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1/19/78

1/6

Stack Emissions
(for 4th Incinerator)N₂11.811 moles N₂ in vent

$$11.811 \text{ moles N}_2 \left(\frac{28 \text{ lb-N}_2}{\text{lbmole}} \right) = 330.7 \text{ lbs N}_2$$

N₂ in combustion air194.649 moles of O₂ in combustion airand O₂:N₂ in air is 0.21:0.79

$$(194.649 \text{ moles O}_2) \left(\frac{0.79}{0.21} \right) = 732.3 \text{ moles N}_2$$

$$(732.3 \text{ moles N}_2) \left(\frac{28 \text{ lb-N}_2}{\text{lbmole}} \right) = 20504.4 \text{ lb N}_2$$

There are 359 ft³ of N₂ per lbmole of N₂
at 32°F and 1 atm.

$$(11.811 + 732.3) \text{ moles N}_2 \left(\frac{359 \text{ ft}^3}{\text{lbmole}} \right) = 267,136 \text{ SCF}$$

N₂ from stack

$$330.7 + 20504.4 = 20835 \text{ lb N}_2$$

$$11.8 + 732.3 = 744.1 \text{ moles N}_2$$

$$267,136 \text{ SCF}$$

O₂There is 194.649 moles of O₂ in
combustion air with only 173.794 moles
required leaving 20.855 moles excess O₂.

2/6

O₂ from stack

$$20.9 \text{ moles O}_2 \left(\frac{32 \text{ lb O}_2}{\text{lbmole}} \right) = 668.8 \text{ lb O}_2$$

$$20.9 \text{ moles O}_2 \left(\frac{359 \text{ ft}^3}{\text{mole}} \right) = 7503 \text{ SCF O}_2$$

CO₂

There are 19.323 moles of CO₂ in the vent

$$19.323 \text{ moles CO}_2 \left(\frac{44 \text{ lb CO}_2}{\text{lbmole}} \right) = 850.2 \text{ lb CO}_2$$

The moles of CO₂ produced is 109.191

$$109.191 \text{ mole CO}_2 \left(\frac{44 \text{ lb CO}_2}{\text{lbmole}} \right) = 4804.4 \text{ lb CO}_2$$

$$(19.323 + 109.191) \text{ mole CO}_2 \left(\frac{359 \text{ ft}^3}{\text{mole}} \right) = 46137 \text{ SCF CO}_2$$

CO₂ from stack

$$850.2 + 4804.4 = 5655 \text{ lb CO}_2$$

$$19.3 + 109.2 = 128.5 \text{ mole CO}_2$$

$$46137 \text{ SCF CO}_2$$

Stack Gas Flow Rate at Process Conditions

Excess 1 mole

Standard conditions: 492°R, 14.7 psia, 359 ft³/mole

Process conditions: 620°R, 15.7 psia

$$V_2 = V_1 \left(\frac{P_1}{P_2} \right) \left(\frac{T_2}{T_1} \right) = 359 \text{ ft}^3 \left(\frac{14.7}{15.7} \right) \left(\frac{620}{492} \right)$$

$$V_2 = 423.6 \text{ ft}^3$$

Vapor Pressure of water at 160°F is 4.739 psia

system pressure = 15.7 psia

$$\text{Volume \% water} = \frac{4.739}{15.7} = 30.2\%$$

	moles	lbs
893.5 { N_2	744.1	20,835
CO_2	128.5	5,655
O_2	20.9	669
H_2O	386.6	6,959
	<u>1280.1</u>	<u>34,118</u>

$$\frac{893.5}{100 - 30.2} = 1280 \text{ total moles}$$

$$(1280 \text{ moles})(.302) = 386.6 \text{ moles } H_2O$$

$$\left(\frac{1280 \text{ moles}}{\text{hr}} \right) \left(\frac{423.6 \text{ ft}^3}{\text{mole}} \right) = 542,208 \text{ ft}^3/\text{hr}$$

$$= 9036.8 \text{ ft}^3/\text{min}$$

$$= 150.6 \text{ ft}^3/\text{sec}$$

Stack Gas Exit Velocity

Stack diameter = 3.0 ft

$$\text{Area} = \frac{\pi D^2}{4} = \frac{\pi (3.0)^2}{4} = 7.07 \text{ ft}^2$$

$$\left(150.6 \frac{\text{ft}^3}{\text{sec}} \right) \left(\frac{1}{7.07 \text{ ft}^2} \right) = 21.3 \text{ ft/sec}$$

4/6

$\mu\text{g}/\text{m}^3$ for NO_x , CO, Hydrocarbons, Particulates

NO_x (assume mo. wt. 46)

$$(200 \times 10^{-6}) (46 \text{ g/gmole}) \left(\frac{1 \text{ gmole}}{22.4 \text{ l}} \right) \left(\frac{1 \text{ l}}{10^{-3} \text{ m}^3} \right) \left(\frac{10^6 \mu\text{g}}{\text{g}} \right) = 41.1 \times 10^4 \mu\text{g}/\text{m}^3$$

CO (mo. wt. 28)

$$(50 \times 10^{-6}) (28 \text{ g/gmole}) \left(\frac{1 \text{ gmole}}{22.4 \text{ l}} \right) \left(\frac{1 \text{ l}}{10^{-3} \text{ m}^3} \right) \left(\frac{10^6 \mu\text{g}}{\text{g}} \right) = 6.25 \times 10^4 \mu\text{g}/\text{m}^3$$

Unburned Hydrocarbons (assume mo. wt. 62)

$$(5.5 \times 10^{-6}) (62 \text{ g/gmole}) \left(\frac{1 \text{ gmole}}{22.4 \text{ l}} \right) \left(\frac{1 \text{ l}}{10^{-3} \text{ m}^3} \right) \left(\frac{10^6 \mu\text{g}}{\text{g}} \right) = 1.52 \times 10^4 \mu\text{g}/\text{m}^3$$

Particulates (150 ppm by wt.) (density of air = .0600 lb/ft³ @ 160°F, 15.7 psia)

$$(150 \times 10^{-6}) (.0600 \text{ lb/ft}^3) \left(\frac{454 \text{ g}}{\text{lb}} \right) \left(\frac{1 \text{ ft}^3}{2.832 \times 10^{-2} \text{ m}^3} \right) \left(\frac{10^6 \mu\text{g}}{\text{g}} \right) = 14.4 \times 10^4 \mu\text{g}/\text{m}^3$$

lb/hr for NO_x , CO, Hydrocarbons, Particulates

NO_x

$$(41.1 \times 10^4 \mu\text{g}/\text{m}^3) \left(\frac{2.832 \times 10^{-2} \text{ m}^3}{\text{ft}^3} \right) \left(\frac{150.6 \text{ ft}^3}{\text{sec}} \right) \left(\frac{3600 \text{ sec}}{\text{hr}} \right) \left(\frac{1 \text{ lb}}{454 \times 10^3 \mu\text{g}} \right) = 13.9 \text{ lb/hr}$$

CO

$$(6.25 \times 10^4 \mu\text{g}/\text{m}^3) \left(\frac{2.832 \times 10^{-2} \text{ m}^3}{\text{ft}^3} \right) \left(\frac{150.6 \text{ ft}^3}{\text{sec}} \right) \left(\frac{3600 \text{ sec}}{\text{hr}} \right) \left(\frac{1 \text{ lb}}{454 \times 10^3 \mu\text{g}} \right) = 2.1 \text{ lb/hr}$$

Hydrocarbons

$$(1.52 \times 10^4 \mu\text{g}/\text{m}^3) \left(\frac{2.832 \times 10^{-2} \text{m}^3}{\text{ft}^3} \right) \left(\frac{150.6 \text{ft}^3}{\text{sec}} \right) \left(\frac{3600 \text{sec}}{\text{hr}} \right) \left(\frac{1 \text{lb}}{454 \times 10^3 \mu\text{g}} \right)$$

$$= .514 \text{ lb/hr}$$

Particulate (150 ppm by wt.) (density of air = .0600 lb/ft³ @ 15.7 psia
70°F)

$$\left(\frac{150.6 \text{ft}^3}{\text{sec}} \right) \left(.0600 \frac{\text{lb}}{\text{ft}^3} \right) \left(\frac{3600 \text{sec}}{\text{hr}} \right) (150 \times 10^{-6}) =$$

$$= 4.88 \text{ lb/hr}$$

μg/m³ for HCl + Cl₂

HCl

$$\left(3.38 \frac{\text{lb}}{\text{hr}} \right) \left(\frac{1 \text{hr}}{3600 \text{sec}} \right) \left(\frac{454 \times 10^3 \mu\text{g}}{\text{lb}} \right) \left(\frac{1 \text{sec}}{150.6 \text{ft}^3} \right) \left(\frac{1 \text{ft}^3}{2.832 \times 10^{-2} \text{m}^3} \right) =$$

$$= 9.99 \times 10^4 \mu\text{g}/\text{m}^3$$

Cl₂

$$\left(5.10 \frac{\text{lb}}{\text{hr}} \right) \left(\frac{1 \text{hr}}{3600 \text{sec}} \right) \left(\frac{454 \times 10^3 \mu\text{g}}{\text{lb}} \right) \left(\frac{1 \text{sec}}{150.6 \text{ft}^3} \right) \left(\frac{1 \text{ft}^3}{2.832 \times 10^{-2} \text{m}^3} \right)$$

$$= 15.08 \times 10^4 \mu\text{g}/\text{m}^3$$

PPM for HCl + Cl₂

HCl

$$\left(9.99 \times 10^4 \frac{\mu\text{g}}{\text{m}^3}\right) \left(\frac{10^{-6} \text{ g}}{\mu\text{g}}\right) \left(\frac{10^{-3} \text{ m}^3}{\text{L}}\right) \left(\frac{1 \text{ g mol}^{-1}}{36.4 \text{ g}}\right) \left(\frac{22.4 \text{ L}}{\text{g mol}^{-1}}\right)$$

$$= 6.09 \times 10^{-5} = 60.9 \text{ ppm}$$

Cl₂

$$\left(15.08 \times 10^4 \frac{\mu\text{g}}{\text{m}^3}\right) \left(\frac{10^{-6} \text{ g}}{\mu\text{g}}\right) \left(\frac{10^{-3} \text{ m}^3}{\text{L}}\right) \left(\frac{1 \text{ g mol}^{-1}}{70.4 \text{ g}}\right) \left(\frac{22.4 \text{ L}}{\text{g mol}^{-1}}\right) =$$

$$= 4.80 \times 10^{-5} = 48.0 \text{ ppm}$$