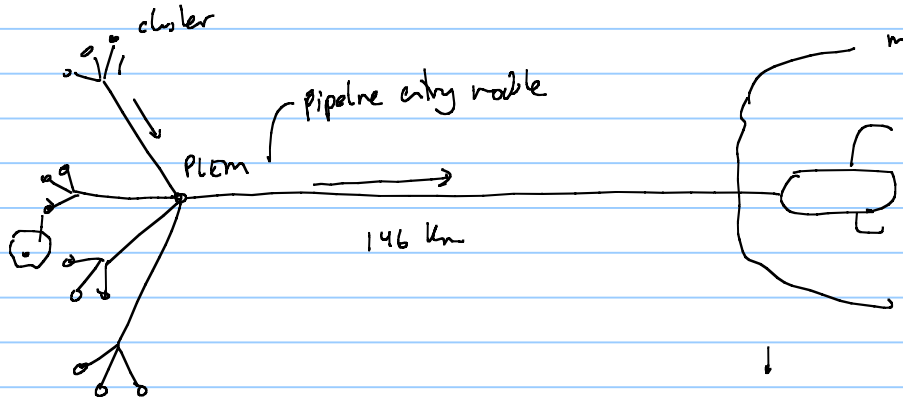
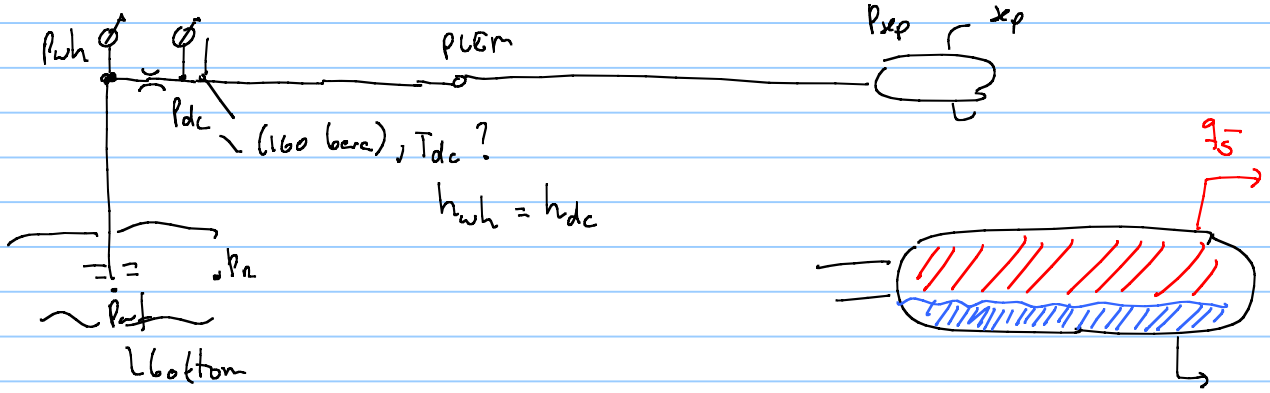
- VBA function for r_{sw}
- Class exercise
- Hydrates

$$\gamma_g = \frac{MW_g}{MW_{air}} = \frac{MW_g}{28.97}$$

Production system

- cell





water in gas wells can cause "liquid loading"

← slug flow (dP is higher)

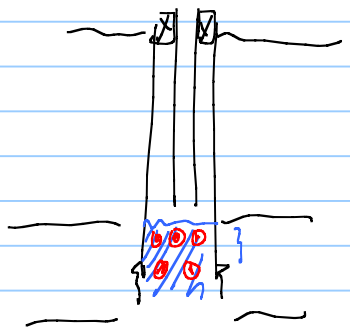
← annular flow

mist flow

single phase flow

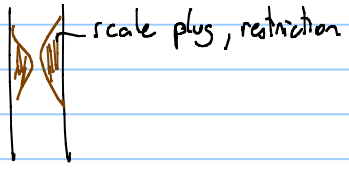
more water → higher viscosity, higher density → higher Δp

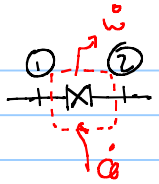
- reduce production rate
- liquid starts accumulating in well



for gas in a sudden expansion (e.g. choke, large and concentrated pressure drop)

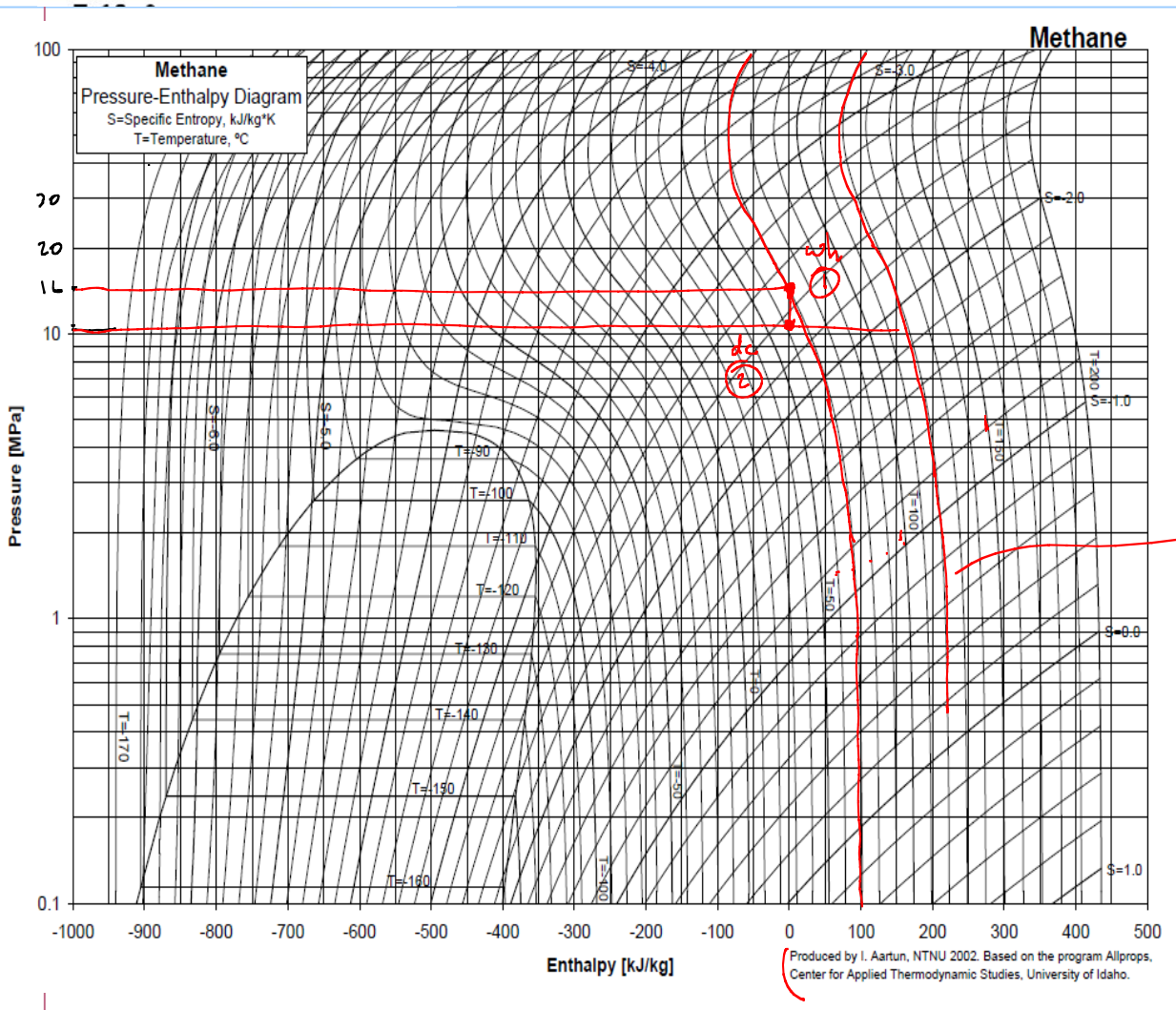
the temperature is also changing due to the pressure drop





isenthalpic

$h_1 = h_2$



$T_{dc} \simeq 60\,C$

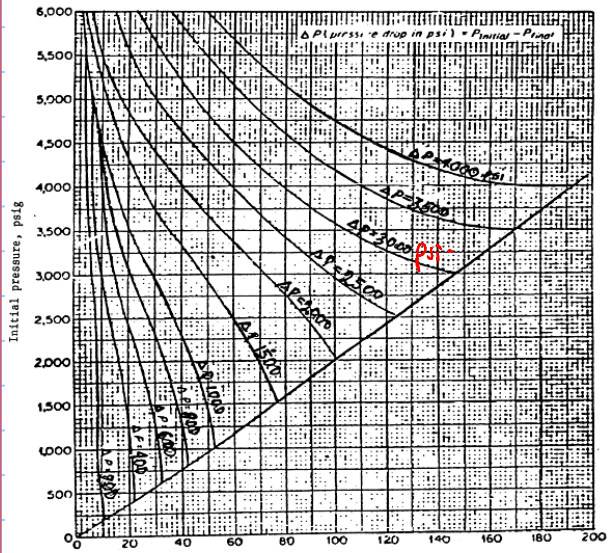
$T = 120\,C$

160 bar to MPa 1st Pa

$P_{dc} = 120$ bar

12 MPa

this cooling effect can be very significant, especially across choke



Temperature change due to pressure drop. (From Vondy et al.)

↝ charts like this are made for different γ_g to predict temperature across the choke.

Prof. Milan Stanko. TPG4135 - Water content in gas field					
Gas MW	16	[Kg/Kmol]			
Gas gravity	0.552				
Water salinity	0.0	[ppm]			
CO2	0.0	[mole %]			
H2S	0.0	[mole %]			
Gas field rate	2.00E+07	[Sm^3/d]			
Nwells	8				
Well gas rate	2.50E+06				
Location	**p**	**T**	**rsw**	**rsw**	**qw**
[-]	[bara]	[C]	[kg/1E06 Sm^3]	[Sm^3/1E06 Sm^3]	[Sm^3/d]
Reservoir	276	90	3360.4	3360.4	
Wellhead	160	70	2263.0	2263.0	
Choke downstream	120	60	1840.4	1840.4	
Separator	30	5	310.2	310.2	

$$q_{w_{TOTAL}} = q_g \cdot r_{sw}\Big|_{@P_R, T_R}$$

$$q_{w_{TOTAL}} = 20\ [m Sm^3/d] \cdot 3360\ \frac{Sm^3}{[m Sm^3]}$$

$$q_{w_{TOTAL}} = 67.2\ E03\ Sm^3/d$$

$$q_{w_{sep}}^{solution} = 20\ E06 \cdot r_{sw}\Big|_{@P_{sep}, T_{sep}}$$

$$q_{w_{sep}} = 20\ [m Sm^3/d] \cdot 310$$

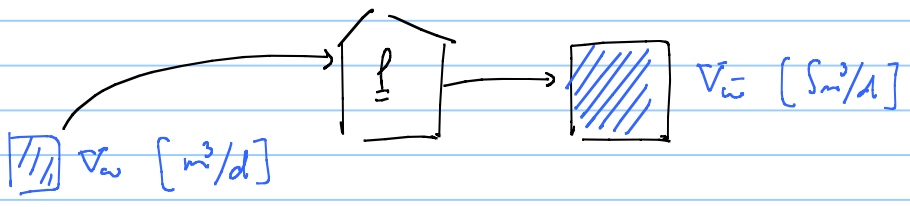
$$q_{w_{sep}} = 6200\ Sm^3/d$$

the free water at separator is the difference between the two

$$q_{w_{sep}}^{Free} = q_{w_{TOTAL}} - q_{w_{sep}}^{solution}$$

$$q_{w_{sep}}^{Free} = 67.2\ E03\ Sm^3/d - 6.2\ E03\ Sm^3/d$$

$$q_{w_{sep}}^{Free} = 61\ E03\ Sm^3/d$$



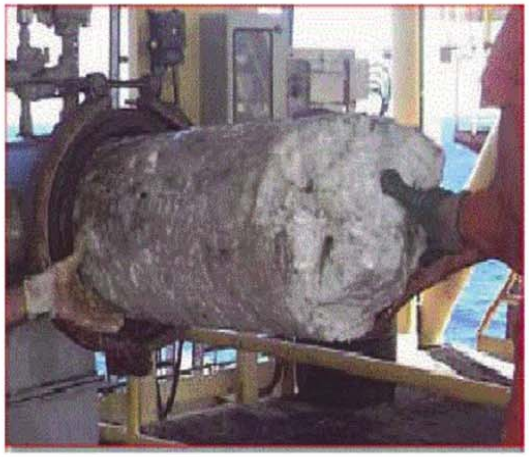
local free water rate at separator inlet

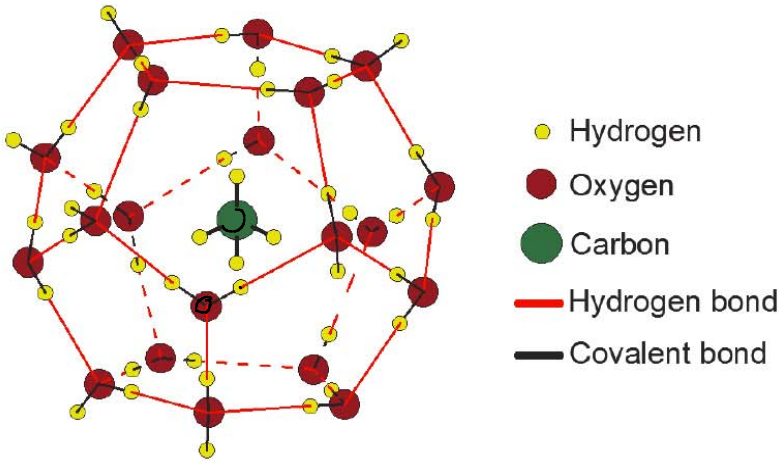
$$q_{w\,sep}^{Free} = q_{\bar{w}\,sep}^{Free} \cdot \underbrace{B_w(P_{sep}, t_{sep})}_{\approx 1}$$

knowing q_w is useful for
↳ local conditions.

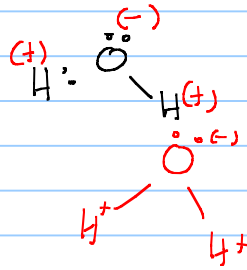
- pressure drop calculations
- to determine liquid loading problem
- to find adequate amount of chemical inhibitor for: corrosion
  hydrates

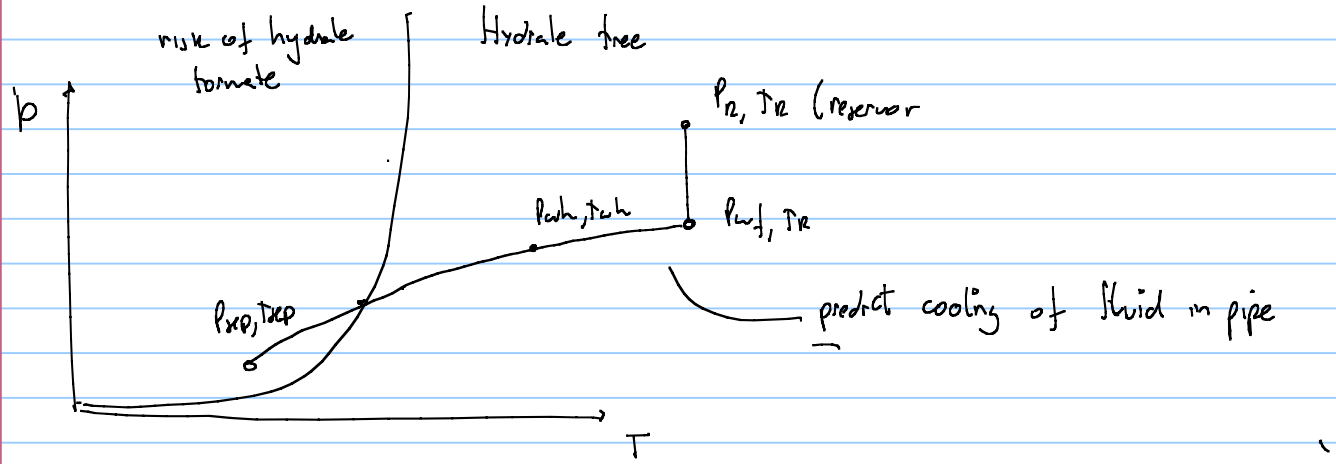
Hydrates



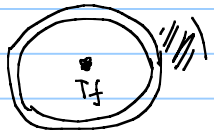


- free water } hydrogen
- small molecules CH_4 C_2H_6, C_3H_8, C_4H_{10}, CO_2, N_2 ~9 Å
- specific conditions of P, T
  low T,

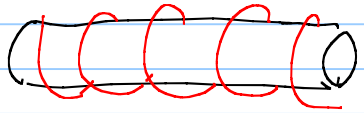




How to avoid hydrate formation? ○ "Slow-down" cooling in pipe { insulation

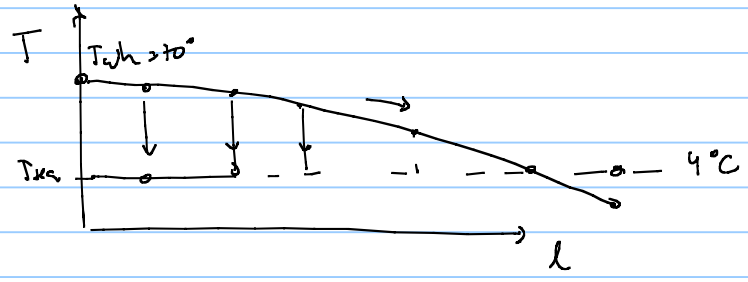


○ T_{sea}

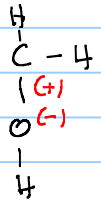


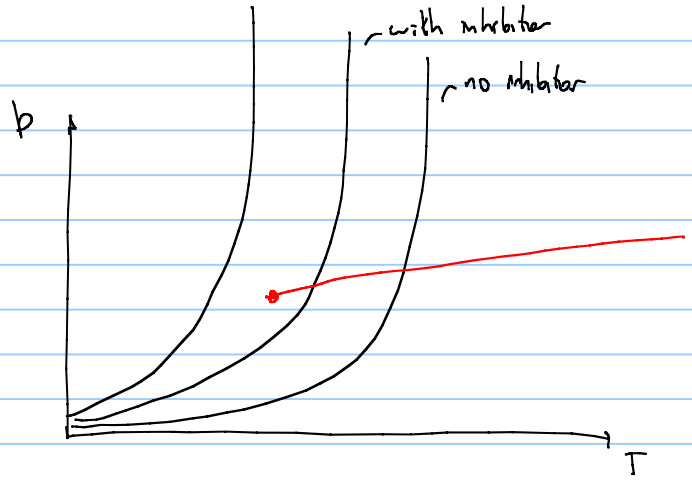
○ add heat to pipe { heat tracing

for the snowhite case



• chemical inhibitor { MeOH, MEG, TEG





Inhibitor quantities are typically given in weight %

$$= \frac{\dot{m}_{inhibitor}\ [kg/s]}{\dot{m}_{inh} + \dot{m}_{water}} \cdot 100$$

[30 - 60] %

is injected typically at wellhead X-mas tree.