Example Calculations

Run Number: Boiler 1 **Date:** 3/24/2003 **Time:** 1605-1705

Emission Calculation Symbols

Required Input Data

O_2	=	4.2	oxygen concentration (dry/volume), (%)
NO_x	=	43.2	oxides of nitrogen concentration (dry/volume), (ppm)
CO	=	55.0	carbon monoxide concentration (dry/volume), (ppm)
SO_2	=	1.5	sulfur dioxide concentration (dry/volume), (ppm)
TAMB	=	70	ambient temperature (dry bulb basis), (^oF)
TWET	=	70	ambient temperature (wet bulb basis), (^oF)
PB	=	30.18	ambient barometric pressure, (" Hg)
SVP	=	0.73916	saturation vapor pressure at TAMB, (" Hg)
DSCFM	=	5780	volumetric flowrate, (dscfm)
$\%H_2O$	=	6.0	moisture in stack gas, (%)
POBS	=	30.18	observed combustor inlet absolute pressure at test, inches of mercury

Fuel Analysis Input

%C	=	85.2	percent by weight of carbon in fuel, (%)
%H	=	12.8	percent by weight of hydrogen fuel, (%)
%N	=	0.01	percent by weight of nitrogen in fuel, (%)
%S	=	0.12	percent by weight of sulfur in fuel, (%)
%O	=	1.84	percent by weight of oxygen in fuel, (%)
GCV	=	19595	gross calorific value of fuel, (Btu/lb)
F_d (M19)*	=	9190	EPA Method 19 published F_d-Factor from Table 19-2, (dscf/10^6 Btu) *(optional use Method 19 value only when fuel analysis data is not available)

Calculated Data

F_d-Factor (Fuel)	=	8991	Fd-Factor calculated from fuel analysis
HAMB	=	0.0156	specific humidity, (pound of H_2O/pound of dry air)
ISO K-Factor	=	1.15	ISO standard ambient conditions K-Factor, dimensionless
NO_x (ppm@15%O_2)	=	15.3	NO_x, parts per million corrected to 15% oxygen
NO_x(ppmISO@15%O_2)	=	17.5	NO_x, parts per million corrected to ISO conditions and 15% oxygen
NO_x (lb/hr)	=	1.79	NO_x, pounds per hour
NO_x (lb/MMBtu)	=	0.0580	NO_x, pounds per million British thermal units
CO (ppm@15%O_2)	=	19.4	CO, parts per million corrected to 15% oxygen
CO (lb/hr)	=	1.39	CO, pounds per hour
CO (lb/MMBtu)	=	0.045	CO, pounds per million British thermal units
SO_2 (ppm@15%O_2)	=	0.5	SO_2, parts per million corrected to 15% oxygen
SO_2 (lb/hr)	=	0.09	SO_2, pounds per hour
SO_2 (lb/MMBtu)	=	0.003	SO_2, pounds per million British thermal units

1. NO_x Concentration Corrected to 15% Oxygen (NO_x at 15% O_2), parts per million

NO_x at 15% O_2 = $(NO_x) \times [(20.9 - 15.0) / (20.9 - O_2)]$

NO_x at 15% O_2 = 15.3 parts per million (ppm)

2. ISO Standard Day Conditions K-Factor, dimensionless

ISO K-Factor = $(((Pref/Pobs)^{0.5}) \times (e^{(19(Hamb - 0.00633))}) \times ((288\ ^{o}K/TAMB)^{1.53}))$

= 1.00 x 1.1930 x 0.9676

ISO K-Factor = 1.15

where,

PREF	=	29.92	reference combustor inlet absolute pressure at 101.3 kilopascals ambient pressure, inches of Hg
POBS	=	30.21	observed combustor inlet absolute pressure at test, inches of mercury
e	=	2.718	transcendental constant, 2.718
HAMB	=	0.0156	humidity ratio in lb H_2O/lb air (determined from ASHRAE Psychrometric Chart)
TAMB	=	294.3	ambient temperature, degrees Kelvin (degrees Celsius + 273.15)

3. NO_x Concentration Corrected to ISO Standard Day Conditions and 15% Oxygen, parts per million

NO_x ISO and 15%O_2 = (NO_x ppm at 15% O_2) x (ISO K-Factor)

NO_x ISO and 15%O_2 = 17.5 ppm

4. Conversion Factor (for the calculation of pounds per dry standard cubic feet)

$$\text{Conv. Factor} = \frac{(2.205\text{E-}03 \text{ pounds/gram}) \times 1.00\text{E-}06}{(22.414 \text{ liters/gram-mole}) \times (0.03531 \text{ ft}^3\text{/liter}) \times (528.27^{o}\text{R}/492.27^{o}\text{R})}$$

Conv. Factor = 2.596E-09 pound per dry standard cubic foot

where,

ft^3/liter	=	cubic feet per liter
^{o}R	=	degrees Rankine
MW	=	molecular weight in grams per gram-mole (g/g-mole)

5a. NO_x Concentration In Pounds Per Dry Standard Cubic Feet, lb/dscf

NO_x Conc. = (ppm) x (molecular weight of NO_2 gas) x (Conv. Factor)

(molecular weight of NO_2 gas = 46 g/g-mole)

NO_x Conc. = 5.16E-06 lb/dscf

5b. CO Concentration In Pounds Per Dry Standard Cubic Feet, lb/dscf

CO Conc. = (ppm) x (molecular weight of CO gas) x (Conv. Factor)
(molecular weight of CO gas = 28 g/g-mole)

CO Conc. = 3.998E-06 lb/dscf

5c. SO_2 Concentration In Pounds Per Dry Standard Cubic Feet, lb/dscf

SO_2 Conc. = (ppm) x (molecular weight of SO_2 gas) x (Conv. Factor)
(molecular weight of CO gas = 64.06 g/g-mole)

SO_2 Conc. = 2.495E-07 lb/dscf

6a. NO_x Emission Rate, pounds per hour

NO_x ER = (lb/dscf) x (DSCFM) x (60 minutes/hour)

NO_x ER = 1.79 lb/hr

6b. CO Emission Rate, pounds per hour

CO ER = (lb/dscf) x (DSCFM) x (60 minutes/hour)

CO ER = 1.39 lb/hr

6c. SO_2 Emission Rate, pounds per hour

SO_2 ER = (lb/dscf) x (DSCFM) x (60 minutes/hour)

SO_2 ER = 0.09 lb/hr

7. F_d-Factor Based On Actual Fuel Analysis, dscf/MMBtu

$$F_d\text{-Factor (Fuel)} = \frac{1.00E06 \times (3.64\%H) + (1.53\%C) + (0.57\%S) + (0.14\%N) - (0.46\%O)}{GCV}$$

F_d-Factor (Fuel) = 8991 dscf/MMBtu

8a. NO_x Emission Rate Using Actual Fuel Analysis F_d-Factor, pounds per million Btu

NO_x ER F_d = (lb/dscf) x (dscf/MMBtu) x [20.9 / (20.9 - O_2)]

NO_x ER F_d = 0.058 lb/MMBtu

8b. NO_x Emission Rate Using EPA Method 19 F_d-Factor, pounds per million Btu

NO_x ER M19 F_d = (lb/dscf) x (dscf/MMBtu) x [20.9 / (20.9 - O_2)]

NO_x ER M19 F_d = 0.059 lb/MMBtu