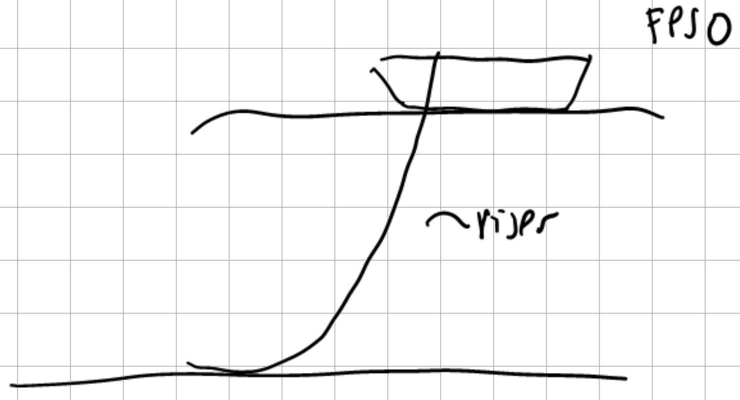
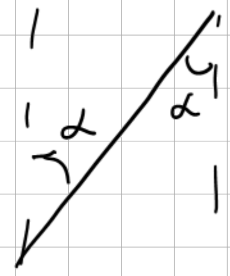
$C_{PL}, C_{FL}, C_{riser}$ $\qquad p_1 \longrightarrow p_2$

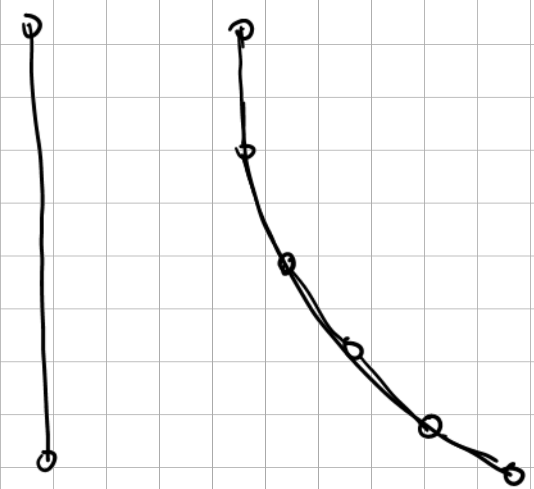
$$q_{sc} = C_T \cdot \left[\left(\frac{p_{wf}^2}{e^S} - p_t^2 \cdot\right)\right]^{0.5}$$

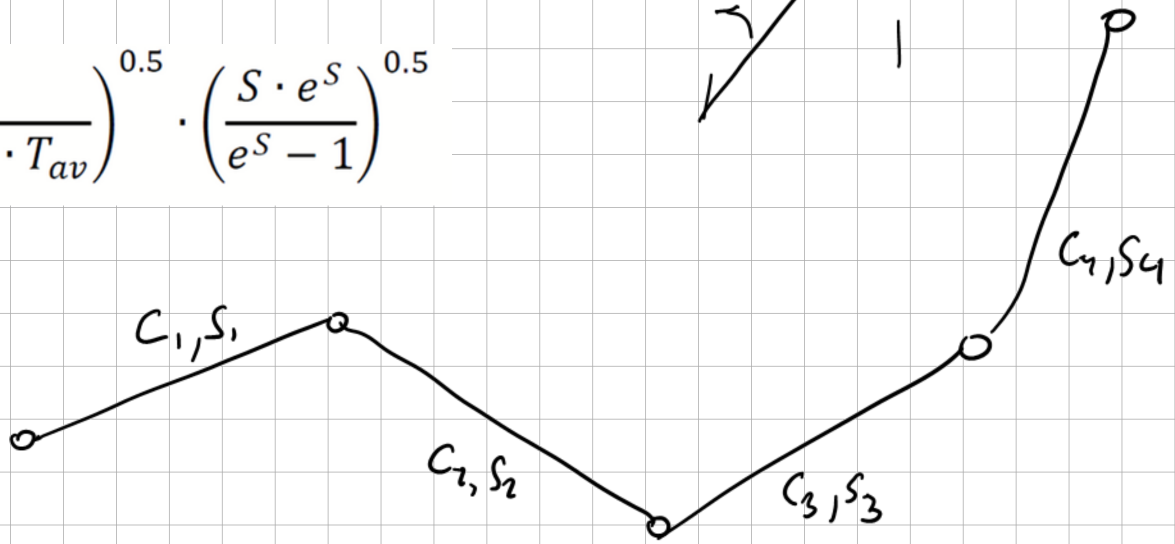


$$S = 2 \cdot L \cdot C_a = 2 \cdot \frac{M_g}{Z_{av} \cdot R \cdot T_{av}} \cdot L \cdot g \cdot \cos(\alpha)$$



$$C_T = \left(\frac{\pi}{4}\right) \cdot \left(\frac{R}{M_{air}}\right)^{0.5} \cdot \left(\frac{T_{sc}}{p_{sc}}\right) \cdot \left(\frac{D^5}{f_M \cdot L \cdot \gamma_g \cdot Z_{av} \cdot T_{av}}\right)^{0.5} \cdot \left(\frac{S \cdot e^S}{e^S - 1}\right)^{0.5}$$





Special case of horizontal pipe $\quad S = 0$ $\qquad S = 0$

however when calculating $C \longrightarrow \dfrac{S \cdot e^S}{(e^S - 1)}$ $\qquad \dfrac{0 \cdot 1}{(1-1)^{\to 0}} = \dfrac{0}{0}$!

use L'Hopital rule

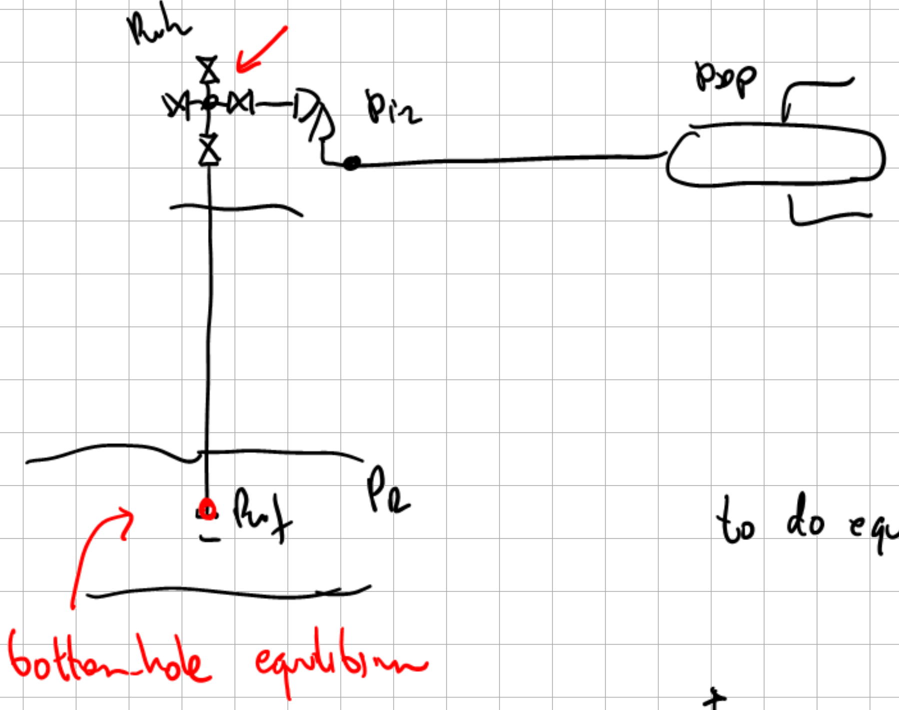
$$\lim_{x \to 0} \frac{f(x)}{g(x)} \rightarrow \text{undefined}$$

$$\lim_{x \to 0} \frac{f'(x)}{g'(x)} \quad \frac{(e^S + Se^S)}{(e^S)} \overset{S \to 0}{=} \frac{1+0}{1} = 1$$

in horizontal pipe $\quad \dfrac{Se^S}{(e^S - 1)} = 1$

if $\phi \uparrow \rightarrow C_{FL} \uparrow \rightarrow$ lower Δp (or larger rate)

if $L \uparrow \rightarrow C_{FL} \downarrow \rightarrow$ higher Δp (or lower rate)

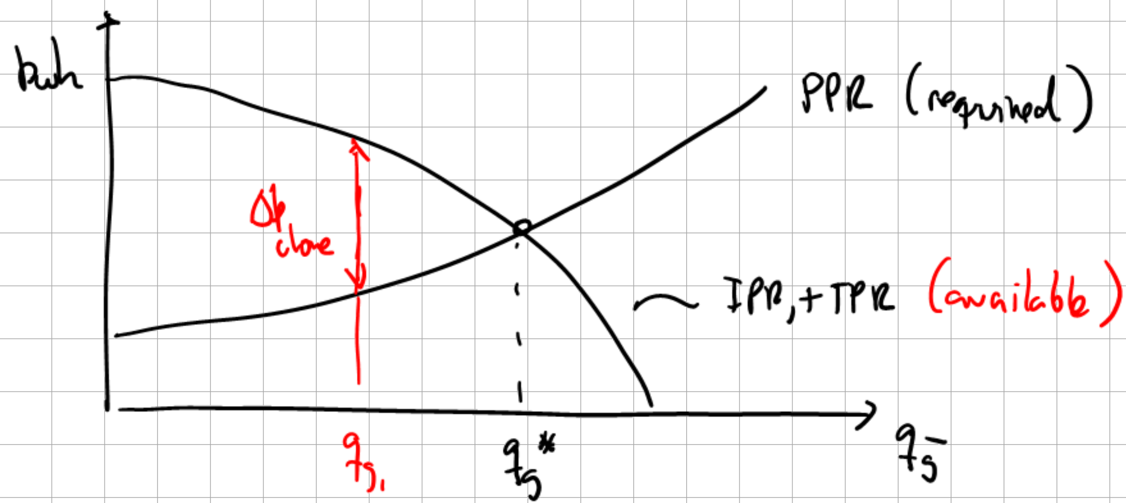


$\Delta p_{choke} = (P_{wh} - P_{in})$

when $\Delta p_{choke} = 0$

$P_{wh} = P_{in}$

to do equilibrium with flowline



p_R, Res pressure	304	bara	
C_R	104	Sm3/d/bar^2n	
n, exponent	0.9		
C_t, tubing	4.25E+04	$Sm^3/d/bar$	
s, elevation	0.155		
C_{fl}, flowline	1.25E+05	4.00E+04	$Sm^3/d/bar$
p_{sep}	40	bara	

$$q_g = c(p_R^2 - p_{wf}^2)^n$$

Tubing performance relationship (TPR)

$$p_{wh} = p_2 = \left(\frac{p_1^2}{e^s} - \frac{q_g^2}{C_T^2}\right)^{0.5}$$

Flowline performance relationship (FPR)

$$\boxed{q_{\bar{g}} = C_{FL} \cdot \left(p_{in}^{\ 2} - p_{out}^{\ 2}\right)}$$

assumed — IPR-qg

pwf [bara]	qg-IPR [Sm3/d]	pwf-TPR [Sm3/d]	WPR [Sm3/d]	PPR - 1 [bara]	PPR - 2 [bara]
304	0.00E+00	43			
250	1.11E+06	52			
200	1.84E+06	64			
150	2.38E+06	74			
100	2.76E+06	82			
50	2.99E+06	87			
0	3.06E+06	89			
84.378937	2.85E+06	84			

wellhead performance relationship

$p_{wf} \rightarrow p_{wh}$

TPR

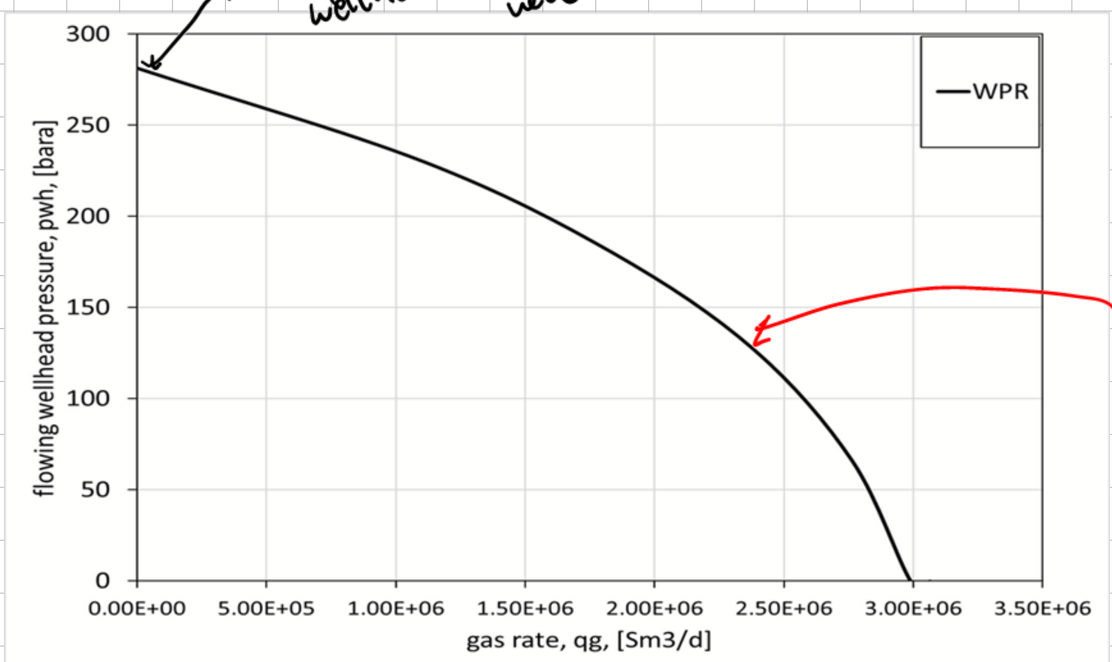
required, with TPR, assuming Pwh = 40 bara

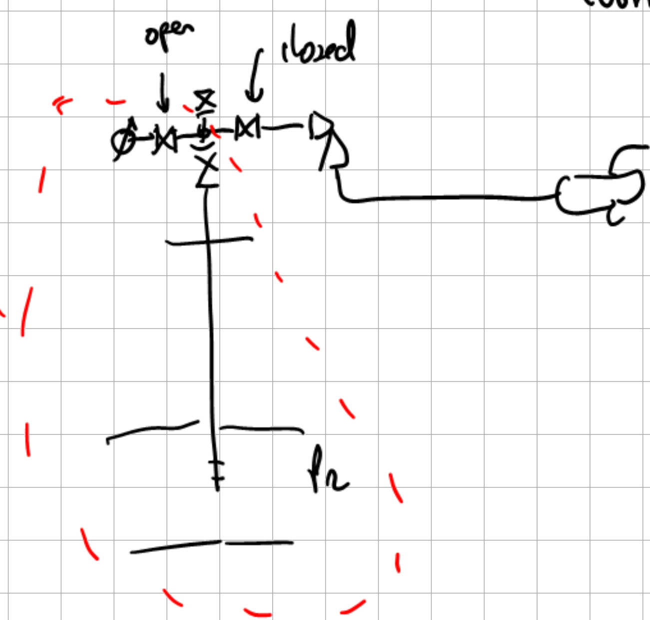
tubing_qg (P1, P2)

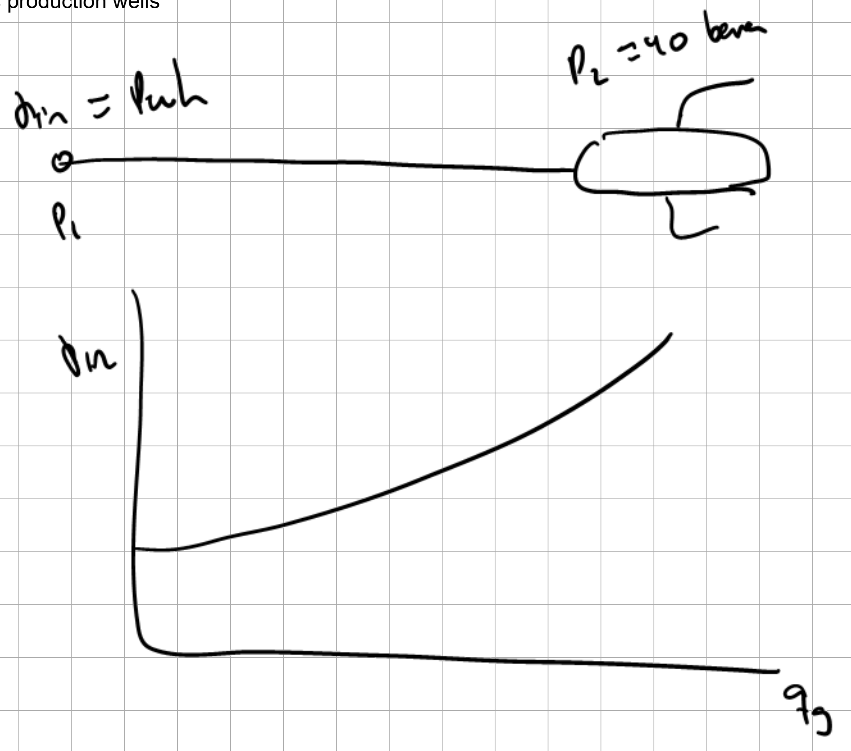
calculated → tubing_P1 (P2, qg)

tubing_P2 (P1, qg)

pressure measured at wellhead with closed well







$$q_g = C_{FL} \cdot \left(\frac{P_1^2}{e^s} - P_2^2 \right)^{0.5}$$

horizontal $s \to 0$

$$q_g = C_{FL} \left(P_1^2 - P_2^2 \right)^{0.5}$$

required pressure

$$P_1 = \sqrt{P_2^2 + \left(\frac{q_g}{C_{FL}} \right)^2}$$

```
Function Linep1(Cfl, p2, qg)
Linep1 = (p2 ^ 2 + (qg / Cfl) ^ 2) ^ 0.5
End Function
```

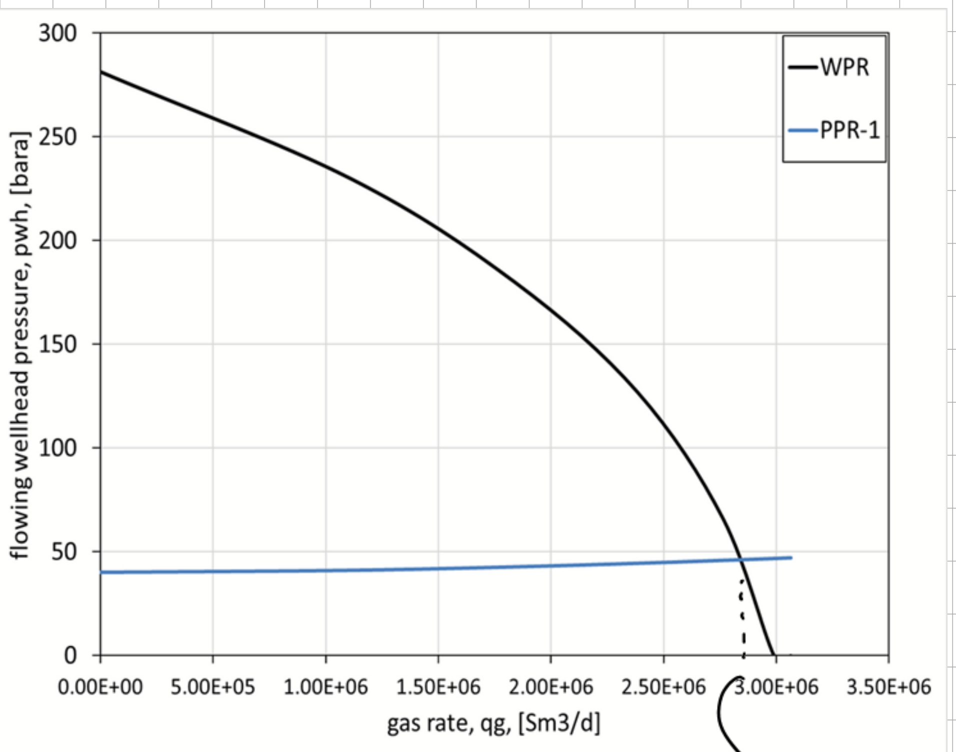
pwf [bara]	qg-IPR [Sm3/d]	pwf-TPR [Sm3/d]	WPR [Sm3/d]
304	0.00E+00	43	281
250	1.11E+06	52	230
200	1.84E+06	64	180
150	2.38E+06	74	127
100	2.76E+06	82	66
50	2.99E+06	87	#VALUE!
0	3.06E+06	89	#VALUE!

$$q_g = C_T \left(\frac{P_{wf}^2}{e^s} - P_{wh}^2 \right)^{0.5}$$

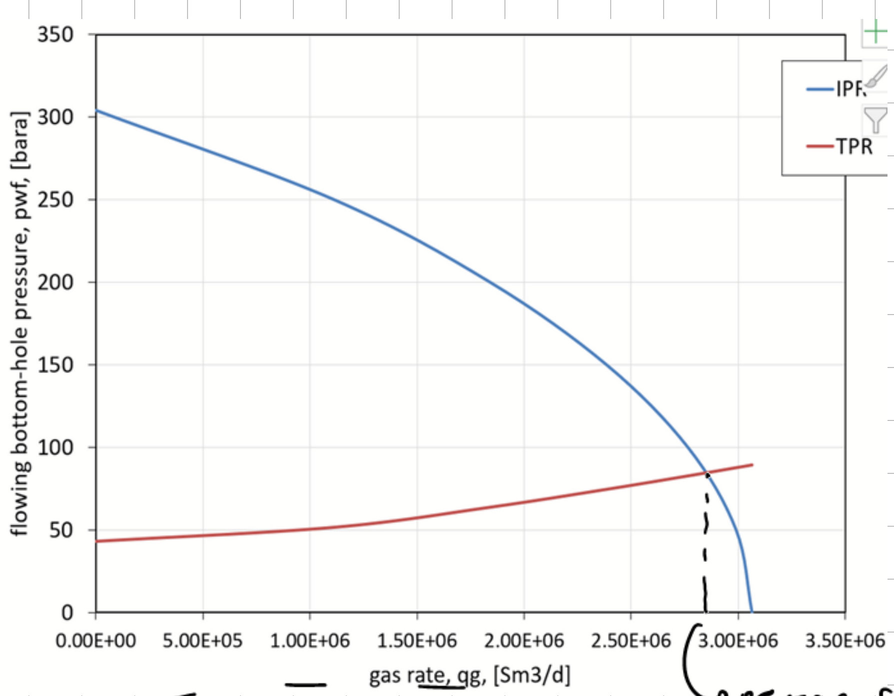
$$P_{wh} = \sqrt{\underbrace{\frac{(P_{wf})^2}{e^s} - \left(\frac{q_g}{C_T} \right)^2}}$$

(+)

(−)



a bit lower



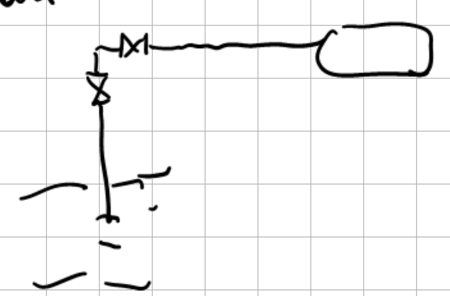
2.85E06 Sm³/d

bottom-hole eq

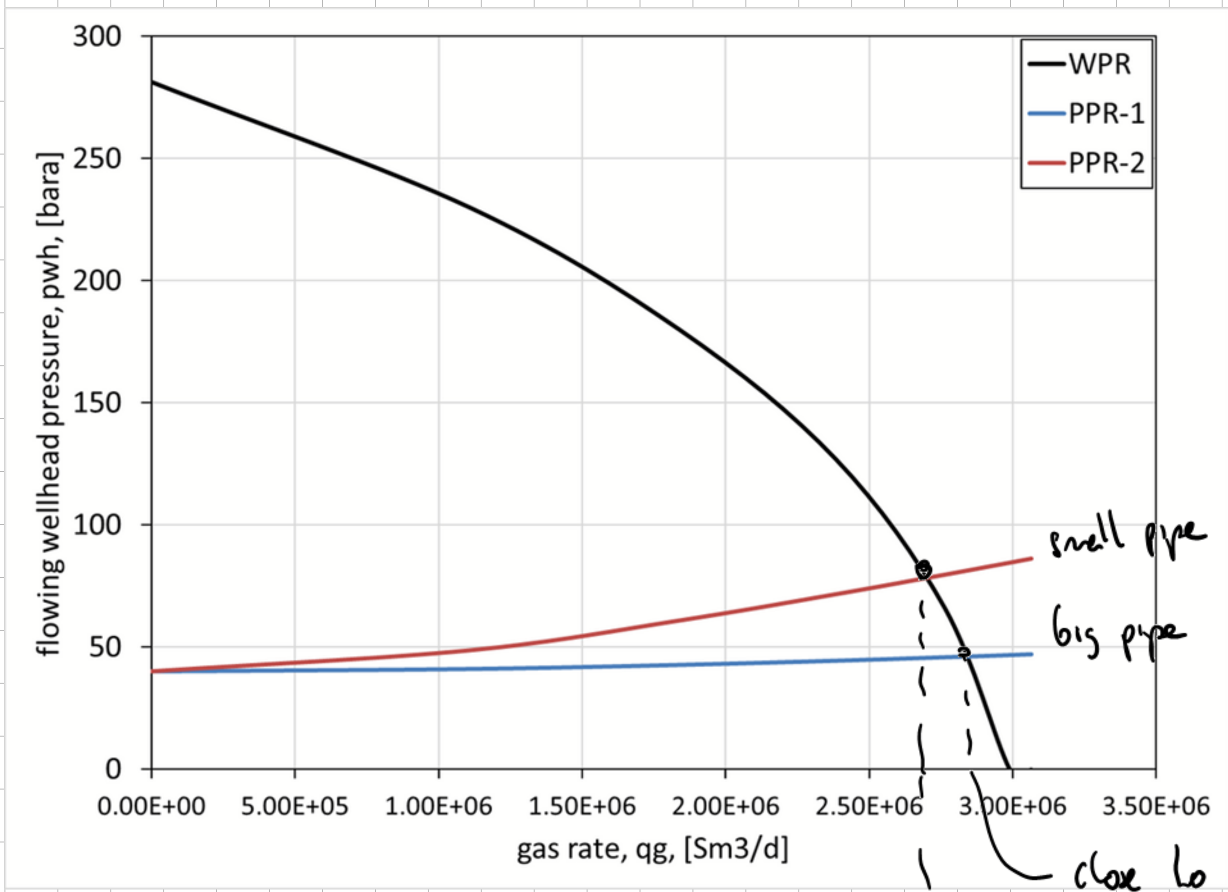
$P_{wh} = 40$ bara

$P_{sep} = 40$ bara

wellhead eq



$P_{wh} = 40$ bara

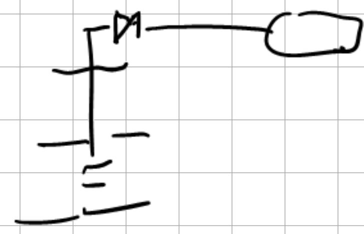


close to 2.85 E06 Sm^3/d

much lower than 2.85 E06 Sm^3/d

wellhead eq

pipeline included



{ Small pipeline
long pipeline