Vapour Release Rate Calculation

Aims:
To estimate the duration that a flammable atmosphere may exist inside the pellet mill conditioner, retentioners and die due to heating a mix of grains, meals, and a combustible liquid (trade name: Salcurb RM) above the flash point of the combustible liquid.

Basis:
1) For the purposes of this estimation consider the process containment to be represented by a 4m x 0.5m x 0.5m box.
2) Consider the vapour emitting surface to be a pool of combustible liquid inside the box. In reality the liquid will be dispersed throughout the mixture.
3) Consider the combustible liquid to be present added at 1% of the mix. In reality the liquid may be added at higher quantities, depending on process requirements.
4) Consider the combustible liquid to be a solution of 50% Propionic acid. This is a conservative assumption as Propionic acid is the major component of the solution, per SDS, and has the highest release rate of all constituents at 80 deg C (the other constituents are Formic Acid and Formaldehyde).
5) Neglect the affects of air movement through the process caused by product movement or steam addition.
6) Neglect the inerting affect of steam addition
7) Consider a process temperature of 80 deg C. Higher or lower temperatures may be experienced, up to 120 deg C approximately, however vapour pressure data for the relevant materials was not available at higher temperatures.
8) For the purposes of the calculation, consider that the mix is constantly being replenished by movement through the equipment and heating of the mixture. Hence it is considered that flammable vapour will build up in locations within the equipment by vapour being deposited as the heated mixture moves through the process.
9) For the purposes of the calculation, the affect of the displacement of air with the flammable vapour is ignored.

1) Calculate release rate of flammable vapour AQp

Airborne Quantity evaporated from the pool surface (AQ_p) is given by:

$$AQ_p = 9.0 \times 10^{-4} \left(A_p^{0.95}\right) \frac{(MW)\,P_v}{T + 273} \quad \text{{kg/sec}} \qquad \textbf{(Equation 8A)}$$

where
A_p = pool area (m2)
MW = molecular weight
P_v = vapour pressure of the liquid at the characteristic pool temperature (kPa)
T = characteristic pool temperature (°C) (see Conditions 1 and 2)

(from Dow Jones Quick Method to Calculate Toxic Vapour Dispersion - 6/7/06
http://www.safety-s2s.eu/modules/s2s_wp4/docs/S2S_CHEMICAL_EXPOSURE_INDEX.pdf)

pool area	2	m^2	*Consider a box 4m x 0.5m x 0.5m and consider it 1/2 full of product. Consider a surface of product as the vapour emitting surface at 2m x 0.5m area*
factor	0.01		*Consider the combustible liquid to be 1% of the product in the pool area*
Adjusted pool area	0.02	m^2	
mol weight	74.08	g/mol	*Molar pass of propionic acid https://cameochemicals.noaa.gov/chemical/9030*
vapour pressure	11	kPA	*9 kPA at 80 deg C http://webbook.nist.gov/cgi/cbook.cgi?ID=C79094&Mask=4&Type=ANTOINE&Plot=on*
pool temp	80	deg C	
Factor	0.5		*Consider 50% of the combustible solution to consist of Propionic Acid.*

Aq = 0.025264 g/sec *Release rate of flammable vapour*

2) Calculate the mass of air in the considered volume

$$m = \frac{pVM}{RT}$$ … ideal gas law

pressure (p)	101325	pascals	*1 atm = 101325 pascals*
volume (v)	1	cubic meters	*Consider a box 4m x 0.5m x 0.5m.*
n	0.5		*Consider 1/2 volume containing air, as remainder filled with product*
molar mass (M)	28.97	g/mol moles	*Molar mass of air*
gas constant (r)	8.314		
temperature (t)	333.15		*At 80 deg C*

m = 529.89 g *mass of air*

3) Calculate concentration of flammable vapour over a given time period

10 Minutes
529.89 grams of air in the calculated volume
15.16 grams of flammable vapour
2.86 % concentration of flammable vapour

2.60 % LEL of Propionic Acid
14.80 % UEL of Propionic Acid

(from https://cameochemicals.noaa.gov/chemical/9030)

60 Minutes
529.89 grams of air in the calculated volume
90.95 grams of flammable vapour
17.16 % concentration of flammable vapour

3) Conclusions

The calculation shows that a flammable mixture may be present atleast once a shift and that the upper flammable limit may be exceeded if ideal conditions exist and flammable vapour is able to build up over time.