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REPORT OF NOx EMISSION TESTING ON THE #8 BOILER EXHAUST STACK AT THE PFIZER FACILITY LOCATED IN KALAMAZOO, MI

Prepared for:

PFIZER, INC.
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Prepared by:

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FEBRUARY 6, 2019
STACK TEST GROUP, INC. PROJECT NO. 18-3114A

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1.0 EXECUTIVE SUMMARY

On February 6, 2019, The Stack Test Group, Inc. performed nitrogen oxides (NOx) emission testing on the #8 boiler at the Pfizer facility located in Kalamazoo, Michigan. Testing was conducted on the exhaust stack of the #8 boiler serving this facility. Three one-hour tests were conducted on this stack. Testing was conducted while firing with natural gas. Presented below are the average results of these tests.

NOx Concentration:	93.1 Parts per Million
NOx Emission Rate:	0.126 Pounds per MMBTU
NOx Emission Limit:	0.20 lb/MMBTU

2.0 INTRODUCTION

The Stack Test Group, Inc. conducted NOx emission testing on the exhaust stack of the #8 boiler (EUEBLR43-8-S1). Testing was performed at the Pharmacia & Upjohn Company, LLC, a subsidiary of Pfizer, Inc., located in Kalamazoo, MI on February 6, 2019. The Portage Steam Generating System is located at 7000 Portage Road, Kalamazoo, MI 49001. The facility generates 175 pounds per square inch gauge pressure steam at 377 degrees Fahrenheit utilizing six boilers. Three of the boilers are stoker coal boilers. Three use natural gas as the primary fuel.

Three NOx tests lasting one-hour in duration were conducted on the #8 boiler. The purpose of this testing was to determine the concentrations and emission rates of the NOx exhausting from the #8 boiler per the requirements of the renewable operating permit (ROP) for this source. The ROP number is MI-ROP-B361002008c. The ROP specifies the NOx testing be completed once during the five year term of this permit.

The exhaust stack for the #8 boiler shares a common stack with the #7 boiler. During this test series, the #7 boiler remained off.

Testing was conducted while Pfizer personnel operated the boiler at the maximum routine operating conditions. Testing was conducted while firing the boiler with natural gas. All pollutant emissions were calculated using the EPA Oxygen F-Factor found in U.S. EPA Reference Method 19. The F-Factor for the #8 boiler was determined to be 8,710 based on the published number in 40 CFR 60 Appendix A Method 19, for natural gas.

Testing was supervised by Mr. Gary A. Kohnke of the Stack Test Group, Inc. and coordinated by Mr. Jeff Robey, Pfizer Environmental of Pharmacia & Upjohn Company, LLC.

All testing followed the guidelines of U.S. EPA Reference Methods 3A and 7E. This report contains a summary of results for the above mentioned tests and all the supporting field, process, and computer generated data.

3.0 SAMPLING AND ANALYTICAL PROCEDURES

3.1 Oxygen (O_2) & Nitrogen Oxides (NOx)

3.1.1 Sample Collection

Oxygen concentrations and nitrogen oxides (NOx) emissions were determined using U.S. EPA Methods 3A & 7E. A gas sample was drawn from the exhaust duct through a filter and transported to a Universal gas conditioner through a heated Teflon line set to 250°F. The gas conditioner removed moisture from the gas stream and pumped a dry gas sample through a Teflon line and manifold flow system to a Servomex Model 1440C paramagnetic oxygen analyzer and a Thermal Electron Corporation (TECO) Model 42C Chemiluminescent NO-NO_2 gas analyzer.

3.1.2 Sample Duration and Frequency

The samples were collected in triplicate with each test lasting sixty minutes in duration. A sample was drawn at least twice as long as the response time before the beginning of each test. The response time was approximately 40 seconds.

3.1.3 Calibration

At the beginning of the test series, the analyzers were calibrated and then checked for calibration error by introducing zero, mid-range and high-range calibration gases to the back of each analyzer. Following each test run, a system bias was performed by introducing a zero and mid-range calibration gases to the outlet of the probe. Calibration gases used were U.S. EPA Protocol 1 certified.

3.1.4 Data Reduction

The analyzer outputs were recorded on a data logger and laptop computer. These one-minute data logger readings were then average using an Excel spreadsheet. The raw data logger readings are included in Appendix E.

4.0 TEST RESULTS

Presented in this section are the results of this test series. Test results are reported in Table 4.1. Table 4.1 presents the NOx results from the #8 boiler exhaust stack. The NOx results in parts per million (ppm) and lb/MMBTU and the oxygen results in terms of percent.

Copies of the calculations used to determine these emission rates may be found in Appendix A. Copies of the calibration data are presented in Appendix B. Copies of the NOx and O_2 data are presented in Appendix C. Copies of the calibration gas certification sheets are presented in Appendix D.

Table 4.1

NOx Test Results
Pfizer
02/06/19
#8 Boiler Exhaust Stack
Firing Natural Gas

Test No:	T1	T2	T3	Avg.
Start Time:	08:05 AM	09:15 AM	10:22 AM	
Finish Time:	09:05 AM	10:15 AM	11:22 AM	
% Oxygen:	4.8	4.8	4.8	4.8
NOx Results:				
NOx, ppmv:	94.0	93.7	91.6	93.1
NOx, lb/DSCF:	1.12E-05	1.12E-05	1.09E-05	1.11E-05
LBS/MMBTU (F-Factor = 8,710):	0.127	0.126	0.124	0.126

APPENDIX A

SAMPLE CALCULATIONS

PFIZER INC.
KALAMAZOO, MI

STG PROJECT No: 18-3114A

SAMPLE CALCULATIONS

The tables presenting the results are generated electronically from raw data. It may not be possible to exactly duplicate these results using a calculator. The reference method data, results and all calculations are carried to sixteen decimal places throughout. The final table is formatted to an appropriate number of significant figures.

1. Volume of water collected (wscf)

$$V_{wstd} = (0.04707)(V_{lc})$$

Where:

V_{lc}	total volume of liquid collected in impingers and silica gel (ml)
V_{wstd}	volume of water collected at standard conditions (ft^3)
0.04707	conversion factor (ft^3/ml)

2. Volume of gas metered, standard conditions (dscf)

$$V_{mstd} = \frac{(17.64)(V_m)\left(P_{bar} + \frac{\Delta H}{13.6}\right)(Y_d)}{(460 + T_m)}$$

Where:

P_{bar}	barometric pressure (in. Hg)
T_m	average dry gas meter temperature (°F)
V_m	volume of gas sample through the dry gas meter at meter conditions (ft^3)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
Y_d	gas meter correction factor (dimensionless)
ΔH	average pressure drop across meter box orifice (in. H_2O)
17.64	conversion factor (°R/in. Hg)
13.6	conversion factor (in. H_2O/in. Hg)
460	°F to °R conversion constant

SAMPLE CALCULATIONS (CONTINUED)

3. Volume of gas metered, standard conditions (dscm)

$$V_{mstd(m)} = \frac{\left(V_{mstd(ft)}\right)}{35.35}$$

Where:

$V_{mstd(ft)}$	volume of gas sample through the dry gas meter at standard conditions (ft^3)
$V_{mstd(m)}$	volume of gas sample through the dry gas meter at standard conditions (m^3)
35.35	conversion factor (ft^3 to m^3)
13.6	conversion factor (in. H_2O/in. Hg)

4. Sample gas pressure (in. Hg)

$$P_s = P_{bar} + \left(\frac{P_g}{13.6}\right)$$

Where:

P_{bar}	barometric pressure (in. Hg)
P_g	sample gas static pressure (in. H_2O)
P_s	absolute sample gas pressure (in. Hg)
13.6	conversion factor (in. H_2O/in. Hg)

5. Actual vapor pressure (in. Hg)[1]

$$P_v = P_s$$

Where:

P_v	vapor pressure, actual (in. Hg)
P_s	absolute sample gas pressure (in. Hg)

6. Moisture content (%)

$$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume (%)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
V_{wstd}	volume of water collected at standard conditions (ft^3)

[1] For effluent gas temperatures over 212°F, P_v is assumed to be equal to P_s.

SAMPLE CALCULATIONS (CONTINUED)

7. Saturated moisture content (%)

$$B_{ws} = \frac{(P_v)}{(P_s)}$$

Where:

B_{ws}	proportion of water vapor in the gas stream by volume at saturated conditions (%)
P_s	absolute sample gas pressure (in. Hg)
P_v	vapor pressure, actual (in. Hg)

Whichever moisture value is smaller is used for B_{wo} in the following calculations.

8. Molecular weight of dry gas stream (lb/lb·mole)

$$M_d = M_{CO_2}\frac{(CO_2)}{(100)} + M_{O_2}\frac{(O_2)}{(100)} + M_{CO+N_2}\frac{(CO+N_2)}{(100)}$$

Where:

Md	dry molecular weight of sample gas (lb/lb·mole)
M_{CO_2}	molecular weight of carbon dioxide (lb/lb·mole)
M_{O_2}	molecular weight of oxygen (lb/lb·mole)
M_{CO+N_2}	molecular weight of carbon monoxide and nitrogen (lb/lb·mole)
CO_2	proportion of carbon dioxide in the gas stream by volume (%)
O_2	proportion of oxygen in the gas stream by volume (%)
$CO+N_2$	proportion of carbon monoxide and nitrogen in the gas stream by volume (%)
100	conversion factor (%)

9. Molecular weight of sample gas (lb/lb·mole)

$$M_s = (M_d)(1 - B_{wo}) + (M_{H_2O})(B_{wo})$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume
M_d	dry molecular weight of sample gas (lb/lb·mole)
M_{H_2O}	molecular weight of water (lb/lb·mole)
M_s	molecular weight of sample gas, wet basis (lb/lb·mole)

SAMPLE CALCULATIONS (CONTINUED)

10. Velocity of sample gas (ft/sec)

$$V_s = (K_p)(C_P)(\overline{\sqrt{\Delta P}})\left(\sqrt{\frac{(\overline{T_s} + 460)}{(M_s)(P_s)}}\right)$$

Where:

K_p	velocity pressure coefficient (dimensionless)
C_p	pitot tube constant
M_s	molecular weight of sample gas, wet basis (lb/lb·mole)
P_s	absolute sample gas pressure (in. Hg)
T_s	average sample gas temperature (°F)
V_s	sample gas velocity (ft/sec)
$\sqrt{\Delta P}$	average square roots of velocity heads of sample gas (in. H_2O)
460	°F to °R conversion constant

11. Total flow of sample gas (acfm)

$$Q_a = (60)(A_s)(V_s)$$

Where:

A_s	cross sectional area of sampling location (ft^2)
Q_a	volumetric flow rate at actual conditions (acfm)
V_s	sample gas velocity (ft/sec)
60	conversion factor (sec/min)

12. Total flow of sample gas (dscfm)

$$Q_{std} = \frac{(Q_a)(P_s)(17.64)(1 - B_{wo})}{(\overline{T_s} + 460)}$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume
P_s	absolute sample gas pressure (in. Hg)
Q_a	volumetric flow rate at actual conditions (acfm)
Q_{std}	volumetric flow rate at standard conditions, dry basis (dscfm)
T_s	average sample gas temperature (°F)
17.64	conversion factor (°R/in. Hg)
460	°F to °R conversion constant

SAMPLE CALCULATIONS (CONTINUED)

13. NOx concentration (lb/dscf)

$$E_{lb/dscf} = \frac{(ppm)(MW)}{(385.3 \times 10^6)}$$

Where:

$E_{lb/dscf}$	emission rate
C_{ppm}	measured concentration in the gas stream (ppmdv)
MW	molecular weight of NOx (46)
385.3	conversion factor

14. NOx emission (lb/hr)

$$E_{lb/hr} = (lb/dscf)(60)(dscfm)$$

Where:

$E_{lb/hr}$	emission rate
$E_{lb/dscf}$	concentration
E_{dscf}	concentration
$60_{min/hr}$	conversion factor

15. NOx emission (lb/MMBTU)

$$E_{lb/MMBTU} = (lb/dscf)(F - Factor)(20.9/(20.9 - O2))$$

Where:

$E_{lb/MMBTU}$	emission rate
$E_{lb/dscf}$	concentration

APPENDIX B

CALIBRATION DATA

Pfizer Inc. Project #18-3114A
Kalamazoo, MI
2/6/2019
Boiler #8

Analyte	Oxygen		Dry
Initial Calibration	Value	Response	Calibration Error
High	24.01	24	0.04%
Mid	12.18	12.2	0.08%
Low (Zero)	0	0.1	0.42%

*Corrected Run Average and Upscale System Bias cell formulas must be adjusted if the high calibration gas is used for post calibration upscale checks.

Type	Run Average	Pre Zero	Post Zero	Pre Upscale	Post Upscale	*Corrected Run Average	Zero System Bias	*Upscale System Bias	Zero Drift	Upscale Drift
Initial System Bias Check			0.1		12.2		0.00%	0.00%		
Run 1	4.9	0.1	0.2	12.2	12.3	4.8	0.42%	0.42%	0.42%	0.42%
Run 2	4.9	0.2	0.1	12.3	12.1	4.8	0.00%	0.42%	0.42%	0.83%
Run 3	4.8	0.1	0.1	12.1	12.1	4.8	0.00%	0.42%	0.00%	0.00%

Pfizer Inc. Project #18-3114A
Kalamazoo, MI
2/6/2019
Boiler #8

Analyte	Nitrous Oxides		Dry
Initial Calibration	Value	Response	Calibration Error
High	97.5	97.8	0.31%
Mid	50.25	50.3	0.05%
Low (Zero)	0	0.3	0.31%

*Corrected Run Average and Upscale System Bias cell formulas must be adjusted if the high calibration gas is used for post calibration upscale checks.

Type	Run Average	Pre Zero	Post Zero	Pre Upscale	Post Upscale	*Corrected Run Average	Zero System Bias	*Upscale System Bias	Zero Drift	Upscale Drift	lb/dscf
Initial System Bias Check			0.4		50.6		0.10%	0.31%			
Run 1	94.0	0.4	0.2	50.6	50.2	94.0	0.10%	0.10%	0.21%	0.41%	1.12E-05
Run 2	94.1	0.2	0.2	50.2	50.9	93.7	0.10%	0.62%	0.00%	0.72%	1.12E-05
Run 3	91.9	0.2	0.3	50.9	50.2	91.6	0.00%	0.10%	0.10%	0.72%	1.09E-05