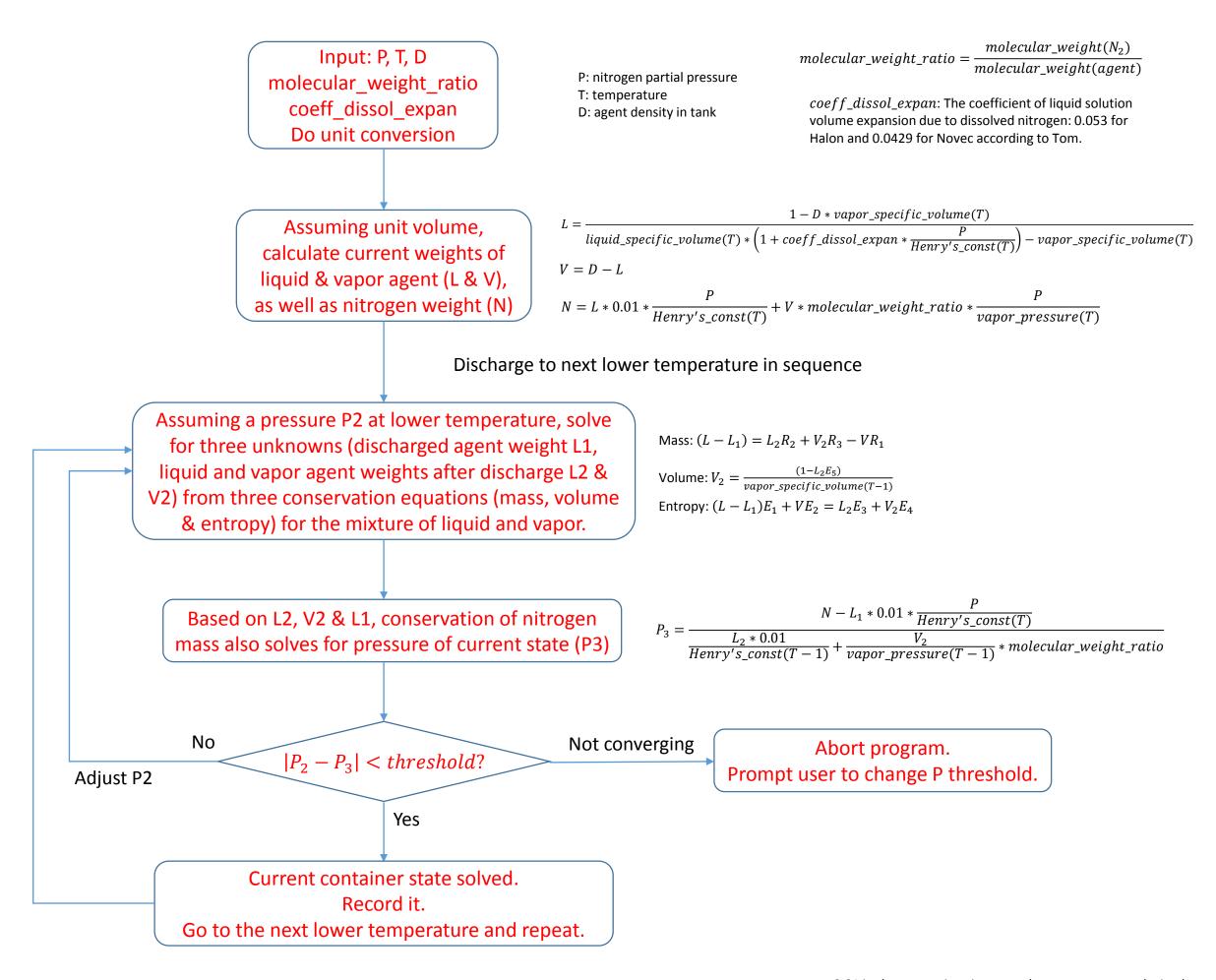
## Williamson Method for Tank State during Discharge



## 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

 $molecular\_weight\_ratio = \frac{molecular\_weight(N_2)}{molecular\_weight(agent)}$ 

 $coeff\_dissol\_expan$ : The coefficient of liquid solution volume expansion due to dissolved nitrogen: 0.053 for Halon and 0.0429 for Novec according to Tom.

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

$$L = 1 V = 0$$

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

$$D = \frac{1 + N}{liquid\_specific\_volume(T) * \left(1 + coeff\_dissol\_expan * \frac{P}{Henry's\_const(T)}\right)}$$

Proceed along the pipe to the next lower temperature. 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)

$$P_{3} = \frac{N}{\frac{L_{2}*0.01}{Henry's\_const(T-1)} + \frac{V_{2}}{vapor\_pressure(T-1)}*molecular\_weight\_ratio}$$

No

Adjust P2

 $|P_2 - P_3| < threshold?$ 

Yes

Not converging

Abort program.

Prompt user to change P threshold.

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

$$D = \frac{1 + N}{liquid\_specific\_volume(T) * \left(1 + 0.053 * \frac{P}{Henry's\_const(T)}\right) * L_2 + vapor\_specific\_volume(T) * V_2}$$