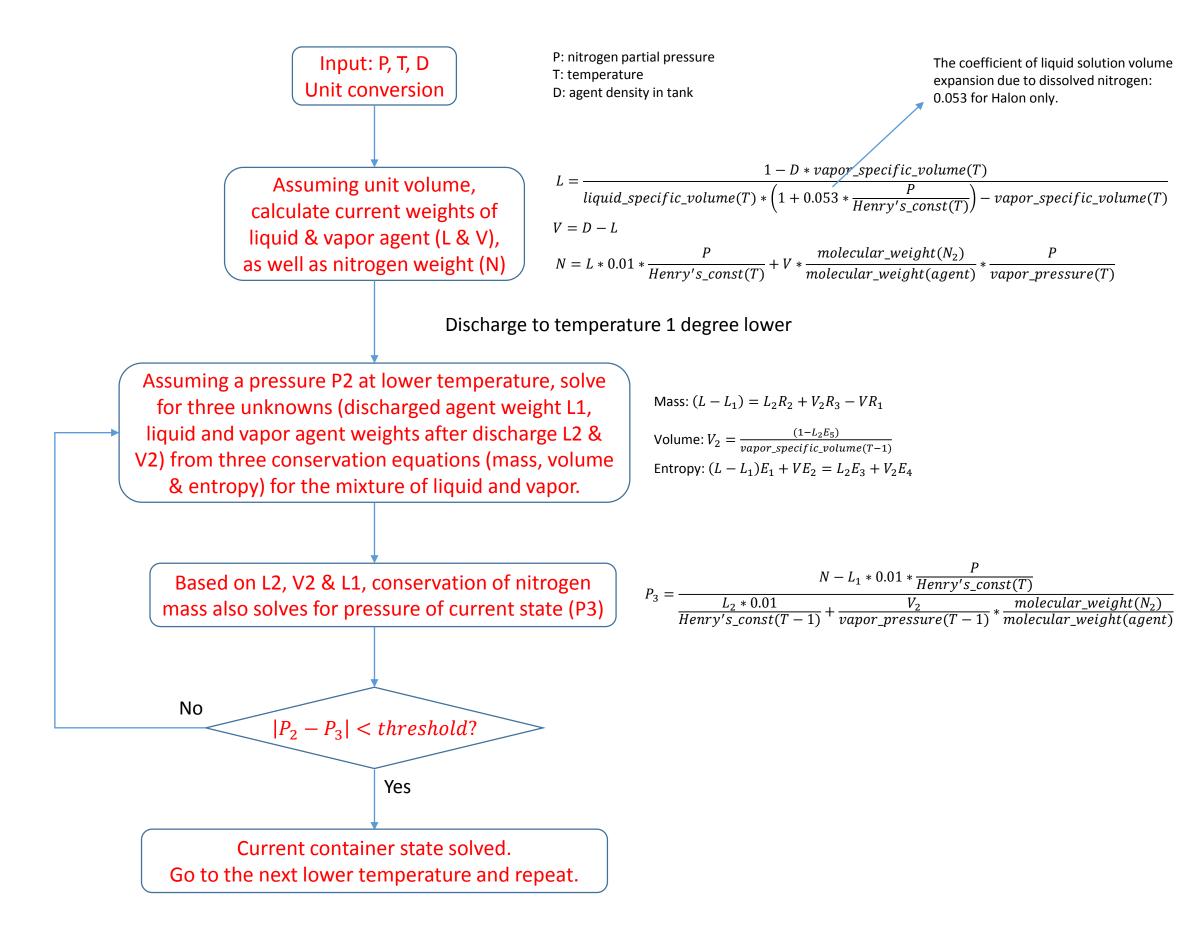
Williamson Method for Tank State during Discharge



Williamson Method for Pipeline Expansion due to Pressure Drop

Input: Pipeline starting P, T from one snapshot of tank discharge Pressure Recession Table

P: nitrogen partial pressure

T: temperature

Starting from only liquid and assuming unit mass agent, calculate weight of nitrogen (N) that's dissolved in the discharged liquid agent, and the total density D of the liquid mixture of nitrogen and agent

$$L = 1 V = 0$$

$$N = L * 0.01 * \frac{P}{Henry's_const(T)}$$

$$D = \frac{1 + N}{liquid_specific_volume(T) * \left(1 + 0.053 * \frac{P}{Henry's_const(T)}\right)}$$

Proceed along the pipe to temperature 1 degree lower. Try to find the pressure and density drop.

Assuming a pressure P2 at the next lower temperature point, solve for two unknowns (liquid and vapor agent weights after expansion L2 & V2) from two conservation equations (mass & enthalpy) for the mixture of liquid and vapor.

Mass:
$$LE_6 + VE_7 = L_2E_8 + V_2E_9$$
 $(L + V = L_2 + V_2 = 1)$
Enthalpy: $LE_1 + VE_2 = L_2E_3 + V_2E_4$

(Conservations of mass for agent and nitrogen are two independent equations.)

Based on L2 & V2, conservation of nitrogen mass also solves for pressure of current state (P3)

$$P_{3} = \frac{N}{\frac{L_{2}*0.01}{Henry's_const(T-1)} + \frac{V_{2}}{vapor_pressure(T-1)} * \frac{molecular_weight(N_{2})}{molecular_weight(agent)}}$$

No

 $|P_2 - P_3| < threshold?$

Yes

Pipe state at current temperature solved. Go to the next lower temperature and repeat.

$$D = \frac{1 + N}{liquid_specific_volume(T) * \left(1 + 0.053 * \frac{P}{Henry's_const(T)}\right) * L_2 + vapor_specific_volume(T) * V_2}$$