PTE Evaluation for Blending, Storage, and Loading into Tanks and Drums

Equipment: Three (3) 5,900 gal Storage Tanks
One (1) Storage Tank for Raw Material A
One (1) Storage Tank for Raw Material B
One (1) Storage Tank for Raw Material C
Four (4) 500 gal Blending Tanks for blending the raw materials above.
One (1) Drum Filling Station

Process Description:

The products are made by blending various amounts of raw materials A, B, and C. The raw materials are pumped to the blend tanks from the raw material storage tanks. Then the materials are heated to 165° F, blended for 3 hours, then cooled before pumped to the drum filling station.

Assumptions:
TANKs Program for Storage Tanks
The Tanks program accounts for working (loading) and breathing (changes in daytime/nighttime temperature) losses from the storage tanks. Assuming tanks are gray/light and are in good condition.

Volumetric Filling Rate for Storage Tanks and blending tanks: 45 gpm

Turnovers for each storage tank:
(1 tank/5,900 gal)(45 gal/min)(60 min/hr)(8760 hr/yr) = 4009 turnover/yr per tank

Turnovers for each blending tank:
(500 gal blend tank)(1 min/45 gal) = 11.11 min to fill product is heated to 165° F (Assuming 2 hr) blended for 3 hours 11.11 min to empty
Total = 5.37 hr/batch

(8760 hr/yr)(batch/5.37 hr) = 1631 turnovers/yr per blend tank

Bottleneck: (4 blend tanks)(1631 batches/yr) = 6524 batches/yr total
(6524 batches/yr total)(500 gal/batch) = 3,262,000 gal/yr

Blending & Heating
To calculate these emissions utilize the equations in the EIIP document located at http://www.epa.gov/ttn/chief/eiip/

These equations utilize the following assumptions:
• Covers are closed during operation, but is possible for vapors to be vented during operation.
• Assuming 10% vapor space in the blender.

Step 1: Calculate the moles of each component using the molecular weight (MW):
Moles = Mass / MW

Step 2: Calculate the liquid mole fraction of each component = $\frac{\text{Moles of Component}}{\text{Total Moles}}$

Step 3: Calculate the partial pressure (P_x) of each VOC component before heating and after heating. P_x (psi) = (Liquid Mole Fraction)(Vapor Pressure (psi))

Step 4: Calculate the vapor mole fraction (y_x) of each component before heating and after heating. $y_x = P_x$ /Total of all the partial pressures of each component

Step 5: Calculate the vapor molecular weight: (MWv) = G(y_x)(MW_x)

Step 6: Calculate the initial (Pa_1) and final (Pa_2) gas pressure in the vessel:
$Pa_1 = 14.7 - \sum(P_x)_{T1}$
$Pa_2 = 14.7 - \sum(P_x)_{T2}$

Step 7: Calculate the volume (V) of free space in the blender:
V = (10% vapor space)(500 gal) = 50 gal = 6.684 ft^3

Step 8: Calculate the number of gas moles displaced (Δn):

$$\Delta n = \left(\frac{V}{R}\right)\left(\frac{Pa_1}{T1} - \frac{Pa_2}{T2}\right)$$

R = Ideal Gas Constant = 10.73 psia ft^3/lb-mole °R

Step 9: Calculate the total VOC emissions (lb/yr)

$$E_{VOC} = \frac{\left(\frac{\sum(P_x)_{T1}}{14.7 - \sum(P_x)_{T1}}\right) + \left(\frac{\sum(P_x)_{T2}}{14.7 - \sum(P_x)_{T2}}\right)}{2} \times \Delta n \times MWv \times CYC$$

CYC = number of cycles per year = 6524 batches/yr total

Raw Material & Product Loading

$$D_L = 12.46\left[\frac{S\ P\ MW_v}{T}\right]$$

*Reference AP- 42 Chapter 5, Equation 1

D_L = Displacement Loss (lb/ 10^3 gallons transferred)

T = Temperature of transferred liquid (°R)
609.6 °R for Product
527.6 °R for Raw Material

P = True Vapor Pressure of liquid loaded (psia)

MW_v = Molecular Weight of the Vapor (lb/lb-mol) (Reference AP-42 Table 7.1-2)
= 199.37 lb/lb-mol
* For a pure liquid, the Molecular Weight of the Vapor is the normal molecular weight that is found from the periodic table.

S = Saturation Factor = 1.45 for splash loading dedicated normal service. (AP-42 Table 5.2-1)

Calculations:

VOC:
Storage: (Working and Breathing Losses)
Raw Material A: (8.25 lb from Tanks 4.0)(1 ton/2000 lb) = 0.004 tpy
Raw Material B: (776.34 lb from Tanks 4.0)(1 ton/2000 lb) = 0.39 tpy
Raw Material C: (Same as above:) 0.39 tpy
Total = 0.004 + 0.39 + 0.39 = **0.784 tpy**

Loading Raw Materials into the Blend Tanks
(12.46)[(1.45)(0.019 psi)(199.37 lb/lb-mol)/527.6 °R] = 0.130 lb VOC/ 10^3 gallons transferred
(0.130 lb VOC/ 10^3 gallons transferred)(3,262,000 gal/yr)(1 ton/2000 lb) = **0.212 tpy VOC**

Blending & Heating

$$\frac{\left(\frac{0.013\,\text{psi}}{14.7\,\text{psi} - 0.013\,\text{psi}}\right) + \left(\frac{0.93\,\text{psi}}{14.7\,\text{psi} - 0.93\,\text{psi}}\right)}{2} \times 0.0036\,\text{mol} \times 264.45\,\text{lb}/\text{mol} \times 6524\,\text{batches}/\text{yr} = 206.25\,\text{lb VOC per yr}$$

= 181.04 lb VOC/yr
(181.04 lb VOC/yr)(1 ton/2000 lb) = **0.091 tpy VOC**

Loading Product into Drums
(12.46)[(1.45)(1 psi)(264.45 lb/lb-mol)/609.6 °R] = 7.84 lb VOC/ 10^3 gallons transferred
(7.84 lb VOC/ 10^3 gallons transferred)(3,262,000 gal/yr)(1 ton/2000 lb) = **12.79 tpy VOC**

Total VOCs = 0.784 + 0.212 + 0.091 + 12.79 = 13.88 tpy