0E-04	E
7440-39-3	Barium	4.4E-03	D
7440-41-7	Beryllium[b]	<1.2E-05	E
7440-43-9	Cadmium[b]	1.1E-03	D
7440-47-3	Chromium[b]	1.4E-03	D
7440-48-4	Cobalt[b]	8.4E-05	D
7440-50-8	Copper	8.5E-04	C
7439-96-5	Manganese[b]	3.8E-04	D
7439-97-6	Mercury[b]	2.6E-04	D
7439-98-7	Molybdenum	1.1E-03	D
7440-02-0	Nickel[b]	2.1E-03	C
7782-49-2	Selenium[b]	<2.4E-05	E
7440-62-2	Vanadium	2.3E-03	D
7440-66-6	Zinc	2.9E-02	E

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. Emission factors preceeded by a less-than symbol are based on method detection limits. To convert from lb/10^6 scf to kg/10^6 m^3, multiply by l6. To convert from lb/10^6 scf to 1b/MMBtu, divide by 1,020.
[b] Hazardous Air Pollutant as defined by Section 112(b) of the Clean Air Act.

PHONE 606-236-3181
FAX 606-236 3184

Sellers
ENGINEERING CO.

MANUFACTURERS OF BOILERS, DEAERATORS, WATER HEATERS AND ACCESSORIES
BOX 48, DANVILLE, KENTUCKY 40423

July 7, 1995

Anne Batson
Los Alamos Labs

FAX: 505-665-8858

Re: Mass Emission Rates
Sellers Low NOx Immersion Boilers

Low NOx Boilers: NOx 30 ppm or .036 lbs./MMBTU
CO 50 ppm or .036 lbs./MMBTU

NOx emission rates were determined in accordance with EPA Test Method 7E using a chemiluminescent analyzer.

CO emission rates were determined by using an electrochemical cell analyzer.

Sellers Engineering Company completely guarantees that our NOx and CO emission rates will not exceed levels mentioned above.

Sincerely,

SELLERS ENGINEERING COMPANY

ROB LARSON
Sales Manager

RL:ly

$$\frac{0.036 \text{ lb}}{10^6 \text{ Btu}} * \frac{1030 \text{ Btu}}{ft^3} = 37.1 \frac{\text{lb}}{10^6 ft^3} \quad NO_x \text{ \& } CO$$

Carpenter Shops

AP-42

10.4 WOODWORKING WASTE COLLECTION OPERATIONS

10.4.1 General[1-5]

Woodworking, as defined in this section, includes any operation that involves the generation of small wood waste particles (shavings, sanderdust, sawdust, etc.) by any kind of mechanical manipulation of wood, bark, or wood byproducts. Common woodworking operations include sawing, planing, chipping, shaping, moulding, hogging, lathing, and sanding. Woodworking operations are found in numerous industries, such as sawmills, plywood, particleboard, and hardboard plants, and furniture manufacturing plants.

Most plants engaged in woodworking employ pneumatic transfer systems to remove the generated wood waste from the immediate proximity of each woodworking operation. These systems are necessary as a housekeeping measure to eliminate the vast quantity of waste material that would otherwise accumulate. They are also a convenient means of transporting the waste material to common collection points for ultimate disposal. Large diameter cyclones have historically been the primary means of separating the waste material from the airstreams in the pneumatic transfer systems, although baghouses have recently been installed in some plants for this purpose.

The waste material collected in the cyclones or baghouses may be burned in wood waste boilers, utilized in the manufacture of other products (such as pulp or particleboard), or incinerated in conical (teepee/wigwam) burners. The latter practice is declining with the advent of more stringent air pollution control regulations and because of the economic attractiveness of utilizing wood waste as a resource.

10.4.2 Emissions[1-6]

The only pollutant of concern in woodworking waste collection operations is particulate matter. The major emission points are the cyclones utilized in the pneumatic transfer systems. The quantity of particulate emissions from a given cyclone will depend on the dimensions of the cyclone, the velocity of the airstream, and the nature of the operation generating the waste. Typical large diameter cyclones found in the industry will only effectively collect particles greater than 40 micrometers in diameter. Baghouses, when employed, collect essentially all of the waste material in the airstream. The wastes from numerous pieces of equipment often feed into the same cyclone, and it is common for the material collected in one or several cyclones to be conveyed to another cyclone. It is also possible for portions of the waste generated by a single operation to be directed to different cyclones.

Because of this complexity, it is useful when evaluating emissions from a given facility to consider the waste handling cyclones as air pollution sources instead of the various woodworking operations that actually generate the particulate matter. Emission factors for typical large diameter cyclones utilized for waste collection in woodworking operations are given in Table 10.4-1.

Emission factors for wood waste boilers, conical burners, and various drying operations—often found in facilities employing woodworking operations—are given in Sections 1.6, 2.3, 10.2, and 10.3.

Table 10.4.1. PARTICULATE EMISSION FACTORS FOR LARGE DIAMETER CYCLONES IN WOODWORKING WASTE COLLECTION SYSTEMS[a]

EMISSION FACTOR RATING: D

Types of waste handled	Particulate emissions[b,c]			
	gr/scf	g/Nm^3	lb/hr	kg/hr
Sanderdust[d]	0.055 (0.005-0.16)	0.126 (0.0114-0.37)	5 (0.2-30.0)	2.3 (0.09-13.6)
Other[e]	0.03 (0.001-0.16)	0.07 (0.002-0.37)	2 (0.03-24.0)	0.91 (0.014-10.9)

[a] Typical waste collection cyclones range from 4 to 16 feet (1.2 to 4.9 meters) in diameter and employ airflows ranging from 2,000 to 26,000 standard cubic feet (57 to 740 normal cubic meters) per minute. Note: if baghouses are used for waste collection, particulate emissions will be negligible.

[b] References 1 through 3.

[c] Observed value ranges are in parentheses.

[d] These factors should be used whenever waste from sanding operations is fed directly into the cyclone in question.

[e] These factors should be used for cyclones handling waste from all operations other than sanding. This includes cyclones that handle waste (including sanderdust) already collected by another cyclone.

References for Section 10.4

1. Source test data supplied by Robert Harris, Oregon Department of Environmental Quality, Portland, OR, September 1975.

2. J.W. Walton, *et al.*, "Air Pollution in the Woodworking Industry", Presented at the 68th Annual Meeting of the Air Pollution Control Association, Boston, MA, June 1975.

3. J.D. Patton and J.W. Walton, "Applying the High Volume Stack Sampler To Measure Emissions from Cotton Gins, Woodworking Operations, and Feed and Grain Mills", Presented at 3rd Annual Industrial Air Pollution Control Conference, Knoxville, TN, March 29-30, 1973.

4. C.F. Sexton, "Control of Atmospheric Emissions from the Manufacturing of Furniture", Presented at 2nd Annual Industrial Air Pollution Control Conference, Knoxville, TN, April 20-21, 1972.

5. A. Mick and D. McCargar, "Air Pollution Problems in Plywood, Particleboard, and Hardboard Mills in the Mid-Willamette Valley", Mid-Williamette Valley Air Pollution Authority, Salem, OR, March 24, 1969.

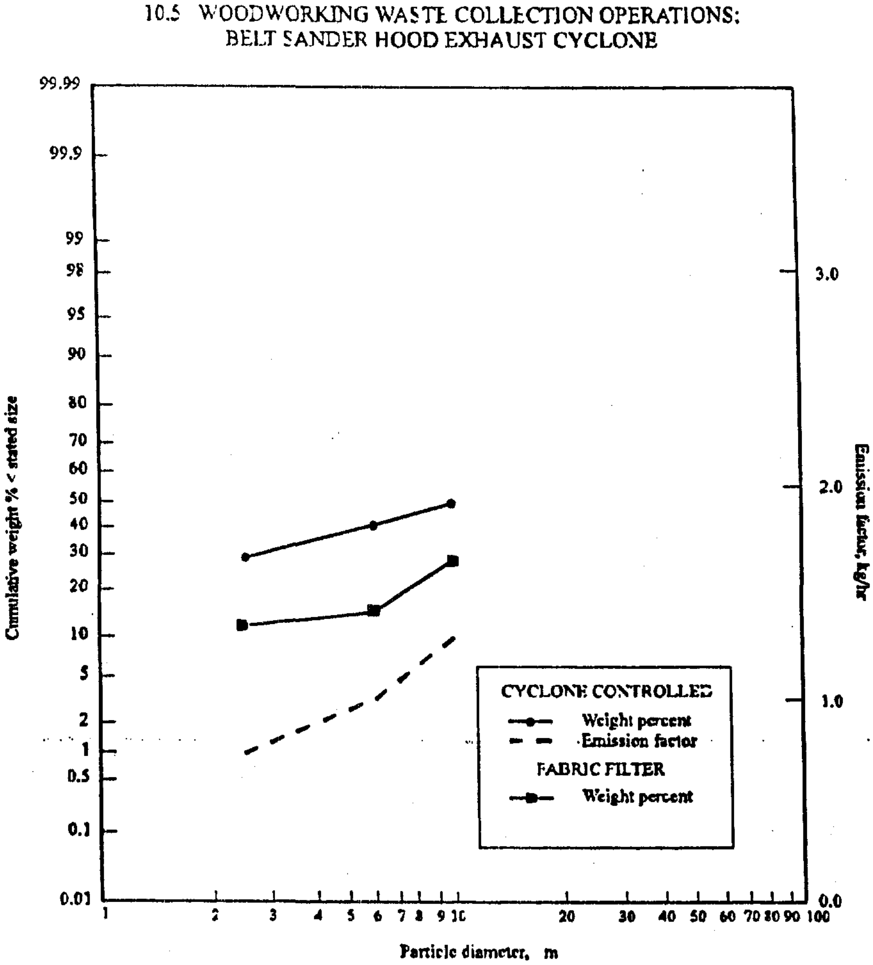
6. Information supplied by the North Carolina Department of Natural and Economic Resources, Raleigh, NC, December 1975.

AP-42

APPENDIX B.1

PARTICLE SIZE DISTRIBUTION DATA AND SIZED EMISSION FACTORS FOR SELECTED SOURCES

10.5 WOODWORKING WASTE COLLECTION OPERATIONS: BELT SANDER HOOD EXHAUST CYCLONE



Aerodynamic particle diameter, m	Cumulative wt. % < stated size		Emission factor, kg/hr of cyclone operation
	Cyclone	After cyclone and fabric filter	After cyclone collector
2.5	29.5	14.3	0.68
6.0	42.7	17.3	0.98
10.0	52.9	32.1	1.22

10.5 WOODWORKING WASTE COLLECTION OPERATIONS: BELT SANDER HOOD EXHAUST CYCLONE

NUMBER OF TESTS: (a) 1, conducted after cyclone control
(b) 1, after cyclone and fabric filter control

STATISTICS: (a)

Aerodynamic particle diameter (µm):	2.5	6.0	10.0
Mean (Cum. %):	29.5	42.7	52.9
Standard deviation (Cum. %):			
Min (Cum. %):			
Max (Cum. %):			

(b)

Aerodynamic particle diameter (µm):	2.5	6.0	10.0
Mean (Cum. %.):	14.3	17.3	32.1
Standard deviation (Cum. %):			
Min (Cum. %):			
Max (Cum. %):			

TOTAL PARTICULATE EMISSION FACTOR: 2.3 kg particulate/hr of cyclone operation. For cyclone-controlled source, this emission factor applies to typical large diameter cyclones into which wood waste is fed directly, not to cyclones that handle waste previously collected in cyclones. If baghouses are used for waste collection, particulate emissions will be negligible. Accordingly, no emission factor is provided for the fabric filter-controlled source. Factors from AP-42.

SOURCE OPERATION: Source was sanding 2-ply panels of mahogany veneer, at 100% of design process rate of 1110 m^2/hr.

SAMPLING TECHNIQUE: (a) Joy train with 3 cyclones
(b) SASS train with cyclones

EMISSION FACTOR RATING: E

REFERENCE:

Emission test data from Environmental Assessment Data Systems, Fine Particle Emission Information System, Series Report No. 238, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1983.

Internal Combustion Sources

TABLE 3.2-1 UNCONTROLLED EMISSION FACTORS FOR 2-STROKE LEAN-BURN ENGINES[a]
(SCC 2-02-002-52)

Pollutant	Emission Factor (lb/MMBtu)[b] (fuel input)	Emission Factor Rating
Criteria Pollutants and Greenhouse Gases		
NO_x[c] 90 - 105% Load	3.17 E+00	A
NO_x[c] <90% Load	1.94 E+00	A
CO[c] 90 - 105% Load	3.86 E-01	A
CO[c] <90% Load	3.53 E-01	A
CO_2[d]	1.10 E+02	A
SO_2[e]	5.88 E-04	A
TOC[f]	1.64 E+00	A
Methane[g]	1.45 E+00	C
VOC[h]	1.20 E-01	C
PM10 (filterable)[i]	3.84 E-02	C
PM2.5 (filterable)[i]	3.84 E-02	C
PM Condensable[j]	9.91 E-03	E
Trace Organic Compounds		
1,1,2,2-Tetrachloroethane[k]	6.63 E-05	C
1,1,2-Trichloroethane[k]	5.27 E-05	C
1,1-Dichloroethane	3.91 E-05	C
1,2,3-Trimethylbenzene	3.54 E-05	D
1,2,4-Trimethylbenzene	1.11 E-04	C
1,2-Dichloroethane	4.22 E-05	D
1,2-Dichloropropane	4.46 E-05	C
1,3,5-Trimethylbenzene	1.80 E-05	D
1,3-Butadiene[k]	8.20 E-04	D
1,3-Dichloropropene[k]	4.38 E-05	C
2,2,4-Trimethylpentane[k]	8.46 E-04	B
2-Methylnaphthalene[k]	2.14 E-05	C
Acenaphthene[k]	1.33 E-06	C

NO_x: $3.17 \frac{lb}{10^6 Btu} \times \frac{1 Btu}{0.000293 kW\text{-}hr} \times \frac{453.59 g}{lb} = 4.91 \frac{g}{kW\text{-}hr}$

Table 3.2-1. UNCONTROLLED EMISSION FACTORS FOR 2-STROKE LEAN-BURN ENGINES

(Continued)

Pollutant	Emission Factor (lb/MMBtu)[b] (fuel input)	Emission Factor Rating
Acenaphthylene[k]	3.17 E-06	C
Acetaldehyde[k,l]	7.76 E-03	A
Acrolein[k,l]	7.78 E-03	A
Anthracene[k]	7.18 E-07	C
Benz(a)anthracene[k]	3.36 E-07	C
Benzene[k]	1.94 E-03	A
Benzo(a)pyrene[k]	5.68 E-09	D
Benzo(b)fluoranthene[k]	8.51 E-09	D
Benzo(e)pyrene[k]	2.34 E-08	D
Benzo(g,h,i)perylene[k]	2.48 E-08	D
Benzo(k)fluoranthene[k]	4.26 E-09	D
Biphenyl[k]	3.95 E-06	C
Butane	4.75 E-03	C
Butyr/Isobutyraldehyde	4.37 E-04	C
Carbon Tetrachloride[k]	6.07 E-05	C
Chlorobenzene[k]	4.44 E-05	C
Chloroform[k]	4.71 E-05	C
Chrysene[k]	6.72 E-07	C
Cyclohexane	3.08 E-04	C
Cyclopentane	9.47 E-05	C
Ethane	7.09 E-02	A
Ethylbenzene[k]	1.08 E-04	B
Ethylene Dibromide[k]	7.34 E-05	C
Fluoranthene[k]	3.61 E-07	C
Fluorene[k]	1.69 E-06	C
Formaldehyde[k,l]	5.52 E-02	A

Table 3.2-1. UNCONTROLLED EMISSION FACTORS FOR 2-STROKE LEAN-BURN ENGINES (Concluded)

Pollutant	Emission Factor (lb/MMBtu)[b] (fuel input)	Emission Factor Rating
Indeno(1,2,3-c,d)pyrene[k]	9.93 E-09	D
Isobutane	3.75 E-03	C
Methanol[k]	2.48 E-03	A
Methylcyclohexane	3.38 E-04	C
Methylene Chloride[k]	1.47 E-04	C
n-Hexane[k]	4.45 E-04	C
n-Nonane	3.08 E-05	C
n-Octane	7.44 E-05	C
n-Pentane	1.53 E-03	C
Naphthalene[k]	9.63 E-05	C
PAH[k]	1.34 E-04	D
Perylene[k]	4.97 E-09	D
Phenanthrene[k]	3.53 E-06	C
Phenol[k]	4.21 E-05	C
Propane	2.87 E-02	C
Pyrene[k]	5.84 E-07	C
Styrene[k]	5.48 E-05	A
Toluene[k]	9.63 E-04	A
Vinyl Chloride[k]	2.47 E-05	C
Xylene[k]	2.68 E-04	A

[a] Reference 7. Factors represent uncontrolled levels. For NO_x, CO, and PM10, "uncontrolled" means no combustion or add-on controls; however, the factor may include turbocharged units. For all other pollutants, "uncontrolled" means no oxidation control; the data set may include units with control techniques used for NOx control, such as PCC and SCR for lean burn engines, and PSC for rich burn engines. Factors are based on large population of engines. Factors are for engines at all loads, except as indicated. SCC = Source Classification Code. TOC = Total Organic Compounds. PM10 = Particulate Matter ≤ 10 microns (μm) aerodynamic diameter. A "<" sign in front of a factor means that the corresponding emission factor is based on one-half of the method detection limit.

[b] Emission factors were calculated in units of (lb/MMBtu) based on procedures in EPA

Method 19. To convert from (lb/MMBtu) to (lb/10^6 scf), multiply by the heat content of the fuel. If the heat content is not available, use 1020 Btu/scf. To convert from (lb/MMBtu) to (lb/hp-hr) use the following equation:

$$\text{lb/hp-hr} = (\text{lb/MMBtu})\,(\text{heat input, MMBtu/hr})\,(1/\text{operating HP, 1/hp})$$

[c] Emission tests with unreported load conditions were not included in the data set.

[d] Based on 99.5% conversion of the fuel carbon to CO_2. CO_2 [lb/MMBtu] = (3.67)(%CON)(C)(D)(1/h), where %CON = percent conversion of fuel carbon to CO_2, C = carbon content of fuel by weight (0.75), D = density of fuel, 4.1 E+04 lb/10^6 scf, and h = heating value of natural gas (assume 1020 Btu/scf at 60°F).

[e] Based on 100% conversion of fuel sulfur to SO_2. Assumes sulfur content in natural gas of 2,000 gr/10^6 scf.

[f] Emission factor for TOC is based on measured emission levels of 43 tests.

[g] Emission factor for methane is determined by subtracting the VOC and ethane emission factors from the TOC emission factor. Measured emission factor for methane compares well with the calculated emission factor, 1.48 lb/MMBtu vs. 1.45 lb/MMBtu, respectively.

[h] VOC emission factor is based on the sum of the emission factors for all speciated organic compounds less ethane and methane.

[i] Considered ≤ 1 μm in aerodynamic diameter. Therefore, for filterable PM emissions, PM10(filterable) = PM2.5(filterable).

[j] No data were available for condensable PM emissions. The presented emission factor reflects emissions from 4SLB engines.

[k] Hazardous Air Pollutant as defined by Section 112(b) of the Clean Air Act.

[l] For lean burn engines, aldehyde emissions quantification using CARB 430 may reflect interference with the sampling compounds due to the nitrogen concentration in the stack. The presented emission factor is based on FTIR measurements. Emissions data based on CARB 430 are available in the background report.

Table 3.3-1. EMISSION FACTORS FOR UNCONTROLLED GASOLINE AND DIESEL INDUSTRIAL ENGINES[a]

Pollutant	Gasoline Fuel (SCC 2-02-003-01, 2-03-003-01) Emission Factor (lb/hp-hr) (power output)	Gasoline Fuel Emission Factor (lb/MMBtu) (fuel input)	Diesel Fuel (SCC 2-02-001-02, 2-03-001-01) Emission Factor (lb/hp-hr) (power output)	Diesel Fuel Emission Factor (lb/MMBtu) (fuel input)	EMISSION FACTOR RATING
NO_x	0.011	1.63	0.031	4.41	D
CO	0.439	62.7	6.68 E-03	0.95	D
SO_x	5.91 E-04	0.084	2.05 E-03	0.29	D
PM-10[b]	7.21 E-04	0.10	2.20 E-03	0.31	D
CO_2[c]	1.08	154	1.15	164	B
Aldehydes	4.85 E-04	0.07	4.63 E-04	0.07	D
TOC					
Exhaust	0.015	2.10	2.47 E-03	0.35	D
Evaporative	6.61 E-04	0.09	0.00	0.00	E
Crankcase	4.85 E-03	0.69	4.41 E-05	0.01	E
Refueling	1.08 E-03	0.15	0.00	0.00	E

[a] References 2,5-6,9-14. When necessary, an average brake-specific fuel consumption (BSFC) of 7,000 Btu/hp-hr was used to convert from lb/MMBtu to lb/hp-hr. To convert from lb/hp-hr to kg/kw-hr, multiply by 0.608. To convert from lb/MMBtu to ng/J, multiply by 430. SCC = Source Classification Code. TOC = total organic compounds.

[b] PM-10 = particulate matter less than or equal to 10 µm aerodynamic diameter. All particulate is assumed to be ≤ 1 µm in size.

[c] Assumes 99% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, 86 weight % carbon in gasoline, average BSFC of 7,000 Btu/hp-hr, diesel heating value of 19,300 Btu/lb, and gasoline heating value of 20,300 Btu/lb.

Table 3.3-2. SPECIATED ORGANIC COMPOUND EMISSION FACTORS FOR UNCONTROLLED DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

Pollutant	Emission Factor (Fuel Input) (lb/MMBtu)
Benzene[b]	9.33 E-04
Toluene[b]	4.09 E-04
Xylenes[b]	2.85 E-04
Propylene[b]	2.58 E-03
1,3-Butadiene[b,c]	<3.91 E-05
Formaldehyde[b]	1.18 E-03
Acetaldehyde[b]	7.67 E-04
Acrolein[b]	<9.25 E-05
Polycyclic aromatic hydrocarbons (PAH)	
Naphthalene[b]	8.48 E-05
Acenaphthylene	<5.06 E-06
Acenaphthene	<1.42 E-06
Fluorene	2.92 E-05
Phenanthrene	2.94 E-05
Anthracene	1.87 E-06
Fluoranthene	7.61 E-06
Pyrene	4.78 E-06
Benzo(a)anthracene	1.68 E-06
Chrysene	3.53 E-07
Benzo(b)fluoranthene	<9.91 E-08
Benzo(k)fluoranthene	<1.55 E-07
Benzo(a)pyrene	<1.88 E-07
Indeno(1,2,3-cd)pyrene	<3.75 E-07
Dibenz(a,h)anthracene	<5.83 E-07
Benzo(g,h,l)perylene	<4.89 E-07
TOTAL PAH	1.68 E-04

[a] Based on the uncontrolled levels of 2 diesel engines from References 6-7. Source Classification Codes 2-02-001-02, 2-03-001-01. To convert from lb/MMBtu to ng/J, multiply by 430.
[b] Hazardous air pollutant listed in the *Clean Air Act*.
[c] Based on data from 1 engine.

Table 3.4-1. GASEOUS EMISSION FACTORS FOR LARGE STATIONARY DIESEL AND ALL STATIONARY DUAL-FUEL ENGINES[a]

Pollutant	Diesel Fuel (SCC 2-02-004-01)			Dual Fuel[b] (SCC 2-02-004-02)		
	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	EMISSION FACTOR RATING	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	EMISSION FACTOR RATING
NO_x						
Uncontrolled	0.024	3.2	B	0.018	2.7	D
Controlled	0.013[c]	1.9[c]	B	ND	ND	NA
CO	5.5 E-03	0.85	C	7.5 E-03	1.16	D
SO_x[d]	8.09 E-03S_1	1.01S_1	B	4.06 E-04S_1 + 9.57 E-03S_2	0.05S_1 + 0.895S_2	B
CO_2[e]	1.16	165	B	0.772	110	B
PM	0.0007[c]	0.1[c]	B	ND	ND	NA
TOC (as CH_4)	7.05 E-04	0.09	C	5.29 E-03	0.8	D
Methane	f	f	E	3.97 E-03	0.6	E
Nonmethane	f	f	E	1.32 E-03	0.2[g]	E

[a] Based on uncontrolled levels for each fuel, from References 2,6-7. When necessary, the average heating value of diesel was assumed to be 19,300 Btu/lb with a density of 7.1 lb/gallon. The power output and fuel input values were averaged independently from each other, because of the use of actual brake-specific fuel consumption (BSFC) values for each data point and of the use of data possibly sufficient to calculate only 1 of the 2 emission factors (e. g., enough information to calculate lb/MMBtu, but not lb/hp-hr). Factors are based on averages across all manufacturers and duty cycles. The actual emissions from a particular engine or manufacturer could vary considerably from these levels. To convert from lb/hp-hr to kg/kw-hr, multiply by 0.608. To convert from lb/MMBtu to ng/J, multiply by 430. SCC = Source Classification Code.

[b] Dual fuel assumes 95% natural gas and 5% diesel fuel.

[c] References 8-26. Controlled NO_x is by ignition timing retard.

[d] Assumes that all sulfur in the fuel is converted to SO_2. S_1 = % sulfur in fuel oil; S_2 = % sulfur in natural gas. For example, if sulfer content is 1.5%, then S = 1.5.

[e] Assumes 100% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, 70 weight % carbon in natural gas, dual-fuel mixture of 5% diesel with 95% natural gas, average BSFC of 7,000 Btu/hp-hr, diesel heating value of 19,300 Btu/lb, and natural gas heating value of 1050 Btu/scf.

[f] Based on data from 1 engine, TOC is by weight 9% methane and 91% nonmethane.

[g] Assumes that nonmethane organic compounds are 25% of TOC emissions from dual-fuel engines. Molecular weight of nonmethane gas stream is assumed to be that of methane.

Table 3.4-3. SPECIATED ORGANIC COMPOUND EMISSION FACTORS FOR LARGE UNCONTROLLED STATIONARY DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

Pollutant	Emission Factor (lb/MMBtu) (fuel input)
Benzene[b]	7.76 E-04
Toluene[b]	2.81 E-04
Xylenes[b]	1.93 E-04
Propylene	2.79 E-03
Formaldehyde[b]	7.89 E-05
Acetaldehyde[b]	2.52 E-05
Acrolein[b]	7.88 E-06

[a]Based on 1 uncontrolled diesel engine from Reference 7. Source Classification Code 2-02-004-01. Not enough information to calculate the output-specific emission factors of lb/hp-hr. To convert from lb/MMBtu to ng/J, multiply by 430.
[b]Hazardous air pollutant listed in the *Clean Air Act*.

Table 3.4-4. PAH EMISSION FACTORS FOR LARGE UNCONTROLLED STATIONARY DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

PAH	Emission Factor (lb/MMBtu) (fuel input)
Naphthalene[b]	1.30 E-04
Acenaphthylene	9.23 E-06
Acenaphthene	4.68 E-06
Fluorene	1.28 E-05
Phenanthrene	4.08 E-05
Anthracene	1.23 E-06
Fluoranthene	4.03 E-06
Pyrene	3.71 E-06
Benz(a)anthracene	6.22 E-07
Chrysene	1.53 E-06
Benzo(b)fluoranthene	1.11 E-06
Benzo(k)fluoranthene	<2.18 E-07
Benzo(a)pyrene	<2.57 E-07
Indeno(1,2,3-cd)pyrene	<4.14 E-07
Dibenz(a,h)anthracene	<3.46 E-07
Benzo(g,h,l)perylene	<5.56 E-07
TOTAL PAH	<2.12 E-04

[a] Based on 1 uncontrolled diesel engine from Reference 7. Source Classification Code 2-02-004-01. Not enough information to calculate the output-specific emission factors of lb/hp-hr. To convert from lb/MMBtu to ng/J, multiply by 430.

[b] Hazardous air pollutant listed in the *Clean Air Act.*

Engine Specification Data
STANDBY POWER

FOR MAXIMUM AVAILABLE POWER USE THE DATA FROM THE CORRESPONDING SAE STANDBY CURVE

General Data

Model	8163-3416/7416
Number of Cylinders	16
Bore and Stroke in (mm)	5.75x5.75 (146x146)
Displacement-in³ (L)	2389 (39.16)
Compression Ratio	15:1
Combustion System	DIRECT INJECTION
Engine Type	63.5° VEE - 2 CYCLE
Aspiration	TURBOCHARGED

Configuration

Turbocharger	TV8403 (1.23)
Charge Air Cooling System	ILCC
Blower Type	STD (EXT. BYPASS)
Blower Drive Ratio	2.28:1
Thrust Bearing Load Limit	
Continuous-lbf (N)	1100 (4890)
Intermittent-lbf (N)	3300 (14680)
Engine Crankcase Vent System	OPEN
Pressure-in H_2O (kPa)(New Engine)	0.8 (0.20)
Max. Pressure-in H_2O (kPa)	2.5 (0.60)

Physical Data

Size

Length-in (mm)	106 (2692)
Width-in (mm)	64 (1626)
Height-in (mm)	68 (1727)
Weight, dry-lb (kg)	10970 (4976)
Weight, wet-lb (kg)	11690 (5303)
Center of Gravity Distance	
From R.F.O.B. (x axis)-in (mm)	37.44 (951)
Above Crankshaft (y axis)-in (mm)	14.46 (367.3)
Right of Crankshaft (z axis)-in (mm)	0.9 (22.9)
Installation Drawing	23505386
Maximum Allowable Static Bending Moment at Rear Face of Block-lbf ft (N•m)	See Eng. Bulletin #45
Max. Allowable Vertical Load at Rear Face of Crankshaft-lb (kg)	2050 (930)

Fuel System

	1800	1500
Fuel Injector/Timing	7185/2.175	7185/2.175
Fuel Consumption-lb/hr (kg/hr)	859.0 (389.6)	695.2 (315.3)
Fuel Consumption-gal/hr (L/hr)	121.0 (458.0)	97.9 (370.6)
Fuel Spill Rate-lb/hr (kg/hr)	1630.0 (739.4)	1365.8 (619.5)
Fuel Spill Rate-gal/hr (L/hr)	229.0 (866.9)	192.1 (727.2)
Total Fuel Flow-lb/hr (kg/hr)	2489 (1129.0)	2062 (935.3)
Total Fuel Flow-gal/hr (L/hr)	350 (1324.9)	290 (1097.8)
Max. Allowable Fuel Pump Suction		
Clean System-in Hg (kPa)	6.0 (20.3)	6.0 (20.3)
Dirty System-in Hg (kPa)	12.0 (40.6)	12.0 (40.6)
Fuel Filter Micron Size		
Primary - Micron	30	30
Secondary - Micron	5	5

Lubrication System

	1800	1500
Oil Pressure		
Rated Speed-lbf/in² (kPa)	65-80 (448-551)	65-80 (448-551)
Low Idle-lbf/in² (kPa)	10 (69)	10 (69)
In Pan Oil Temperature-°F (°C)	230 (107.3) max.	230 (107.3) max.
Oil Flow-gal/min (L/min)	150 (568)	135 (511)
Oil Pan Capacity		
High-qt (L)	160 (151.4)	160 (151.4)
Low-qt (L)	114 (107.9)	114 (107.9)
Total Engine Oil Capacity with filters-qt (L)	200 (189.3)	200 (189.3)
Engine Angularity Limits		
Front up - degrees	15	15
Front down - degrees	15	15
Side tilt - degrees	NOT AVAILABLE	NOT AVAILABLE

Electrical System

Recommended Battery Capacity (CCA @ 0°F)	
24 Volt System	
Above 32°F (0°C)-A	950/STARTER
Below 32°F (0°C)-A	1250/STARTER
Max. Allowable Resistance of Starting Circuit	
24 volt system - ohm	0.002/STARTER

Part Load Fuel Consumption

Fuel-gal/hr (L/hr) -	1800	1500
0% Power	11.8 (44.7)	8.4 (31.8)
25% Power	31.7 (120.0)	27.3 (103.3)
50% Power	56.6 (214.3)	48.0 (181.7)
75% Power	83.5 (316.1)	71.4 (270.3)
100% Power	115.4 (436.8)	97.9 (370.6)

Cooling System

	1800	1500
Engine Heat Rejection		
Engine Coolant-Btu/min (kW)	47200 (830)	40500 (713)
ILCC Coolant-Btu/min (kW)	27700 (487)	19960 (351)
Total Btu/min (kW)	74900 (1317)	60500 (1064)
Engine Radiated Heat-Btu/min (kW)	8800 (155)	8800 (151)
Coolant Flow		
Engine Coolant-gal/min (L/min)	473 (1790)	392 (1484)
ILCC Coolant-gal/min (L/min)	57 (216)	48 (182)
Total-gal/min (L/min)	530 (2006)	440 (1666)
Minimum Coolant Flow gal/min (L/min)	95% OF RATED FLOW	
Thermostat		
Start to Open-°F (°C)	170 (77.6)	170 (77.6)
Fully Open-°F (°C)	185 (84.5)	185 (84.5)
Minimum Water Pump Inlet Pressure		
Rapid Warmup Radiator	POSITIVE	POSITIVE
Conventional Radiator-in. Hg (kPa)	-3 (-10.10)	-3 (-10.10)
Engine Coolant Capacity-qt (L)	187 (177)	187 (177)
Min. Pressure Cap-lbf/in² (kPa)	14 (96.5)	14 (96.5)
Remote Pressurization lbf/in² (kPa)	7-10 (48.3-69.0)	
Max. Coolant Pressure (Exclusive of Pressure Cap and/or Head)-lbf/in² (kPa)	30 (207)	30 (207)
Maximum Cooling System Static Head Nonpressure Cap-ft H_2O (kPa)	50 (149)	50 (149)
Max. Top Tank Temperature-°F (°C)	200 (93)	200 (93)
Min. Top Tank Temperature-°F (°C)	160 (74)	160 (74)
Maximum Intercooler Coolant in Temp. Above Ambient Air Temp. °F (°C)	30 (17)	30 (17)
Maximum Intercooler Coolant In Temperature °F (°C)	150 (66)	150 (66)
Min. Coolant Fill Rate-gal/min (L/min)	5 (19.0)	5 (19.0)
Deaeration-Air Injection Capacity-ft³/min (m³/min)	1.6 (0.46)	1.6 (0.46)
Drawdown - Percentage of the Total Cooling System Capacity	SEE ENG. BLTN. #50	
Heat Exchanger Raw Water Flow gal/min (L)	172 (651)	172 (651)
Max. Suction Pressure (Raw Water) in. Hg. (kPa)	5 (16.93)	5 (16.93)
Max. Discharge Pressure (Raw Water) lbf/in² (kPa)	10 (68.95)	10 (68.95)

Air System

	1800	1500
Max. Allowable Temperature Rise (Ambient Air to Engine Inlet)-°F (°C)	30 (17)	30 (17)
Air Intake Restriction Max. Limit		
Clean Air Cleaner-in H_2O (kPa)	10.5 (2.6)	7.5 (1.9)
Dirty Air Cleaner-in H_2O (kPa)	17.5 (4.4)	13.0 (3.2)
Engine Air Flow - ft³/min (m³/min)	5900 (167)	5160 (146)
Engine Air Box/Manifold Pressure-in Hg (kPa)	64 (217)	54.5 (184)
Recommended Intake Pipe Dia.		
Single-in (mm)	12 (305)	12 (305)
Dual-in (mm)	8 (203)	8 (203)

Exhaust System

	1800	1500
Exhaust Flow-ft³/min (m³/min)	14300 (404)	12560 (355)
Exhaust Temperature-°F (°C)	840 (449)	850 (454)
Maximum Allowable Back Pressure-in Hg (kPa)(New System)	1.5 (5.1)	1.0 (3.4)
Pressure-in Hg (kPa)(Dirty System)	2.0 (6.8)	1.5 (5.1)
Recommended Exhaust Pipe Dia.		
Single-in (mm)	14 (356)	12 (305)
Dual-in (mm)	10 (254)	8 (203)

See modeling section for stack parameters for stack as designed for LANL

Performance Data

	1800	1500
Power Output-bhp (kW)	2340 (1746)	1950 (1455)
Full Load Speed-r/min	1800	1500
BMEP-lbf/in² (kPa)	215 (1486)	215 (1486)
Piston Speed-ft/min (m/min)	1725 (526)	1438 (438)
Friction Power-fhp (kW)	350 (261)	250 (187)
Altitude Capability-ft (m)	6500 (1978)	6500 (1978)
Noise - db(A) @ 1m	NOT AVAIL.	NOT AVAIL.
Smoke - Bosch Number	2.8	2.9

Emission Data-g/hr (at percent load) - 1800 r/min

	0%	25%	50%	75%	100%
NO_x	1220	6800	12500	19400	22200
CO	680	500	1410	6200	14900
HC	1000	550	860	540	300

1500 kW generator derated for altitude

Emission Data-g/hr (at percent load) - 1500 r/min.

	0%	25%	50%	75%	100%
NO_x	2300	6300	11900	19100	18300
CO	720	400	2200	7000	15300
HC	870	430	600	615	320

This engine is able to develop more than rated power. If this engine is allowed to operate at higher than rated power, even for short periods of time, the cooling system must be adequate. Refer to the corresponding SAE standby engine heat rejection, altitude limitations and performance data for engine specifications.

All values at rated speed and power and with standard engine hardware unless otherwise noted.

Curve No. E4-9165-32-44
Date: 11-4-88
Rev./Date: 5/6-11-91
Sht. 2 of 4

Paper Shredder

99-0003

Document Disentegrator:	Model :	SEM1424
	Manufacturer:	Security Engineered Systems
	Capacity:	2000 lbs/hr
	Exhaust dust:	Roughly 1%
	Exhaust Controls:	3 hp electric motor with fabric filter (#FT140)
	Control Efficiency:	greater than 5 micron 99%
		Between 1 and 5 micron 93%
		Less than 0.3 micron 82%

This information was given to me over the phone. I spoke with Mr. Dave LeFrances (508) 366-1488 ext. 266. This shredder has a 3 hp exhaust system with a model #FT140 filter tube. The filter has been tested at the above efficiencies. The exhaust system is an integral element of the shredders operation, but the filter can be removed for cleaning. In fact, periodic routine maintenance requires the filter tubes to be removed and shaken down. He indicated that the shredder is an enclosed system with approximately 1% of the dust reporting to the exhaust filters and the remaining shredded product reporting to a collection shoot or drum. He did not have any information on the particle size distribution of the particulate matter in the exhaust. He assumed that we could collect a sample and have it analyzed for particle size. His recommendation for estimating emissions was to assume 1% of the input by weight is exhausted to the filter tubes or actually measure the quantity collected in the filters over time and back calculate an exhaust estimate based on filter efficiencies.

EPA **Air Pollution Technology Fact Sheet**

1. Name of Technology: Cyclones

This type of technology is a part of the group of air pollution controls collectively referred to as "precleaners," because they are oftentimes used to reduce the inlet loading of particulate matter (PM) to downstream collection devices by removing larger, abrasive particles. Cyclones are also referred to as cyclone collectors, cyclone separators, centrifugal separators, and inertial separators. In applications where many small cyclones are operating in parallel, the entire system is called a multiple tube cyclone, multicyclone, or multiclone.

2. Type of Technology:

Removal of PM by centrifugal and inertial forces, induced by forcing particulate-laden gas to change direction.

3. Applicable Pollutants:

Cyclones are used to control PM, and primarily PM greater than 10 micrometers (μm) in aerodynamic diameter. However, there are high efficiency cyclones designed to be effective for PM less than or equal to 10 μm and less than or equal to 2.5 μm in aerodynamic diameter (PM_{10} and $PM_{2.5}$). Although cyclones may be used to collect particles larger than 200 μm, gravity settling chambers or simple momentum separators are usually satisfactory and less subject to abrasion (Wark, 1981; Perry, 1984).

4. Achievable Emission Limits/Reductions:

The collection efficiency of cyclones varies as a function of particle size and cyclone design. Cyclone efficiency generally increases with (1) particle size and/or density, (2) inlet duct velocity, (3) cyclone body length, (4) number of gas revolutions in the cyclone, (5) ratio of cyclone body diameter to gas exit diameter, (6) dust loading, and (7) smoothness of the cyclone inner wall. Cyclone efficiency will decrease with increases in (1) gas viscosity, (2) body diameter, (3) gas exit diameter, (4) gas inlet duct area, and (5) gas density. A common factor contributing to decreased control efficiencies in cyclones is leakage of air into the dust outlet (EPA, 1998).

Control efficiency ranges for single cyclones are often based on three classifications of cyclone, i.e., conventional, high-efficiency, and high-throughput. The control efficiency range for conventional single cyclones is estimated to be 70 to 90 percent for PM, 30 to 90 percent for PM_{10}, and 0 to 40 percent for $PM_{2.5}$.

High efficiency single cyclones are designed to achieve higher control of smaller particles than conventional cyclones. According to Cooper (1994), high efficiency single cyclones can remove 5 μm particles at up to 90 percent efficiency, with higher efficiencies achievable for larger particles. The control efficiency ranges for high efficiency single cyclones are 80 to 99 percent for PM, 60 to 95 percent for PM_{10}, and 20 to 70 percent for $PM_{2.5}$. Higher efficiency cyclones come with higher pressure drops, which require higher energy costs to move the waste gas through the cyclone. Cyclone design is generally driven by a specified pressure-drop limitation, rather than by meeting a specified control efficiency (Andriola, 1999; Perry, 1994).

According to Vatavuk (1990), high throughput cyclones are only guaranteed to remove particles greater than 20 μm, although collection of smaller particles does occur to some extent. The control efficiency ranges for high-throughput cyclones are 80 to 99 percent for PM, 10 to 40 percent for PM_{10}, and 0 to 10 percent for $PM_{2.5}$. Multicyclones are reported to achieve from 80 to 95 percent collection efficiency for 5 μm particles (EPA, 1998).

5. ***Applicable Source Type:*** Point

6. ***Typical Industrial Applications:***

Cyclones are designed for many applications. Cyclones themselves are generally not adequate to meet stringent air pollution regulations, but they serve an important purpose as precleaners for more expensive final control devices such as fabric filters or electrostatic precipitators (ESPs). In addition to use for pollution control work, cyclones are used in many process applications, for example, they are used for recovering and recycling food products and process materials such as catalysts (Cooper, 1994).

Cyclones are used extensively after spray drying operations in the food and chemical industries, and after crushing, grinding and calcining operations in the mineral and chemical industries to collect salable or useful material. In the ferrous and nonferrous metallurgical industries, cyclones are often used as a first stage in the control of PM emissions from sinter plants, roasters, kilns, and furnaces. PM from the fluid-cracking process are removed by cyclones to facilitate catalyst recycling. Fossil-fuel and wood-waste fired industrial and commercial fuel combustion units commonly use multiple cyclones (generally upstream of a wet scrubber, ESP, or fabric filter) which collect fine PM (< 2.5 μm) with greater efficiency than a single cyclone. In some cases, collected fly ash is reinjected into the combustion unit to improve PM control efficiency (AWMA, 1992; Avallone, 1996; STAPPA/ALAPCO, 1996; EPA, 1998).

7. ***Emission Stream Characteristics:***

   a. ***Air Flow:*** Typical gas flow rates for a single cyclone unit are 0.5 to 12 standard cubic meters per second (sm^3/sec) (1,060 to 25,400 standard cubic feet per minute (scfm)). Flows at the high end of this range and higher (up to approximately 50 sm^3/sec or 106,000 scfm) use multiple cyclones in parallel (Cooper, 1994). There are single cyclone units employed for specialized applications which have flow rates of up to approximately 30 sm^3/sec (63,500 scfm) and as low as 0.0005 sm^3/sec (1.1 scfm) (Wark, 1981; Andriola, 1999).

b. ***Temperature:*** Inlet gas temperatures are only limited by the materials of construction of the cyclone, and have been operated at temperatures as high as 540°C (1000°F) (Wark, 1981; Perry, 1994).

c. ***Pollutant Loading:*** Waste gas pollutant loadings typically range from 2.3 to 230 grams per standard cubic meter (g/sm^3) (1.0 to 100 grains per standard cubic foot (gr/scf)) (Wark, 1981). For specialized applications, loadings can be as high as 16,000 g/sm^3 (7,000 gr/scf), and as low as 1 g/sm^3 (0.44 gr/scf) (Avallone, 1996; Andriola, 1999).

d. ***Other Considerations:*** Cyclones perform more efficiently with higher pollutant loadings, provided that the device does not become choked. Higher pollutant loadings are generally associated with higher flow designs (Andriola, 1999).

8. Emission Stream Pretreatment Requirements:

No pretreatment is necessary for cyclones.

9. Cost Information:

The following are cost ranges (expressed in third quarter 1995 dollars) for a single conventional cyclone under typical operating conditions, developed using an EPA cost-estimating spreadsheet (EPA, 1996), and referenced to the volumetric flow rate of the waste stream treated. For purposes of calculating the example cost effectiveness, flow rates are assumed to be between 0.5 and 12 sm^3/sec (1,060 and 25,400 scfm), the PM inlet loading is assumed to be approximately 2.3 and 230 g/sm^3 (1.0 to 100 gr/scf) and the control efficiency is assumed to be 90 percent. The costs do not include costs for disposal or transport of collected material. Capital costs can be higher than in the ranges shown for applications which require expensive materials. As a rule, smaller units controlling a waste stream with a low PM concentration will be more expensive (per unit volumetric flow rate and per quantity of pollutant controlled) than a large unit controlling a waste stream with a high PM concentration.

a. ***Capital Cost:*** \$4,200 to \$5,100 per sm^3/sec (\$2.00 to \$2.40 per scfm)

b. ***O & M Cost:*** \$2,400 to \$27,800 per sm^3/sec (\$1.10 to \$13.10 per scfm), annually

c. ***Annualized Cost:*** \$2,800 to \$28,300 per sm^3/sec (\$1.30 to \$13.40 per scfm), annually

d. ***Cost Effectiveness:*** \$0.45 to \$460 per metric ton (\$0.41 to \$420 per short ton), annualized cost per ton per year of pollutant controlled

Flow rates higher than approximately 10 sm^3/sec (21,200 scfm), and up to approximately 50 sm^3/sec (106,000 scfm), usually employ multiple cyclones operating in parallel. Assuming the same range of pollutant loading and an efficiency of 90 percent, the following cost ranges (expressed in third quarter 1995 dollars) were developed for multiple cyclones, using an EPA cost-estimating spreadsheet (EPA, 1996), and referenced to the volumetric flow rate of the waste stream treated.

a. ***Capital Cost:*** \$4,100 to \$5,000 per sm^3/sec (\$2.00 to \$2.40 per scfm)

b. ***O & M Cost:*** \$1,600 to \$2,600 per sm^3/sec (\$0.75 to \$1.20 per scfm), annually

c. ***Annualized Cost:*** \$2,000 to \$3,100 per sm^3/sec (\$0.90 to \$1.50 per scfm), annually

d. ***Cost Effectiveness:*** \$0.32 to \$50 per metric ton (\$0.29 to \$46 per short ton), annualized cost per ton per year of pollutant controlled

10. Theory of Operation:

Cyclones use inertia to remove particles from the gas stream. The cyclone imparts centrifugal force on the gas stream, usually within a conical shaped chamber. Cyclones operate by creating a double vortex inside the cyclone body. The incoming gas is forced into circular motion down the cyclone near the inner surface of the cyclone tube. At the bottom of the cyclone, the gas turns and spirals up through the center of the tube and out of the top of the cyclone (AWMA, 1992).

Particles in the gas stream are forced toward the cyclone walls by the centrifugal force of the spinning gas but are opposed by the fluid drag force of the gas traveling through and out of the cyclone. For large particles, inertial momentum overcomes the fluid drag force so that the particles reach the cyclone walls and are collected. For small particles, the fluid drag force overwhelms the inertial momentum and causes these particles to leave the cyclone with the exiting gas. Gravity also causes the larger particles that reach the cyclone walls to travel down into a bottom hopper. While they rely on the same separation mechanism as momentum separators, cyclones are more effective because they have a more complex gas flow pattern (AWMA, 1992).

Cyclones are generally classified into four types, depending on how the gas stream is introduced into the device and how the collected dust is discharged. The four types include tangential inlet, axial discharge; axial inlet, axial discharge; tangential inlet, peripheral discharge; and axial inlet, peripheral discharge. The first two types are the most common (AWMA, 1992).

Pressure drop is an important parameter because it relates directly to operating costs and control efficiency. Higher control efficiencies for a given cyclone can be obtained by higher inlet velocities, but this also increases the pressure drop. In general, 18.3 meters per second (60 feet per second) is considered the best operating velocity. Common ranges of pressure drops for cyclones are 0.5 to 1 kilopascals (kPa) (2 to 4 in. H_2O) for low-efficiency units (high throughput), 1 to 1.5 kPa (4 to 6 in. H_2O) for medium-efficiency units (conventional), and 2 to 2.5 kPa (8 to 10 in. H_2O) for high-efficiency units (AWMA, 1992).

When high-efficiency (which requires small cyclone diameter) and large throughput are both desired, a number of cyclones can be operated in parallel. In a multiple tube cyclone, the housing contains a large number of tubes that have a common gas inlet and outlet in the chamber. The gas enters the tubes through axial inlet vanes which impart a circular motion (AWMA, 1992). Another high-efficiency unit, the wet cyclonic separator, uses a combination of centrifugal force and water spray to enhance control efficiency.

11. Advantages/Pros:

Advantages of cyclones include (AWMA, 1992; Cooper, 1994; and EPA, 1998):

1. Low capital cost;
2. No moving parts, therefore, few maintenance requirements and low operating costs;
3. Relatively low pressure drop (2 to 6 inches water column), compared to amount of PM removed;
4. Temperature and pressure limitations are only dependent on the materials of construction;
5. Dry collection and disposal; and
6. Relatively small space requirements.

12. Disadvantages/Cons:

Disadvantages of cyclones include (AWMA, 1992; Cooper, 1994; and EPA, 1998):

1. Relatively low PM collection efficiencies, particularly for PM less than 10 μm in size;
2. Unable to handle sticky or tacky materials; and
3. High efficiency units may experience high pressure drops.

13. Other Considerations:

Using multiple cyclones, either in parallel or in series, to treat a large volume of gas results in higher efficiencies, but at the cost of a significant increase in pressure drop. Higher pressure drops translate to higher energy usage and operating costs. Several designs should be considered to achieve the optimum combination of collection efficiency and pressure drop (Cooper, 1994).

14. References:

Andriola, 1999. T. Andriola, Fisher-Klosterman, Inc., (502) 572-4000, personal communication with Eric Albright, October 14, 1999.

Avallone, 1996. "Marks' Standard Handbook for Mechanical Engineers," edited by Eugene Avallone and Theodore Baumeister, McGraw-Hill, New York, NY, 1996.

AWMA, 1992. Air & Waste Management Association, Air Pollution Engineering Manual, Van Nostrand Reinhold, New York, NY, 1992.

Cooper, 1994. David Cooper and F. Alley, Air Pollution Control: A Design Approach, 2nd Edition, Waveland Press, Prospect Heights, IL, 1994.

EPA, 1996. U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, EPA 453/B-96-001, Research Triangle Park, NC February, 1996.

EPA, 1998. U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC, October, 1998.

Perry, 1984. "Perry's Chemical Engineers' Handbook," edited by Robert Perry and Don Green, 6th Edition, McGraw-Hill, New York, NY, 1984.

STAPPA/ALAPCO, 1996. State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO), "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," STAPPA/ALAPCO, Washington, DC, July, 1996.

Vatavuk, 1990. W.M. Vatavuk, "Estimating Costs of Air Pollution Control," Lewis Publishers, Chelsea, MI, 1990.

Wark, 1981. Kenneth Wark and Cecil Warner, "Air Pollution: Its Origin and Control," Harper Collins, New York, NY, 1981.

Air Pollution Technology Fact Sheet

1. ***Name of Technology:*** *Fabric Filter - Pulse-Jet Cleaned Type (also referred to as Baghouses)*

2. ***Type of Technology:*** *Control Device - Capture/Disposal*

3. ***Applicable Pollutants:*** *Particulate Matter (PM), including particulate matter less than or equal to 10 micrometers (μm) in aerodynamic diameter (PM_{10}), particulate matter less than or equal to 2.5 μm in aerodynamic diameter ($PM_{2.5}$), and hazardous air pollutants (HAPs) that are in particulate form, such as most metals (mercury is the notable exception, as a significant portion of emissions are in the form of elemental vapor).*

4. ***Achievable Emission Limits/Reductions:***

Typical new equipment design efficiencies are between 99 and 99.9%. Older existing equipment have a range of actual operating efficiencies of 95 to 99.9%. Several factors determine fabric filter collection efficiency. These include gas filtration velocity, particle characteristics, fabric characteristics, and cleaning mechanism. In general, collection efficiency increases with increasing filtration velocity and particle size.

For a given combination of filter design and dust, the effluent particle concentration from a fabric filter is nearly constant, whereas the overall efficiency is more likely to vary with particulate loading. For this reason, fabric filters can be considered to be constant outlet devices rather than constant efficiency devices. Constant effluent concentration is achieved because at any given time, part of the fabric filter is being cleaned. As a result of the cleaning mechanisms used in fabric filters, the collection efficiency is constantly changing. Each cleaning cycle removes at least some of the filter cake and loosens particles which remain on the filter. When filtration resumes, the filtering capability has been reduced because of the lost filter cake and loose particles are pushed through the filter by the flow of gas. As particles are captured, the efficiency increases until the next cleaning cycle. Average collection efficiencies for fabric filters are usually determined from tests that cover a number of cleaning cycles at a constant inlet loading. (EPA, 1998a)

5. ***Applicable Source Type:*** *Point*

6. *Typical Industrial Applications:*

Fabric filters can perform very effectively in many different applications. Common applications of fabric filter systems with pulse-jet cleaning are presented in Table 1, however, fabric filters can be used in most any process where dust is generated and can be collected and ducted to a central location.

Table 1. Typical Industrial Applications of Pulse-Jet Cleaned Fabric Filters (EPA 1997; EPA, 1998a)

Application	*Source Category Code (SCC)*
Utility Boilers (Coal)	*1-01-002...003*
Industrial Boilers (Coal, Wood)	*1-02-001...003, 1-02-009*
Commercial/Institutional Boilers (Coal, Wood)	*1-03-001...003, 1-03-009*
Ferrous Metals Processing:	
Iron and Steel Production	*3-03-008...009*
Steel Foundries	*3-04-007,-009*
Mineral Products:	
Cement Manufacturing	*3-05-006...007*
Coal Cleaning	*3-05-010*
Stone Quarrying and Processing	*3-05-020*
Other	*3-05-003...999*
Asphalt Manufacture	*3-05-001...002*
Grain Milling	*3-02-007*

7. *Emission Stream Characteristics:*

a. ***Air Flow:*** *Baghouses are separated into two groups, standard and custom, which are further separated into low, medium, and high capacity. Standard baghouses are factory-built, off the shelf units. They may handle from less than 0.10 to more than 50 standard cubic meters per second (sm^3/sec) (("hundreds" to more than 100,000 standard cubic feet per minute (scfm)). Custom baghouses are designed for specific applications and are built to the specifications prescribed by the customer. These units are generally much larger than standard units, i.e., from 50 to over 500 sm^3/sec (100,000 to over 1,000,000 scfm). (EPA, 1998b)*

b. ***Temperature:*** *Typically, gas temperatures up to about 260°C (500°F), with surges to about 290°C (550°F) can be accommodated routinely, with the appropriate fabric material. Spray coolers or dilution air can be used to lower the temperature of the pollutant stream. This prevents the temperature limits of the fabric from being exceeded. Lowering the temperature, however, increases the humidity of the pollutant stream. Therefore, the minimum temperature of the pollutant stream must remain* *above the dew point of any condensable in the stream. The baghouse and associated ductwork should be insulated and possibly heated if condensation may occur. (EPA, 1998b)*

c. ***Pollutant Loading:*** *Typical inlet concentrations to baghouses are 1 to 23 grams per cubic meter (g/m^3) (0.5 to 10 grains per cubic foot (gr/ft^3)), but in extreme cases, inlet conditions may vary between 0.1 to more than 230 g/m^3 (0.05 to more than 100 gr/ft^3). (EPA, 1998b)*

d. ***Other Considerations:*** *Moisture and corrosives content are the major gas stream characteristics requiring design consideration. Standard fabric filters can be used in pressure or vacuum service, but only within the range of about ± 640 millimeters of water column (25 inches of water column). Well-designed and operated baghouses have been shown to be capable of reducing overall particulate emissions to less than 0.05 g/m^3 (0.010 gr/ft^3), and in a number of cases, to as low as 0.002 to 0.011 g/m^3 (0.001 to 0.005 gr/ft^3). (AWMA, 1992)*

8. *Emission Stream Pretreatment Requirements:*

Because of the wide variety of filter types available to the designer, it is not usually required to pretreat a waste stream's inlet temperature. However, in some high temperature applications, the cost of high temperature-resistant bags must be weighed against the cost of cooling the inlet temperature with spray coolers or dilution air (EPA, 1998b). When much of the pollutant loading consists of relatively large particles, mechanical collectors such as cyclones may be used to reduce the load on the fabric filter, especially at high inlet concentrations (EPA, 1998b).

9. *Cost Information:*

Cost estimates are presented below for pulse-jet cleaned fabric filters. The costs are expressed in fourth quarter 1998 dollars. The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998b).

Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading. The costs presented are for flow rates of 470 m^3/sec (1,000,000 scfm) and 1.0 m^3/sec (2,000 scfm), respectively, and a pollutant loading of 9 g/m^3 (4.0 gr/ft^3).

Pollutants that require an unusually high level of control or that require the fabric filter bags or the unit itself to be constructed of special materials, such as Gore-Tex or stainless steel, will increase the costs of the system (EPA, 1998b). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, *the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20%.*

a. ***Capital Cost:*** *\$13,100 to \$54,900 per sm^3/s (\$6 to \$26 per scfm)*

b. ***O & M Cost:*** *\$11,200 to \$51,700 per sm^3/s (\$5 to \$24 per scfm), annually*

c. ***Annualized Cost:*** *\$13,100 to \$83,400 per sm^3/s (\$6 to \$39 per scfm), annually*

d. ***Cost Effectiveness:*** *\$46 to \$293 per metric ton (\$42 to \$266 per short ton)*

10. Theory of Operation:

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, causing PM in the flue gas to be collected on the fabric by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with a number of the individual fabric filter units housed together in a group. Bags are most common type of fabric filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. Fabric filters are frequently referred to as baghouses because the fabric is usually configured in cylindrical bags. Bags may be 6 to 9 m (20 to 30 ft) long and 12.7 to 30.5 centimeters (cm) (5 to 12 inches) in diameter. Groups of bags are placed in isolable compartments to allow cleaning of the bags or replacement of some of the bags without shutting down the entire fabric filter. (STAPPA/ALAPCO, 1996)

Operating conditions are important determinants of the choice of fabric. Some fabrics (e.g., polyolefins, nylons, acrylics, polyesters) are useful only at relatively low temperatures of 95 to 150°C (200 to 300°F). For high-temperature flue gas streams, more thermally stable fabrics such as fiberglass, Teflon®, or Nomex® must be used (STAPPA/ALAPCO, 1996).

Practical application of fabric filters requires the use of a large fabric area in order to avoid an unacceptable pressure drop across the fabric. Baghouse size for a particular unit is determined by the choice of air-to-cloth ratio, or the ratio of volumetric air flow to cloth area. The selection of air-to-cloth ratio depends on the particulate loading and characteristics, and the cleaning method used. A high particulate loading will require the use of a larger baghouse in order to avoid forming too heavy a dust cake, which would result in an excessive pressure drop As an example, a baghouse for a 250 MW utility boiler may have 5,000 separate bags with a total fabric area approaching 46,500 m^2 (500,000 square feet). (ICAC, 1999)

Determinants of baghouse performance include the fabric chosen, the cleaning frequency and methods, and the particulate characteristics. Fabrics can be chosen which will intercept a greater fraction of particulate, and some fabrics are coated with a membrane with very fine openings for enhanced removal of submicron particulate. Such fabrics tend to be more expensive.

Pulse-jet cleaning of fabric filters is relatively new compared to other types of fabric filters, since they have only been used for the past 30 years. This cleaning mechanism has consistently grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters. Pulse-jet cleaned fabric filters can only operate as external cake collection devices. The bags are closed at the bottom, open at the top, and supported by internal retainers, called cages. Particulate-laden gas flows into the bag, with diffusers often used to prevent oversized particles from damaging the bags. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles are collected on the outside of the bags and drop into a hopper below the fabric filter. (EPA, 1998a)

During pulse-jet cleaning, a short burst, 0.03 to 0.1 seconds in duration, of high pressure [415 to 830 kiloPascals (kPa) (60 to 120 pounds per square inch gage (psig))] air is injected into the bags (EPA, 1998a; AWMA, 1992). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric, pushing it away from the cage, and then snaps it back dislodging the dust cake. The cleaning cycle is regulated by a remote timer connected to a solenoid valve. The burst of air is controlled by the solenoid valve and is released into blow pipes that have nozzles located above the bags. The bags are usually cleaned row by row (EPA, 1998a).

There are several unique attributes of pulse-jet cleaning. Because the cleaning pulse is very brief, the flow of dusty gas does not have to be stopped during cleaning. The other bags continue to filter, taking on extra duty because of he bags being cleaned. In general, there is no change in fabric filter pressure drop or performance as a result of pulse-jet cleaning. This enables the pulse-jet fabric filters to operate on a continuous basis with solenoid valves as the only significant moving parts. Pulse-jet cleaning is also more intense and occurs with greater frequency than the other fabric filter cleaning methods. This intense cleaning dislodges nearly all of the dust cake each time the bag is pulsed. As a result, pulse-jet filters do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in pulse-jet fabric filters because they do not require a dust cake to achieve high collection efficiencies. It has been found that woven fabrics used with pulse-jet fabric filters leak a great deal of dust after they are cleaned. (EPA, 1998a)

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulse-jet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other types of fabric filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable. (EPA, 1998a)

11. Advantages/Pros:

Fabric filters in general provide high collection efficiencies on both coarse and fine (submicron) particulates. They are relatively insensitive to fluctuations in gas stream conditions. Efficiency and pressure drop are relatively unaffected by large changes in inlet dust *loadings for continuously cleaned filters. Filter outlet air is very clean and may be recirculated within the plant in many cases (for energy conservation). Collected material is collected dry for subsequent processing or disposal. Corrosion and rusting of components are usually not problems. Operation is relatively simple. Unlike electrostatic precipitators, fabric filter systems do not require the use of high voltage, therefore, maintenance is simplified and flammable dust may be collected with proper care. The use of selected fibrous or granular filter aids (precoating) permits the high-efficiency collection of submicron smokes and gaseous contaminants. Filter collectors are available in a large number of configurations, resulting in a range of dimensions and inlet and outlet flange locations to suit installation requirements. (AWMA, 1992)*

12. *Disadvantages/Cons:*

Temperatures much in excess of 290°C (550°F) require special refractory mineral or metallic fabrics, which can be expensive. Certain dusts may require fabric treatments to reduce dust seepage, or in other cases, assist in the removal of the collected dust. Concentrations of some dusts in the collector, approximately 50 g/m³ (22 gr/ft³), may represent a fire or explosion hazard if a spark or flame is accidentally admitted. Fabrics can burn if readily oxidizable dust is being collected. Fabric filters have relatively high maintenance requirements (e.g., periodic bag replacement). Fabric life may be shortened at elevated temperatures and in the presence of acid or alkaline particulate or gas constituents. They cannot be operated in moist environments; hygroscopic materials, condensation of moisture, or tarry adhesive components may cause crusty caking or plugging of the fabric or require special additives. Respiratory protection for maintenance personnel may be required when replacing fabric. Medium pressure drop is required, typically in the range of 100 to 250 mm of water column (4 to 10 inches of water column). (AWMA, 1992)

A specific disadvantage of pulse-jet units that use very high gas velocities is that the dust from the cleaned bags can be drawn immediately to the other bags. If this occurs, little of the dust falls into the hopper and the dust layer on the bags becomes too thick. To prevent this, pulse-jet fabric filters can be designed with separate compartments that can be isolated for cleaning. (EPA, 1998a)

13. *Other Considerations:*

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters therefore may be good candidates for collecting fly ash from low-sulfur coals or fly ash containing high unburned carbon levels, which respectively have high and low resistivities, and thus are relatively difficult to collect with electrostatic precipitators. (STAPPA/ALAPCO, 1996)

14. References:

AWMA, 1992. Air & Waste Management Association, Air Pollution Engineering Manual, *Van Nostrand Reinhold, New York.*

EPA, 1997. U.S. EPA, Office of Air Quality Planning and Standards, "Compilation of Air Pollutant Emission Factors, Volume I, Fifth Edition, Research Triangle Park, NC., October.

EPA, 1998a. U.S. EPA, Office of Air Quality Planning and Standards, "Stationary Source Control Techniques Document for Fine Particulate Matter," EPA-452/R-97-001, Research Triangle Park, NC., October.

EPA, 1998b. U.S. EPA, Office of Air Quality Planning and Standards, "OAQPS Control Cost Manual," Fifth Edition, Chapter 5, EPA 453/B-96-001, Research Triangle Park, NC. December.

ICAC, 1999. Institute of Clean Air Companies internet web page www.icac.com, Control Technology Information - Fabric Filters, page last updated January 11, 1999.

STAPPA/ALAPCO, 1996. State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials, "Controlling Particulate Matter Under the Clean Air Act: A Menu of Options," July.

Power Plant at Technical Area 3 (TA-3-22)

TABLE 1.4-2. EMISSION FACTORS FOR CRITERIA POLLUTANTS AND GREENHOUSE GASES FROM NATURAL GAS COMBUSTION[a]

Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
CO_2[b]	120,000	A
Lead	0.0005	D
N_2O (Uncontrolled)	2.2	E
N_2O (Controlled-low-NO_X burner)	0.64	E
PM (Total)[c]	7.6	D
PM (Condensable)[c]	5.7	D
PM (Filterable)[c]	1.9	B
SO_2[d]	0.6	A
TOC	11	B
Methane	2.3	B
VOC	5.5	C

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by 16. To convert from $lb/10^6$ scf to 1b/MMBtu, divide by 1,020. The emission factors in this table may be converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to this average heating value. TOC = Total Organic Compounds. VOC = Volatile Organic Compounds.

[b] Based on approximately 100% conversion of fuel carbon to CO_2. CO_2[$lb/10^6$ scf] = (3.67) (CON) (C)(D), where CON = fractional conversion of fuel carbon to CO_2, C = carbon content of fuel by weight (0.76), and D = density of fuel, $4.2x10^4$ $lb/10^6$ scf.

[c] All PM (total, condensible, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the PM emission factors presented here may be used to estimate PM_{10}, $PM_{2.5}$ or PM_1 emissions. Total PM is the sum of the filterable PM and condensible PM. Condensible PM is the particulate matter collected using EPA Method 202 (or equivalent). Filterable PM is the particulate matter collected on, or prior to, the filter of an EPA Method 5 (or equivalent) sampling train.

[d] Based on 100% conversion of fuel sulfur to SO_2.
Assumes sulfur content is natural gas of 2,000 grains/10^6 scf. The SO_2 emission factor in this table can be converted to other natural gas sulfur contents by multiplying the SO_2 emission factor by the ratio of the site-specific sulfur content (grains/10^6 scf) to 2,000 grains/10^6 scf.

Table 1.4-2 (Metric And English Units). EMISSION FACTORS FOR SULFUR DIOXIDE (SO_2), NITROGEN OXIDES (NO_x), AND CARBON MONOXIDE (CO) FROM NATURAL GAS COMBUSTION[a]

Combustor Type (Size, 10^6 Btu/hr Heat Input) (SCC)[b]	SO_2[c]			NO_x[d]			CO[e]		
	kg/10^6 m^3	lb/10^6 ft^3	RATING	kg/10^6 m^3	lb/10^6 ft^3	RATING	kg/10^6 m^3	lb/10^6 ft^3	RATING
Utility/large Industrial Boilers (>100) (1-01-006-01, 1-01-006-04)									
Uncontrolled	9.6	0.6	A	8800	550[f]	A	640	40	A
Controlled - Low NO_x burners	9.6	0.6	A	1300	81[f]	D	ND	ND	NA
Controlled - Flue gas recirculation	9.6	0.6	A	850	53[f]	D	ND	ND	NA
Small Industrial Boilers (10 - 100) (1-02-006-02)									
Uncontrolled	9.6	0.6	A	2240	140	A	560	35	A
Controlled - Low NO_x burners	9.6	0.6	A	1300	81[f]	D	980	61	D
Controlled - Flue gas recirculation	9.6	0.6	A	480	30	C	590	37	C
Commercial Boilers (0.3 - <10) (1-03-006-03)									
Uncontrolled	9.6	0.6	A	1600	100	B	330	21	C
Controlled - Low NO_x burners	9.6	0.6	A	270	17	C	425	27	C
Controlled - Flue gas recirculation	9.6	0.6	A	580	36	D	ND	ND	NA
Residential Furnaces (<0.3) (No SCC)									
Uncontrolled	9.6	0.6	A	1500	94	B	640	40	B

[a] Units are kg of pollutant/10^6 cubic meters natural gas fired and lb of pollutant/10^6 cubic feet natural gas fired. Based on an average natural gas fired higher heating value of 8270 kcal/m^3 (1000 Btu/scf). The emission factors in this table may be converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to this average heating value. ND = no data. NA = not applicable.

[b] SCC = Source Classification Code.

[c] Reference 7. Based on average sulfur content of natural gas, 4600 g/10^6 Nm^3 (2000 gr/10^6 scf).

Table 1.4-2 (cont.).

[d] References 10,15-19. Expressed as NO_2. For tangentially fired units, use 4400 kg/10^6 m^3 (275 lb/10^6 ft^3). At reduced loads, multiply factor by load reduction coefficient in Figure 1.4-1. Note that NO_x emissions from controlled boilers will be reduced at low load conditions.

[e] References 9-10,16-18,20-21.

[f] Emission factors apply to packaged boilers only.

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
91-57-6	2-Methylnaphthalene[b, c]	2.4E-05	D
56-49-5	3-Methylchloranthrene[b, c]	<1.8E-06	E
	7,12-Dimethylbenz(a)anthracene[b,c]	<1.6E-05	E
83-32-9	Acenaphthene[b,c]	<1.8E-06	E
203-96-8	Acenaphthylene[b,c]	<1.8E-06	E
120-12-7	Anthracene[b,c]	<2.4E-06	E
56-55-3	Benz(a)anthracene[b,c]	<1.8E-06	E
71-43-2	Benzene[b]	2.1E-03	B
50-32-8	Benzo(a)pyrene[b,c]	<1.2E-06	E
205-99-2	Benzo(b)fluoranthene[b,c]	<1.8E-06	E
191-24-2	Benzo(g,h,i)perylene[b,c]	<1.2E-06	E
205-82-3	Benzo(k)fluoranthene[b,c]	<1.8E-06	E
106-97-8	Butane	2.1E+00	E
218-01-9	Chrysene[b,c]	<1.8E-06	E
53-70-3	Dibenzo(a,h)anthracene[b,c]	<1.2E-06	E
25321-22-6	Dichlorobenzene[b]	1.2E-03	E
74-84-0	Ethane	3.1E+00	E
206-44-0	Fluoranthene[b,c]	3.0E-06	E
86-73-7	Fluorene[b,c]	2.8E-06	E
50-00-0	Formaldehyde[b]	7.5E-02	B
110-54-3	Hexane[b]	1.8E+00	E
193-39-5	Indeno(1,2,3-cd)pyrene[b,c]	<1.8E-06	E
91-20-3	Naphthalene[b]	6.1E-04	E
109-66-0	Pentane	2.6E+00	E
85-01-8	Phenanathrene[b,c]	1.7E-05	D

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION (Continued)

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
74-98-6	Propane	1.6E+00	E
129-00-0	Pyrene[b, c]	5.0E-06	E
108-88-3	Toluene[b]	3.4E-03	C

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by 16. To convert from $1b/10^6$ scf to lb/MMBtu, divide by 1,020. Emission Factors preceeded with a less-than symbol are based on method detection limits.

[b] Hazardous Air Pollutant (HAP) as defined by Section 112(b) of the Clean Air Act.

[c] HAP because it is Polycyclic Organic Matter (POM). POM is a HAP as defined by Section 112(b) of the Clean Air Act.

[d] The sum of individual organic compounds may exceed the VOC and TOC emission factors due to differences in test methods and the availability of test data for each pollutant.

TABLE 1.4-4. EMISSION FACTORS FOR METALS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
7440-38-2	Arsenic[b]	2.0E-04	E
7440-39-3	Barium	4.4E-03	D
7440-41-7	Beryllium[b]	<1.2E-05	E
7440-43-9	Cadmium[b]	1.1E-03	D
7440-47-3	Chromium[b]	1.4E-03	D
7440-48-4	Cobalt[b]	8.4E-05	D
7440-50-8	Copper	8.5E-04	C
7439-96-5	Manganese[b]	3.8E-04	D
7439-97-6	Mercury[b]	2.6E-04	D
7439-98-7	Molybdenum	1.1E-03	D
7440-02-0	Nickel[b]	2.1E-03	C
7782-49-2	Selenium[b]	<2.4E-05	E
7440-62-2	Vanadium	2.3E-03	D
7440-66-6	Zinc	2.9E-02	E

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. Emission factors preceeded by a less-than symbol are based on method detection limits. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by l6. To convert from $lb/10^6$ scf to 1b/MMBtu, divide by 1,020.

[b] Hazardous Air Pollutant as defined by Section 112(b) of the Clean Air Act.

Table 1.3-1. CRITERIA POLLUTANT EMISSION FACTORS FOR FUEL OIL COMBUSTION[a]

Firing Configuration (SCC)[a]	SO_2[b]		SO_3[c]		NO_x[d]		CO[e]		Filterable PM[f]	
	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING
Boilers > 100 Million Btu/hr										
No. 6 oil fired, normal firing (1-01-004-01), (1-02-004-01), (1-03-004-01)	157S	A	5.7S	C	47	A	5	A	9.19(S)+3.22	A
No. 6 oil fired, normal firing, low NO_x burner (1-01-004-01), (1-02-004-01)	157S	A	5.7S	C	40	B	5	A	9.19(S)+3.22	A
No. 6 oil fired, tangential firing, (1-01-004-04)	157S	A	5.7S	C	32	A	5	A	9.19(S)+3.22	A
No. 6 oil fired, tangential firing, low NO_x burner (1-01-004-04)	157S	A	5.7S	C	26	E	5	A	9.19(S)+3.22	A
No. 5 oil fired, normal firing (1-01-004-05), (1-02-004-04)	157S	A	5.7S	C	47	B	5	A	10	B
No. 5 oil fired, tangential firing (1-01-004-06)	157S	A	5.7S	C	32	B	5	A	10	B
No. 4 oil fired, normal firing (1-01-005-04), (1-02-005-04)	150S	A	5.7S	C	47	B	5	A	7	B
No. 4 oil fired, tangential firing (1-01-005-05)	150S	A	5.7S	C	32	B	5	A	7	B
No. 2 oil fired (1-01-005-01), (1-02-005-01), (1-03-005-01)	~~157S~~ 142S	A	5.7S	C	24	D	5	A	2	A
No.2 oil fired, LNB/FGR, (1-01-005-01), (1-02-005-01), (1-03-005-01)	157S	A	5.7S	A	10	D	5	A	2	A

AP-42 Section 1.3 - Fuel Oil Combustion Errata

Updated 4/28/00

1. In table 1.3-1, for boilers > 100 million BTU/hr, the SO2 emission factor for both no. 2 oil fired and for no. 2 oil fired with LNB/FGR, is 142S, not 157S.
2. In table 1.3-1, for boilers < 100 million BTU/hr, the filterable PM emission factor for no. 6 oil fired is 9.19(S)+3.22, not 10. The factor for no. 5 oil fired is 10, not 9.19(S) +3.22. These two factors were reversed.
3. In table 1.3-8, the correct N2O factor is 0.53 lb/1000 gal for No 6 oil and 0.26 lb/1000 gal for distillate oil.

Table 1.3-3. EMISSION FACTORS FOR TOTAL ORGANIC COMPOUNDS (TOC), METHANE, AND NONMETHANE TOC (NMTOC) FROM UNCONTROLLED FUEL OIL COMBUSTION[a]

EMISSION FACTOR RATING: A

Firing Configuration (SCC)	TOC[b] Emission Factor (lb/10^3 gal)	Methane[b] Emission Factor (lb/10^3 gal)	NMTOC[b] Emission Factor (lb/10^3 gal)
Utility boilers			
No. 6 oil fired, normal firing (1-01-004-01)	1.04	0.28	0.76
No. 6 oil fired, tangential firing (1-01-004-04)	1.04	0.28	0.76
No. 5 oil fired, normal firing (1-01-004-05)	1.04	0.28	0.76
No. 5 oil fired, tangential firing (1-01-004-06)	1.04	0.28	0.76
No. 4 oil fired, normal firing (1-01-005-04)	1.04	0.28	0.76
No. 4 oil fired, tangential firing (1-01-005-05)	1.04	0.28	0.76
Industrial boilers			
No. 6 oil fired (1-02-004-01/02/03)	1.28	1.00	0.28
No. 5 oil fired (1-02-004-04)	1.28	1.00	0.28
Distillate oil fired (1-02-005-01/02/03)	0.252	0.052	0.2
No. 4 oil fired (1-02-005-04)	0.252	0.052	0.2
Commercial/institutional/residential combustors			
No. 6 oil fired (1-03-004-01/02/03)	1.605	0.475	1.13
No. 5 oil fired (1-03-004-04)	1.605	0.475	1.13
Distillate oil fired (1-03-005-01/02/03)	0.556	0.216	0.34
No. 4 oil fired (1-03-005-04)	0.556	0.216	0.34
Residential furnace (A2104004/A2104011)	2.493	1.78	0.713

[a] To convert from lb/10^3 gal to kg/10^3 L, multiply by 0.12. SCC = Source Classification Code.

[b] References 29-32. Volatile organic compound emissions can increase by several orders of magnitude if the boiler is improperly operated or is not well maintained.

Rock Crusher

Table 3.3-1. EMISSION FACTORS FOR UNCONTROLLED GASOLINE AND DIESEL INDUSTRIAL ENGINES[a]

Pollutant	Gasoline Fuel (SCC 2-02-003-01, 2-03-003-01) Emission Factor (lb/hp-hr) (power output)	Gasoline Fuel Emission Factor (lb/MMBtu) (fuel input)	Diesel Fuel (SCC 2-02-001-02, 2-03-001-01) Emission Factor (lb/hp-hr) (power output)	Diesel Fuel Emission Factor (lb/MMBtu) (fuel input)	EMISSION FACTOR RATING
NO_x	0.011	1.63	0.031	4.41	D
CO	0.439	62.7	6.68 E-03	0.95	D
SO_x	5.91 E-04	0.084	2.05 E-03	0.29	D
PM-10[b]	7.21 E-04	0.10	2.20 E-03	0.31	D
CO_2[c]	1.08	154	1.15	164	B
Aldehydes	4.85 E-04	0.07	4.63 E-04	0.07	D
TOC					
Exhaust	0.015	2.10	2.47 E-03	0.35	D
Evaporative	6.61 E-04	0.09	0.00	0.00	E
Crankcase	4.85 E-03	0.69	4.41 E-05	0.01	E
Refueling	1.08 E-03	0.15	0.00	0.00	E

[a] References 2,5-6,9-14. When necessary, an average brake-specific fuel consumption (BSFC) of 7,000 Btu/hp-hr was used to convert from lb/MMBtu to lb/hp-hr. To convert from lb/hp-hr to kg/kw-hr, multiply by 0.608. To convert from lb/MMBtu to ng/J, multiply by 430. SCC = Source Classification Code. TOC = total organic compounds.

[b] PM-10 = particulate matter less than or equal to 10 µm aerodynamic diameter. All particulate is assumed to be ≤ 1 µm in size.

[c] Assumes 99% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, 86 weight % carbon in gasoline, average BSFC of 7,000 Btu/hp-hr, diesel heating value of 19,300 Btu/lb, and gasoline heating value of 20,300 Btu/lb.

Table 3.3-2. SPECIATED ORGANIC COMPOUND EMISSION FACTORS FOR UNCONTROLLED DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

Pollutant	Emission Factor (Fuel Input) (lb/MMBtu)
Benzene[b]	9.33 E-04
Toluene[b]	4.09 E-04
Xylenes[b]	2.85 E-04
Propylene[b]	2.58 E-03
1,3-Butadiene[b,c]	<3.91 E-05
Formaldehyde[b]	1.18 E-03
Acetaldehyde[b]	7.67 E-04
Acrolein[b]	<9.25 E-05
Polycyclic aromatic hydrocarbons (PAH)	
Naphthalene[b]	8.48 E-05
Acenaphthylene	<5.06 E-06
Acenaphthene	<1.42 E-06
Fluorene	2.92 E-05
Phenanthrene	2.94 E-05
Anthracene	1.87 E-06
Fluoranthene	7.61 E-06
Pyrene	4.78 E-06
Benzo(a)anthracene	1.68 E-06
Chrysene	3.53 E-07
Benzo(b)fluoranthene	<9.91 E-08
Benzo(k)fluoranthene	<1.55 E-07
Benzo(a)pyrene	<1.88 E-07
Indeno(1,2,3-cd)pyrene	<3.75 E-07
Dibenz(a,h)anthracene	<5.83 E-07
Benzo(g,h,l)perylene	<4.89 E-07
TOTAL PAH	1.68 E-04

[a] Based on the uncontrolled levels of 2 diesel engines from References 6-7. Source Classification Codes 2-02-001-02, 2-03-001-01. To convert from lb/MMBtu to ng/J, multiply by 430.
[b] Hazardous air pollutant listed in the *Clean Air Act*.
[c] Based on data from 1 engine.

Table 11.19.2-2 (English Units). EMISSION FACTORS FOR CRUSHED STONE PROCESSING OPERATIONS[a]

Source[b]	Total Particulate Matter	EMISSION FACTOR RATING	Total PM-10[c]	EMISSION FACTOR RATING
Screening (SCC 3-05-020-02,-03)	—[d]		0.015[e]	C
Screening (controlled) (SCC 3-05-020-02-03)	—[d]		0.00084[e]	C
Primary crushing (SCC 3-05-020-01)	0.00070[f]	E	ND[g]	
Secondary crushing (SCC 3-05-020-02)	ND		ND[g]	
Tertiary crushing (SCC 3-05-020-03)	—[d]		0.0024[h]	C
Primary crushing (controlled) (SCC 3-05-020-01)	ND		ND[g]	NA
Secondary crushing (controlled) (SCC 3-05-020-02)	ND		ND[g]	NA
Tertiary crushing (controlled) (SCC 3-05-020-03)	—[d]		0.00059[h]	C
Fines crushing[j] (SCC 3-05-020-05)	—[d]		0.015	E
Fines crushing (controlled)[j] (SCC 3-05-020-05)	—[d]		0.0020	E
Fines screening[j] (SCC 3-05-020-21)	—[d]		0.071	E
Fines screening (controlled)[j] (SCC 3-05-020-21)	—[d]		0.0021	E
Conveyor transfer point[k] (SCC 3-05-020-06)	—[d]		0.0014	D
Conveyor transfer point (controlled)[k] (SCC 3-05-020-06)	—[d]		4.8×10^{-5}	D
Wet drilling: unfragmented stone[m] (SCC 3-05-020-10)	ND		8.0×10^{-5}	E
Truck unloading: fragmented stone[m] (SCC 3-05-020-31)	ND		1.6×10^{-5}	E
Truck loading--conveyor: crushed stone[n] (SCC 3-05-020-32)	ND		0.00010	E

[a] Emission factors represent uncontrolled emissions unless noted. Emission factors in lb/ton of material throughput. SCC = Source Classification Code. ND = no data.

[b] Controlled sources (with wet suppression) are those that are part of the processing plant that employs current wet suppression technology similar to the study group. The moisture content of the study group without wet suppression systems operating (uncontrolled) ranged from 0.21 to 1.3 percent and the same facilities operating wet suppression systems (controlled) ranged from 0.55 to 2.88 percent. Due to carry over or the small amount of moisture required, it has been shown that each source, with the exception of crushers, does not need to employ direct water sprays. Although the moisture content was the only variable measured, other process features may have as much influence on emissions from a given source. Visual observations from each source under normal operating conditions are probably the best indicator of which emission factor is most appropriate. Plants that employ sub-standard control measures as indicated by visual observations should use the uncontrolled factor with an appropriate control efficiency that best reflects the effectiveness of the controls employed.

[c] Although total suspended particulate (TSP) is not a measurable property from a process, some states may require estimates of TSP emissions. No data are available to make these estimates. However, relative ratios in AP-42 Sections 13.2.2 and 13.2.4 indicate that TSP emission factors may be estimated by multiplying PM-10 by 2.1.

Table 11.19.2-2 (cont.).

[d] Emission factors for total particulate are not presented pending a re-evaluation of the EPA Method 201a test data and/or results of emission testing. This re-evaluation is expected to be completed by July 1995.
[e] References 9, 11, 15-16.
[f] Reference 1.
[g] No data available, but emission factors for PM-10 emission factors for tertiary crushing can be used as an upper limit for primary or secondary crushing.
[h] References 10-11, 15-16.
[j] Reference 12.
[k] References 13-14.
[m] Reference 3.
[n] Reference 4.

Emission factor estimates for stone quarry blasting operations are not presented here because of the sparsity and unreliability of available test data. While a procedure for estimating blasting emissions is presented in Section 11.9, Western Surface Coal Mining, that procedure should not be applied to stone quarries because of dissimilarities in blasting techniques, material blasted, and size of blast areas. Milling of fines is not included in this section as this operation is normally associated with nonconstruction aggregate end uses and will be covered elsewhere when information is adequate. Emission factors for fugitive dust sources, including paved and unpaved roads, materials handling and transfer, and wind erosion of storage piles, can be determined using the predictive emission factor equations presented in AP-42 Section 13.2.

References For Section 11.19.2

1. *Air Pollution Control Techniques for Nonmetallic Minerals Industry*, EPA-450/3-82-014, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 1982.

2. Written communication from J. Richards, Air Control Techniques, P.C., to B. Shrager, MRI. March 18, 1994.

3. P. K. Chalekode *et al.*, *Emissions from the Crushed Granite Industry: State of the Art*, EPA-600/2-78-021, U. S. Environmental Protection Agency, Washington, DC, February 1978.

4. T. R. Blackwood *et al.*, *Source Assessment: Crushed Stone*, EPA-600/2-78-004L, U. S. Environmental Protection Agency, Washington, DC, May 1978.

5. F. Record and W. T. Harnett, *Particulate Emission Factors for the Construction Aggregate Industry, Draft Report*, GCA-TR-CH-83-02, EPA Contract No. 68-02-3510, GCA Corporation, Chapel Hill, NC, February 1983.

6. *Review Emission Data Base and Develop Emission Factors for the Construction Aggregate Industry*, Engineering-Science, Inc., Arcadia, CA, September 1984.

7. C. Cowherd, Jr. *et al.*, *Development of Emission Factors for Fugitive Dust Sources*, EPA-450/3-74-037, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

Steam Plant at Technical Area 21 (TA-21-357)

Table 1.4-1. EMISSION FACTORS FOR NITROGEN OXIDES (NO_x) AND CARBON MONOXIDE (CO) FROM NATURAL GAS COMBUSTION[a]

Combustor Type (MMBtu/hr Heat Input) [SCC]	NO_x[b]		CO	
	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
Large Wall-Fired Boilers (>100) [1-01-006-01, 1-02-006-01, 1-03-006-01]				
Uncontrolled (Pre-NSPS)[c]	280	A	84	B
Uncontrolled (Post-NSPS)[c]	190	A	84	B
Controlled - Low NO_x burners	140	A	84	B
Controlled - Flue gas recirculation	100	D	84	B
Small Boilers (<100) [1-01-006-02, 1-02-006-02, 1-03-006-02, 1-03-006-03]				
Uncontrolled	100	B	84	B
Controlled - Low NO_x burners	50	D	84	B
Controlled - Low NO_x burners/Flue gas recirculation	32	C	84	B
Tangential-Fired Boilers (All Sizes) [1-01-006-04]				
Uncontrolled	170	A	24	C
Controlled - Flue gas recirculation	76	D	98	D
Residential Furnaces (<0.3) [No SCC]				
Uncontrolled	94	B	40	B

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by 16. Emission factors are based on an average natural gas higher heating value of 1,020 Btu/scf. To convert from $lb/10^6$ scf to lb/MMBtu, divide by 1,020. The emission factors in this table may be converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to this average heating value. SCC = Source Classification Code. ND = no data. NA = not applicable.

[b] Expressed as NO_2. For large and small wall fired boilers with SNCR control, apply a 24 percent reduction to the appropriate NO_x emission factor. For tangential-fired boilers with SNCR control, apply a 13 percent reduction to the appropriate NO_x emission factor.

[c] NSPS=New Source Performance Standard as defined in 40 CFR 60 Subparts D and Db. Post-NSPS units are boilers with greater than 250 MMBtu/hr of heat input that commenced construction modification, or reconstruction after August 17, 1971, and units with heat input capacities between 100 and 250 MMBtu/hr that commenced construction modification, or reconstruction after June 19, 1984.

TABLE 1.4-2. EMISSION FACTORS FOR CRITERIA POLLUTANTS AND GREENHOUSE GASES FROM NATURAL GAS COMBUSTION[a]

Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
CO_2[b]	120,000	A
Lead	0.0005	D
N_2O (Uncontrolled)	2.2	E
N_2O (Controlled-low-NO_X burner)	0.64	E
PM (Total)[c]	7.6	D
PM (Condensable)[c]	5.7	D
PM (Filterable)[c]	1.9	B
SO_2[d]	0.6	A
TOC	11	B
Methane	2.3	B
VOC	5.5	C

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from $lb/10^6$ scf to $kg/10^6\ m^3$, multiply by 16. To convert from $lb/10^6$ scf to 1b/MMBtu, divide by 1,020. The emission factors in this table may be converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to this average heating value. TOC = Total Organic Compounds. VOC = Volatile Organic Compounds.

[b] Based on approximately 100% conversion of fuel carbon to CO_2. $CO_2[lb/10^6\ scf] = (3.67)\ (CON)\ (C)(D)$, where CON = fractional conversion of fuel carbon to CO_2, C = carbon content of fuel by weight (0.76), and D = density of fuel, $4.2x10^4$ $lb/10^6$ scf.

[c] All PM (total, condensible, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the PM emission factors presented here may be used to estimate PM_{10}, $PM_{2.5}$ or PM_1 emissions. Total PM is the sum of the filterable PM and condensible PM. Condensible PM is the particulate matter collected using EPA Method 202 (or equivalent). Filterable PM is the particulate matter collected on, or prior to, the filter of an EPA Method 5 (or equivalent) sampling train.

[d] Based on 100% conversion of fuel sulfur to SO_2.
Assumes sulfur content is natural gas of 2,000 grains/10^6 scf. The SO_2 emission factor in this table can be converted to other natural gas sulfur contents by multiplying the SO_2 emission factor by the ratio of the site-specific sulfur content (grains/10^6 scf) to 2,000 grains/10^6 scf.

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor (lb/10^6 scf)	Emission Factor Rating
91-57-6	2-Methylnaphthalene[b, c]	2.4E-05	D
56-49-5	3-Methylchloranthrene[b, c]	<1.8E-06	E
	7,12-Dimethylbenz(a)anthracene[b,c]	<1.6E-05	E
83-32-9	Acenaphthene[b,c]	<1.8E-06	E
203-96-8	Acenaphthylene[b,c]	<1.8E-06	E
120-12-7	Anthracene[b,c]	<2.4E-06	E
56-55-3	Benz(a)anthracene[b,c]	<1.8E-06	E
71-43-2	Benzene[b]	2.1E-03	B
50-32-8	Benzo(a)pyrene[b,c]	<1.2E-06	E
205-99-2	Benzo(b)fluoranthene[b,c]	<1.8E-06	E
191-24-2	Benzo(g,h,i)perylene[b,c]	<1.2E-06	E
205-82-3	Benzo(k)fluoranthene[b,c]	<1.8E-06	E
106-97-8	Butane	2.1E+00	E
218-01-9	Chrysene[b,c]	<1.8E-06	E
53-70-3	Dibenzo(a,h)anthracene[b,c]	<1.2E-06	E
25321-22-6	Dichlorobenzene[b]	1.2E-03	E
74-84-0	Ethane	3.1E+00	E
206-44-0	Fluoranthene[b,c]	3.0E-06	E
86-73-7	Fluorene[b,c]	2.8E-06	E
50-00-0	Formaldehyde[b]	7.5E-02	B
110-54-3	Hexane[b]	1.8E+00	E
193-39-5	Indeno(1,2,3-cd)pyrene[b,c]	<1.8E-06	E
91-20-3	Naphthalene[b]	6.1E-04	E
109-66-0	Pentane	2.6E+00	E
85-01-8	Phenanathrene[b,c]	1.7E-05	D

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION (Continued)

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
74-98-6	Propane	1.6E+00	E
129-00-0	Pyrene[b, c]	5.0E-06	E
108-88-3	Toluene[b]	3.4E-03	C

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by 16. To convert from $1b/10^6$ scf to lb/MMBtu, divide by 1,020. Emission Factors preceeded with a less-than symbol are based on method detection limits.

[b] Hazardous Air Pollutant (HAP) as defined by Section 112(b) of the Clean Air Act.

[c] HAP because it is Polycyclic Organic Matter (POM). POM is a HAP as defined by Section 112(b) of the Clean Air Act.

[d] The sum of individual organic compounds may exceed the VOC and TOC emission factors due to differences in test methods and the availability of test data for each pollutant.

Table 1.3-1. CRITERIA POLLUTANT EMISSION FACTORS FOR FUEL OIL COMBUSTION[a]

Firing Configuration (SCC)[a]	SO_2[b]		SO_3[c]		NO_x[d]		CO[e]		Filterable PM[f]	
	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING
Boilers > 100 Million Btu/hr										
No. 6 oil fired, normal firing (1-01-004-01), (1-02-004-01), (1-03-004-01)	157S	A	5.7S	C	47	A	5	A	9.19(S)+3.22	A
No. 6 oil fired, normal firing, low NO_x burner (1-01-004-01), (1-02-004-01)	157S	A	5.7S	C	40	B	5	A	9.19(S)+3.22	A
No. 6 oil fired, tangential firing, (1-01-004-04)	157S	A	5.7S	C	32	A	5	A	9.19(S)+3.22	A
No. 6 oil fired, tangential firing, low NO_x burner (1-01-004-04)	157S	A	5.7S	C	26	E	5	A	9.19(S)+3.22	A
No. 5 oil fired, normal firing (1-01-004-05), (1-02-004-04)	157S	A	5.7S	C	47	B	5	A	10	B
No. 5 oil fired, tangential firing (1-01-004-06)	157S	A	5.7S	C	32	B	5	A	10	B
No. 4 oil fired, normal firing (1-01-005-04), (1-02-005-04)	150S	A	5.7S	C	47	B	5	A	7	B
No. 4 oil fired, tangential firing (1-01-005-05)	150S	A	5.7S	C	32	B	5	A	7	B
No. 2 oil fired (1-01-005-01), (1-02-005-01), (1-03-005-01)	157S	A	5.7S	C	24	D	5	A	2	A
No.2 oil fired, LNB/FGR, (1-01-005-01), (1-02-005-01), (1-03-005-01)	157S	A	5.7S	A	10	D	5	A	2	A

Table 1.3-1. (cont.)

Firing Configuration (SCC)[a]	SO_2[b]		SO_3[c]		NO_x[d]		CO[e]		Filterable PM[f]	
	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING	Emission Factor ($lb/10^3$ gal)	EMISSION FACTOR RATING
Boilers < 100 Million Btu/hr										
No. 6 oil fired (1-02-004-02/03) (1-03-004-02/03)	157S	A	2S	A	55	A	5	A	10	B
No. 5 oil fired (1-03-004-04)	157S	A	2S	A	55	A	5	A	9.19(S)+3.22	A
No. 4 oil fired (1-03-005-04)	150S	A	2S	A	20	A	5	A	7	B
Distillate oil fired (1-02-005-02/03) (1-03-005-02/03)	142S	A	2S	A	20	A	5	A	2	A
Residential furnace (A2104004/A2104011)	142S	A	2S	A	18	A	5	A	0.4[g]	B

[a] To convert from $lb/10^3$ gal to $kg/10^3$ L, multiply by 0.120. SCC = Source Classification Code.

[b] References 1-2,6-9,14,56-60. S indicates that the weight % of sulfur in the oil should be multiplied by the value given. For example, if the fuel is 1% sulfur, then S = 1.

[c] References 1-2,6-8,16,57-60. S indicates that the weight % of sulfur in the oil should be multiplied by the value given. For example, if the fuel is 1% sulfur, then S = 1.

[d] References 6-7,15,19,22,56-62. Expressed as NO_2. Test results indicate that at least 95% by weight of NO_x is NO for all boiler types except residential furnaces, where about 75% is NO. For utility vertical fired boilers use 105 $lb/10^3$ gal at full load and normal (>15%) excess air. Nitrogen oxides emissions from residual oil combustion in industrial and commercial boilers are related to fuel nitrogen content, estimated by the following empirical relationship: lb $NO_2/10^3$ gal = 20.54 + 104.39(N), where N is the weight % of nitrogen in the oil. For example, if the fuel is 1% nitrogen, then N = 1.

[e] References 6-8,14,17-19,56-61. CO emissions may increase by factors of 10 to 100 if the unit is improperly operated or not well maintained.

[f] References 6-8,10,13-15,56-60,62-63. Filterable PM is that particulate collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. Particulate emission factors for residual oil combustion are, on average, a function of fuel oil sulfur content where S is the weight % of sulfur in oil. For example, if fuel oil is 1% sulfur, then S = 1.

[g] Based on data from new burner designs. Pre-1970's burner designs may emit filterable PM as high as 3.0 $lb/10^3$ gal.

sulfur content .34%

Table 1.3-2. CONDENSABLE PARTICULATE MATTER EMISSION FACTORS FOR OIL COMBUSTION[a]

Firing Configuration[b] (SCC)	Controls	CPM - TOT[c, d]		CPM - IOR[c, d]		CPM - ORG[c, d]	
		Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING	Emission Factor (lb/10^3 gal)	EMISSION FACTOR RATING
No. 2 oil fired (1-01-005-01, 1-02-005-01, 1-03-005-01)	All controls, or uncontrolled	1.3[d, e]	D	65% of CPM-TOT emission factor[c]	D	35% of CPM-TOT emission factor[c]	D
No. 6 oil fired (1-01-004-01/04, 1-02-004-01, 1-03-004-01)	All controls, or uncontrolled	1.5[f]	D	85% of CPM-TOT emission factor[d]	E	15% of CPM-TOT emission factor[d]	E

[a] All condensable PM is assumed to be less than 1.0 micron in diameter.

[b] No data are available for numbers 3, 4, and 5 oil. For number 3 oil, use the factors provided for number 2 oil. For numbers 4 and 5 oil, use the factors provided for number 6 oil.

[c] CPM-TOT = total condensable particulate matter.
CPM-IOR = inorganic condensable particulate matter.
CPM-ORG = organic condensable particulate matter.

[d] To convert to lb/MMBtu of No. 2 oil, divide by 140 MMBtu/10^3 gal. To convert to lb/MMBtu of No. 6 oil, divide by 150 MMBtu/10^3 gal.

[e] References: 76-78.

[f] References: 79-82.

Table 1.3-3. EMISSION FACTORS FOR TOTAL ORGANIC COMPOUNDS (TOC), METHANE, AND NONMETHANE TOC (NMTOC) FROM UNCONTROLLED FUEL OIL COMBUSTION[a]

EMISSION FACTOR RATING: A

Firing Configuration (SCC)	TOC[b] Emission Factor (lb/10^3 gal)	Methane[b] Emission Factor (lb/10^3 gal)	NMTOC[b] Emission Factor (lb/10^3 gal)
Utility boilers			
No. 6 oil fired, normal firing (1-01-004-01)	1.04	0.28	0.76
No. 6 oil fired, tangential firing (1-01-004-04)	1.04	0.28	0.76
No. 5 oil fired, normal firing (1-01-004-05)	1.04	0.28	0.76
No. 5 oil fired, tangential firing (1-01-004-06)	1.04	0.28	0.76
No. 4 oil fired, normal firing (1-01-005-04)	1.04	0.28	0.76
No. 4 oil fired, tangential firing (1-01-005-05)	1.04	0.28	0.76
Industrial boilers			
No. 6 oil fired (1-02-004-01/02/03)	1.28	1.00	0.28
No. 5 oil fired (1-02-004-04)	1.28	1.00	0.28
Distillate oil fired (1-02-005-01/02/03)	0.252	0.052	0.2
No. 4 oil fired (1-02-005-04)	0.252	0.052	0.2
Commercial/institutional/residential combustors			
No. 6 oil fired (1-03-004-01/02/03)	1.605	0.475	1.13
No. 5 oil fired (1-03-004-04)	1.605	0.475	1.13
Distillate oil fired (1-03-005-01/02/03)	0.556	0.216	0.34
No. 4 oil fired (1-03-005-04)	0.556	0.216	0.34
Residential furnace (A2104004/A2104011)	2.493	1.78	0.713

[a] To convert from lb/10^3 gal to kg/10^3 L, multiply by 0.12. SCC = Source Classification Code.
[b] References 29-32. Volatile organic compound emissions can increase by several orders of magnitude if the boiler is improperly operated or is not well maintained.

Table 1.3-8. EMISSION FACTORS FOR NITROUS OXIDE (N_2O), POLYCYCLIC ORGANIC MATTER (POM), AND FORMALDEHYDE (HCOH) FROM FUEL OIL COMBUSTION[a]

EMISSION FACTOR RATING: E

Firing Configuration (SCC)	Emission Factor (lb/10^3 gal)		
	N_2O[b]	POM[c]	HCOH[c]
Utility/industrial/commercial boilers			
No. 6 oil fired (1-01-004-01, 1-02-004-01, 1-03-004-01)	0.11	0.0011 - 0.0013[d]	0.024 - 0.061
Distillate oil fired (1-01-005-01, 1-02-005-01, 1-03-005-01)	0.11	0.0033[e]	0.035 - 0.061
Residential furnaces (A2104004/A2104011)	0.05	ND	ND

[a] To convert from lb/10^3 gal to kg/10^3 L, multiply by 0.12. SCC = Source Classification Code. ND = no data.
[b] References 45-46. EMISSION FACTOR RATING = B.
[c] References 29-32.
[d] Particulate and gaseous POM.
[e] Particulate POM only.

Table 1.3-10. EMISSION FACTORS FOR TRACE ELEMENTS FROM DISTILLATE FUEL OIL COMBUSTION SOURCES[a]

EMISSION FACTOR RATING: E

Firing Configuration (SCC)	Emission Factor ($lb/10^{12}$ Btu)										
	As	Be	Cd	Cr	Cu	Pb	Hg	Mn	Ni	Se	Zn
Distillate oil fired (1-01-005-01, 1-02-005-01, 1-03-005-01)	4	3	3	3	6	9	3	6	3	15	4

[a] Data are for distillate oil fired boilers, SCC codes 1-01-005-01, 1-02-005-01, and 1-03-005-01. References 29-32, 40-44 and 83. To convert from $lb/10^{12}$ Btu to pg/J, multiply by 0.43.

Storage Tanks

TANKS 4.0
Emissions Report - Detail Format
Tank Identification and Physical Characteristics

Identification

User Identification:	TA-03-779
City:	Los Alamos
State:	New Mexico
Company:	LANL
Type of Tank:	Vertical Fixed Roof Tank
Description:	TA-03-779 No. 2 Fuel Oil Tank

Tank Dimensions

Shell Height (ft):	31.80
Diameter (ft):	35.00
Liquid Height (ft):	28.50
Avg. Liquid Height (ft):	28.50
Volume (gallons):	205,118.12
Turnovers:	2.44
Net Throughput (gal/yr):	500,000.00
Is Tank Heated (y/n):	N

Paint Characteristics

Shell Color/Shade:	Gray/Light
Shell Condition:	Good
Roof Color/Shade:	Gray/Light
Roof Condition:	Good

Roof Characteristics

Type:	Dome
Height (ft):	0.00
Radius (ft) (Dome Roof):	35.00

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig):	0.00

Meteorological Data used in Emissions Calculations: Roswell, New Mexico (Avg Atmospheric Pressure = 12.73 psia)

TANKS 4.0
Emissions Report - Detail Format
Liquid Contents of Storage Tank

Mixture/Component	Month	Daily Liquid Surf. Temperatures (deg F) Avg.	Min.	Max.	Liquid Bulk Temp. (deg F)	Vapor Pressures (psia) Avg.	Min.	Max.	Vapor Mol. Weight	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Distillate fuel oil no. 2	All	69.79	57.58	82.00	63.06	0.0089	0.0060	0.0130	130.0000			188.00	Option 5: A=12.101, B=8907

TANKS 4.0
Emissions Report - Detail Format
Detail Calculations (AP-42)

Annual Emission Calculations	
Standing Losses (lb):	37.7332
Vapor Space Volume (cu ft):	5,484.6834
Vapor Density (lb/cu ft):	0.0002
Vapor Space Expansion Factor:	0.0928
Vented Vapor Saturation Factor:	0.9973
Tank Vapor Space Volume	
Vapor Space Volume (cu ft):	5,484.6834
Tank Diameter (ft):	35.0000
Vapor Space Outage (ft):	5.7007
Tank Shell Height (ft):	31.8000
Average Liquid Height (ft):	28.5000
Roof Outage (ft):	2.4007
Roof Outage (Dome Roof)	
Roof Outage (ft):	2.4007
Dome Radius (ft):	35.0000
Shell Radius (ft):	17.5000
Vapor Density	
Vapor Density (lb/cu ft):	0.0002
Vapor Molecular Weight (lb/lb-mole):	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0089
Daily Avg. Liquid Surface Temp. (deg. R):	529.4625
Daily Average Ambient Temp. (deg. F):	60.8167
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	522.7267
Tank Paint Solar Absorptance (Shell):	0.5400
Tank Paint Solar Absorptance (Roof):	0.5400
Daily Total Solar Insulation Factor (Btu/sqft day):	1,810.0000
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0928
Daily Vapor Temperature Range (deg. R):	48.8472
Daily Vapor Pressure Range (psia):	0.0070
Breather Vent Press. Setting Range(psia):	0.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0089
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0060
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0130
Daily Avg. Liquid Surface Temp. (deg R):	529.4625
Daily Min. Liquid Surface Temp. (deg R):	517.2507
Daily Max. Liquid Surface Temp. (deg R):	541.6743
Daily Ambient Temp. Range (deg. R):	29.8333
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	0.9973
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0089
Vapor Space Outage (ft):	5.7007
Working Losses (lb):	13.7736

TANKS 4.0
Emissions Report - Detail Format
Detail Calculations (AP-42)- (Continued)

Vapor Molecular Weight (lb/lb-mole):	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0089
Annual Net Throughput (gal/yr.):	500,000.0000
Annual Turnovers:	2.4376
Turnover Factor:	1.0000
Maximum Liquid Volume (gal):	205,118.1195
Maximum Liquid Height (ft):	28.5000
Tank Diameter (ft):	35.0000
Working Loss Product Factor:	1.0000
Total Losses (lb):	51.5068

TANKS 4.0
Emissions Report - Detail Format
Individual Tank Emission Totals

Annual Emissions Report

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Distillate fuel oil no. 2	13.77	37.73	51.51

$51.51\ lb \cdot \frac{1\ ton}{2000\ lb} = 0.0258\ tons/yr$