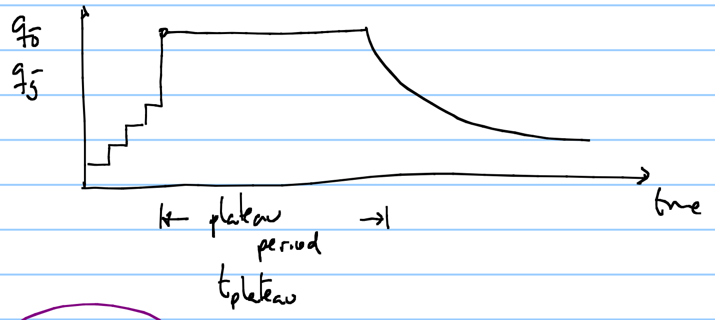
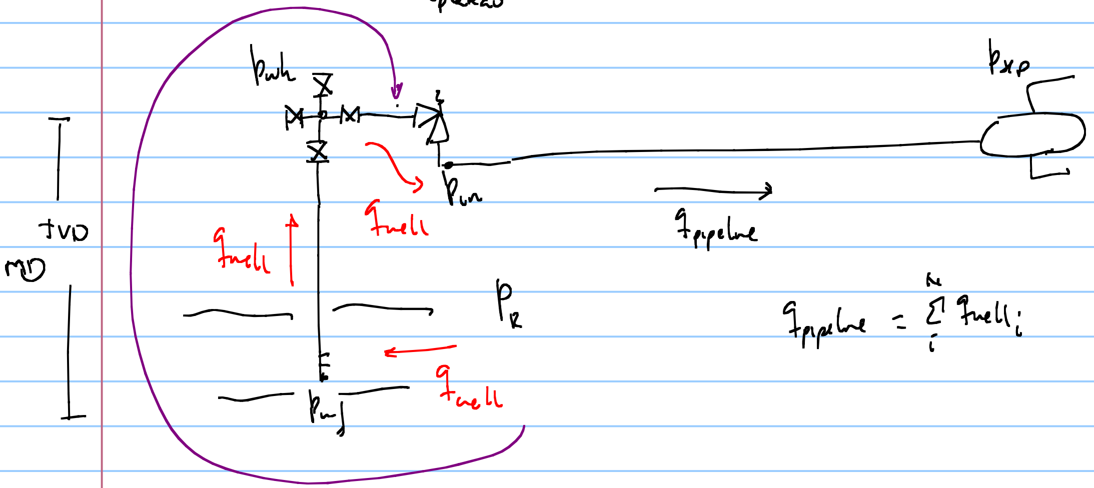
Note Title

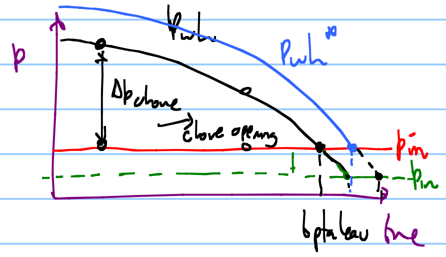
Notes to Youtube video nr. 8

Measure to prolong plateau duration





$$q_{pipeline} = \sum_{i}^{N} q_{well_i}$$



Reservoir ⟶ bottom-hole ⟶ wellhead ⟶ pipe inlet ⟶ separator

TYPE OF FLOW: formation, tubing, choke, pipeline

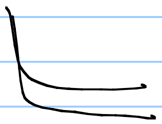
$\Delta p_{drawdown}$ Δp_{tubing} Δp_{choke} $\Delta p_{pipeline}$

measures to reduce Δp

$\Delta p_{drawdown}$
- stimulation
- acidizing
- fracking
- re completion
- side-tracking
- multi laterals
- reduce rate per well (drilling more well)

$$\underbrace{q_g}_{\text{content}} = \overset{\downarrow}{\underbrace{C_R}} \overbrace{\left(P_R^2 - P_{wf}^2\right)^n}^{\simeq \Delta p_{drawdown}}$$

reducing



$q_{field} \simeq q_{well} \cdot N_{well}$

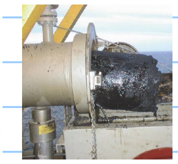
Δp_{tubing}
- "increase" C_T.
  - increase the diameter
  - artificial lift → gas lift
    - → jet pump
    - → plunger lift
    - → rod pumping
    - → Progressive cavity pumps (PCP)
    - → Electric submersible pumps (ESP)

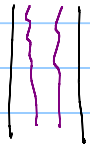
$$q_g = C_T \overbrace{\left(\frac{P_{wf}^2}{e^S} - P_{wh}^2\right)}^{\propto \Delta p_{tubing}}{}^{0.5}$$

- measures to mitigate phenomena that causes tubing diameter to be reduced in time

- scaling

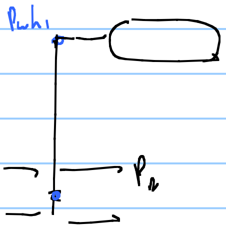
- wax
- asphaltene





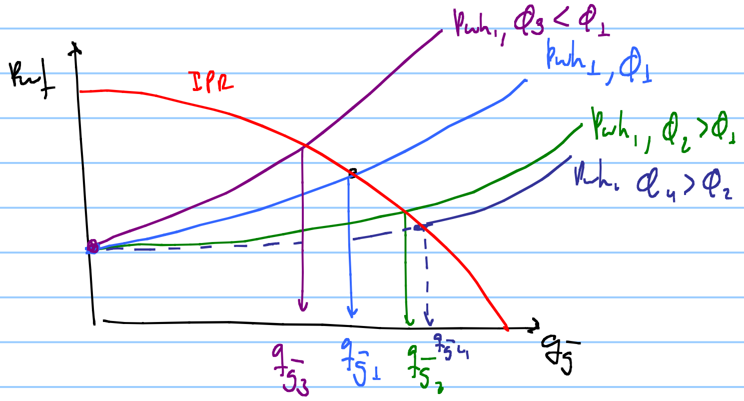
How to determine tubing size

- get more rate ↑Q ↑q_g
- keep cost low ↑Q ↑$



$P_{wh} = const = P_{sep}$

big Q, ↓v_g, ↓f, ↓Δp



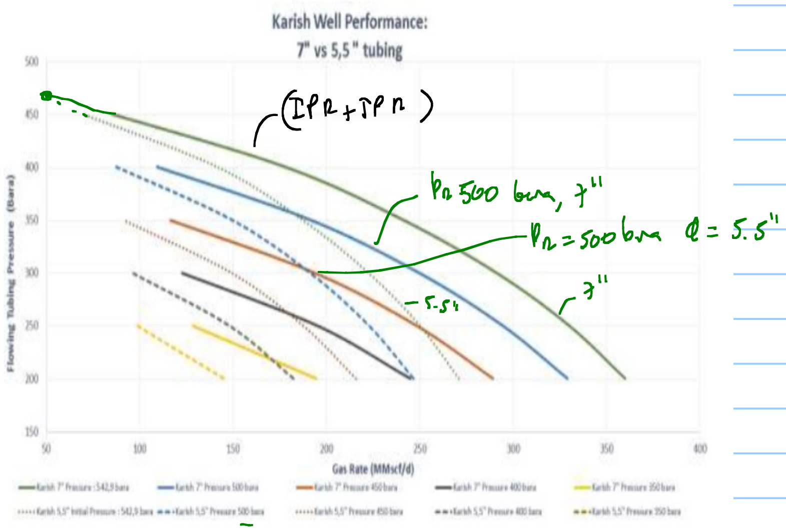
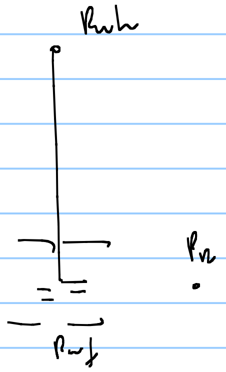
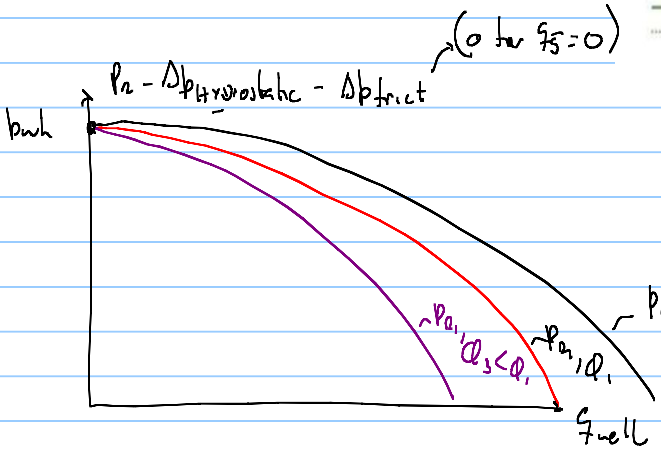


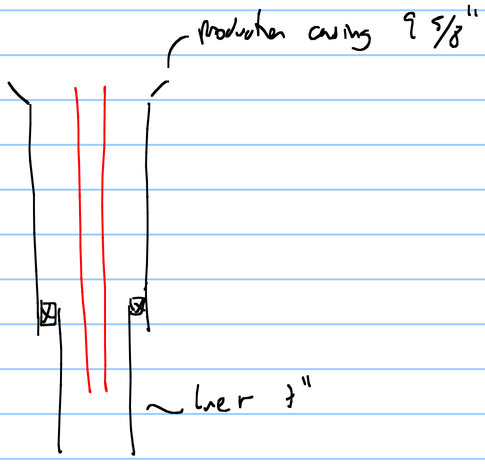
Figure 6-25 Karish PQ Curves





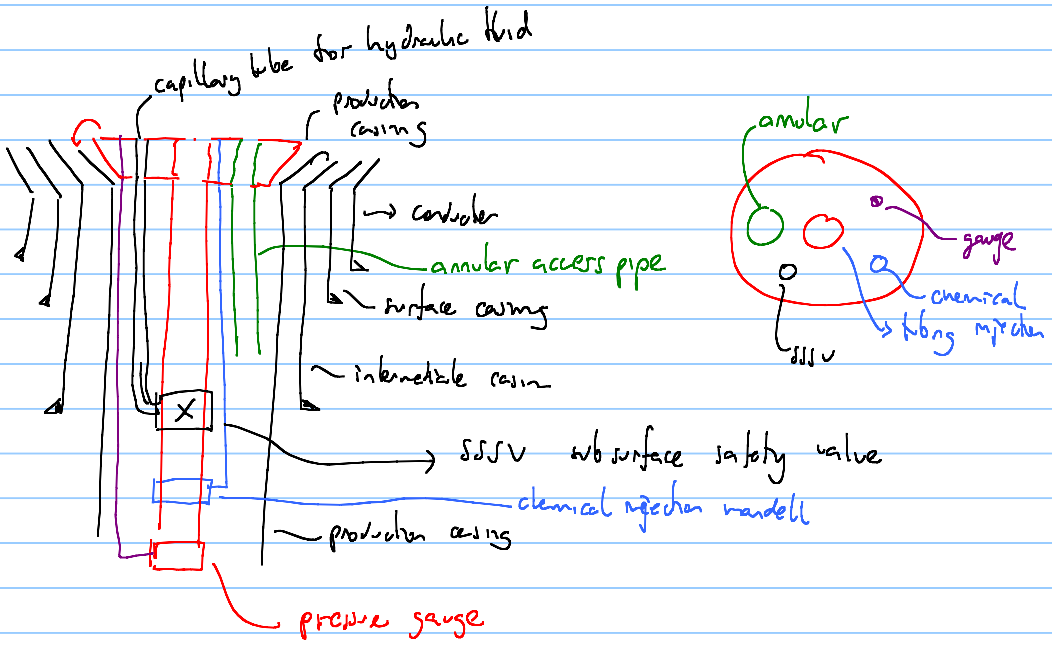
wellhead performance relationship

- completion considerations
  possible to run the tubing in well



- tubing hanger

due to structural integrity of tubing hanger, tubing diameter might be limited



- erosional velocity

$V_s \leq \underline{V_{erosional}}$

$\frac{q_g(P,T)}{A} = V_{sg}$ ↳ superficial gas velocity

A: cross section area of tubing

$q_g(P,T) = q_{\bar{g}} \, B_g(P,T)$

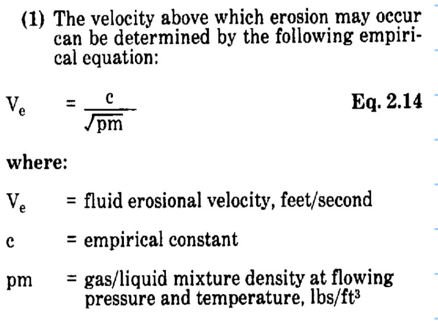
$q_o(P,T) = q_{\bar{o}} \, B_o(P,T)$

$q_w(P,T) = q_{\bar{w}} \, B_w(P,T)$

standards to define $V_{erosional}$

→ API 14 E

. DNV Recommended Practice RP O501)


(1) The velocity above which erosion may occur can be determined by the following empirical equation:

$$V_e = \frac{c}{\sqrt{pm}} \qquad \textbf{Eq. 2.14}$$

where:

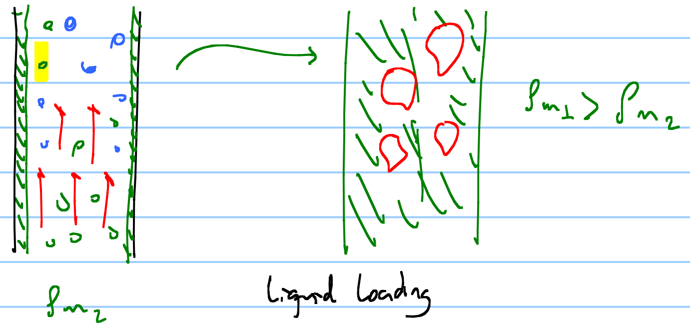
V_e = fluid erosional velocity, feet/second

c = empirical constant

pm = gas/liquid mixture density at flowing pressure and temperature, lbs/ft³

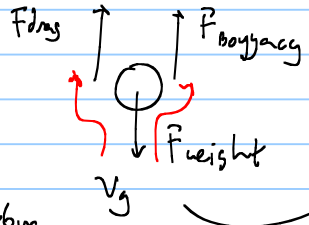
$$\rho_m = \rho_o\left(\frac{q_o}{q_o+q_g+q_w}\right) + \rho_g \cdot \frac{q_g}{(q_o+q_g+q_w)} + \rho_w\left(\frac{q_w}{q_o+q_g+q_w}\right)$$

- In gas wells, V_s must be higher than the critical liquid loading velocity



Liquid loading

Turner criteria



→ V_{gc} critical gas velocity

$v_g \geq V_{gc}$ for all points in the tubing

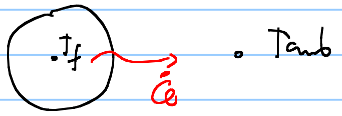
if ϕ is big, then v_g is small and then it could happen $v_g < V_{gc}$

$\Delta p_{pipeline}$
- increase diameter $
- parallel pipeline $

$$q_g = C_{PL} \overbrace{\left(P_{in}^2 - P_{out}^2\right)}^{\propto \Delta p_{pipe}}{}^{0.5}$$

Considerations for choosing pipe diameter

- erosion
- heat transfer



$$\dot{Q} = \underset{\downarrow}{U} \cdot \underset{\sim}{\pi \phi} \cdot L \left(T_f - T_{amb}\right)$$

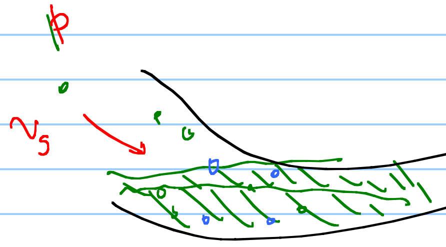
overall heat transfer coefficient

big ϕ → big $\dot{Q}$ → low T_f

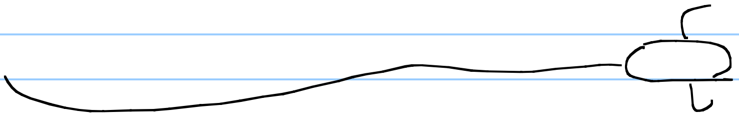
- ↳ liquid dropout in gas systems
- ↳ wax appearance in oil pipes
- ↳ hydrate formation
- ↳ high oil viscosity

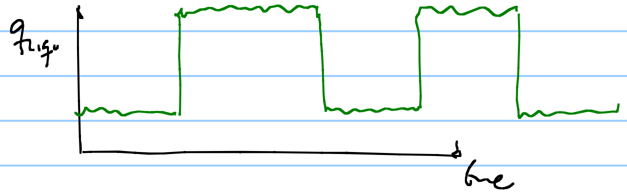
- liquid accumulation in gas pipelines

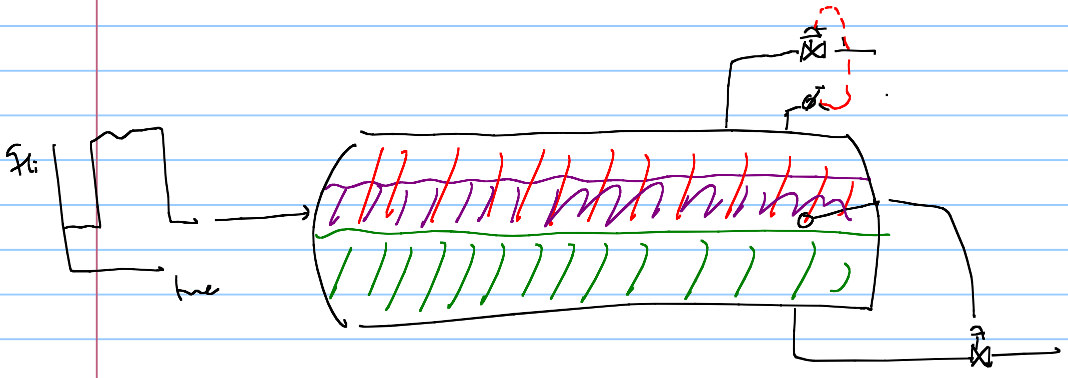
↑ Δp_{pipe}

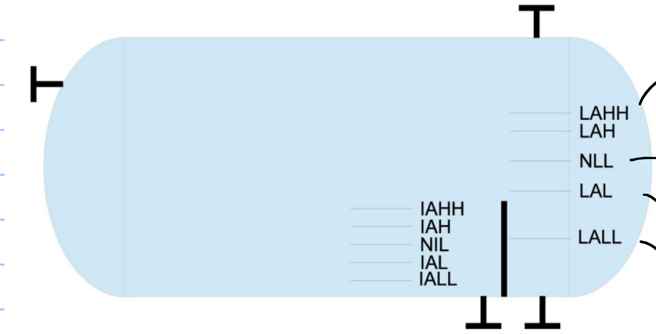


liquid slug might be created in the pipe









level alarm high high

Normal liquid level

level alarm low

level alarm low low