APPS 2018
ASIA PACIFIC PERFORATING SYMPOSIUM

Selection of perforation technique for brown fields: A novel approach

PERFORATORS.ORG
INTERNATIONAL PERFORATING FORUM

EXPRO

APPS-05-18

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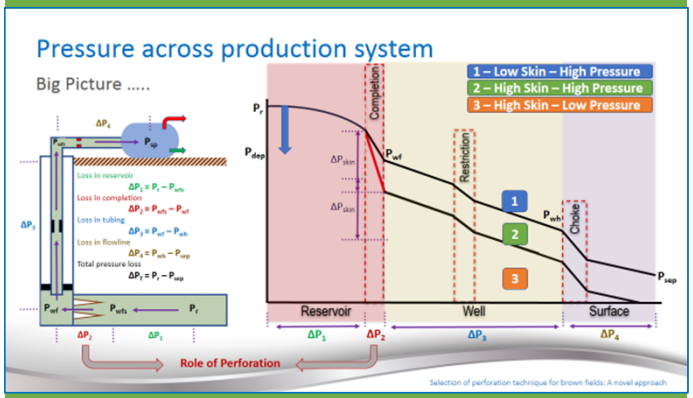
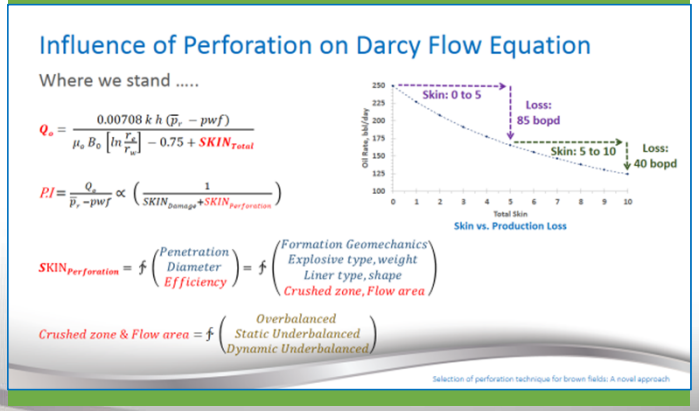
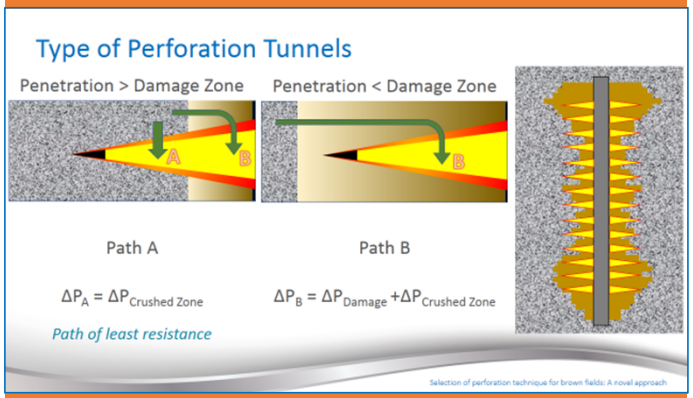
Outline

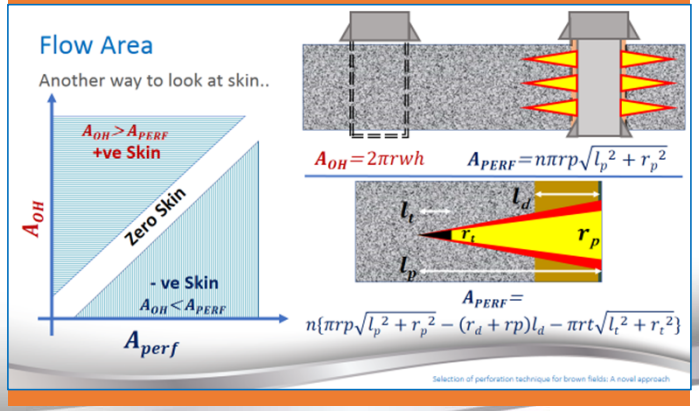
Big Picture



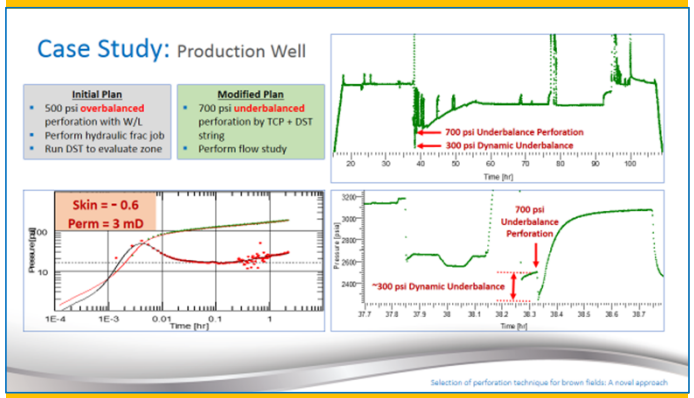


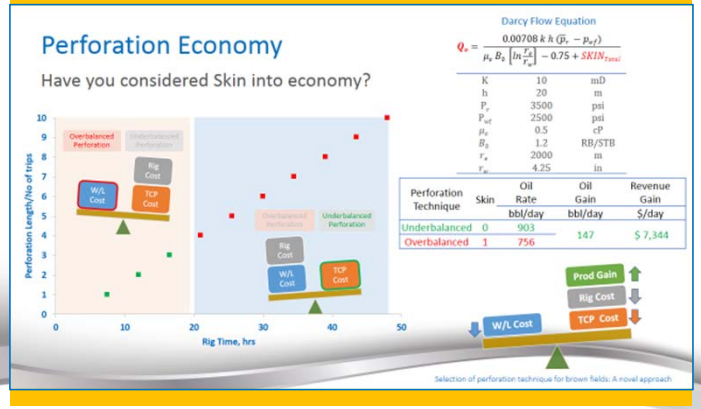
Theory





Case Study / Economy

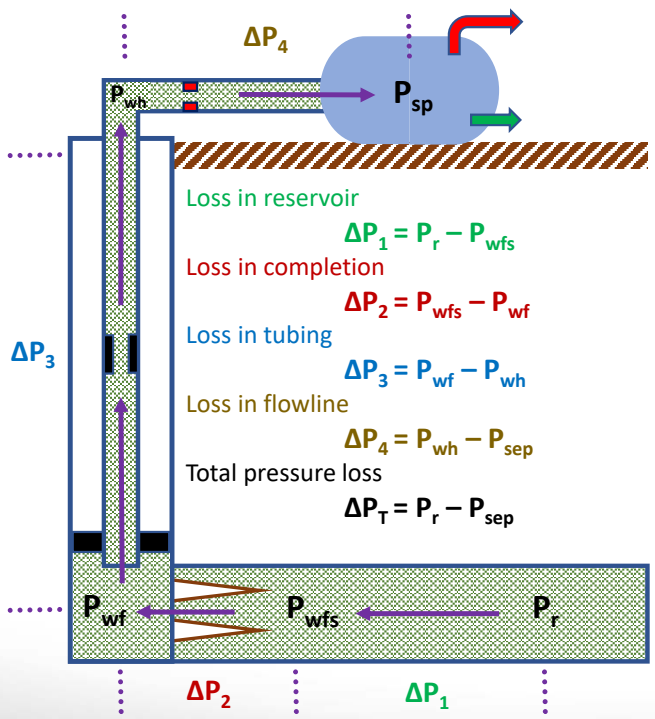


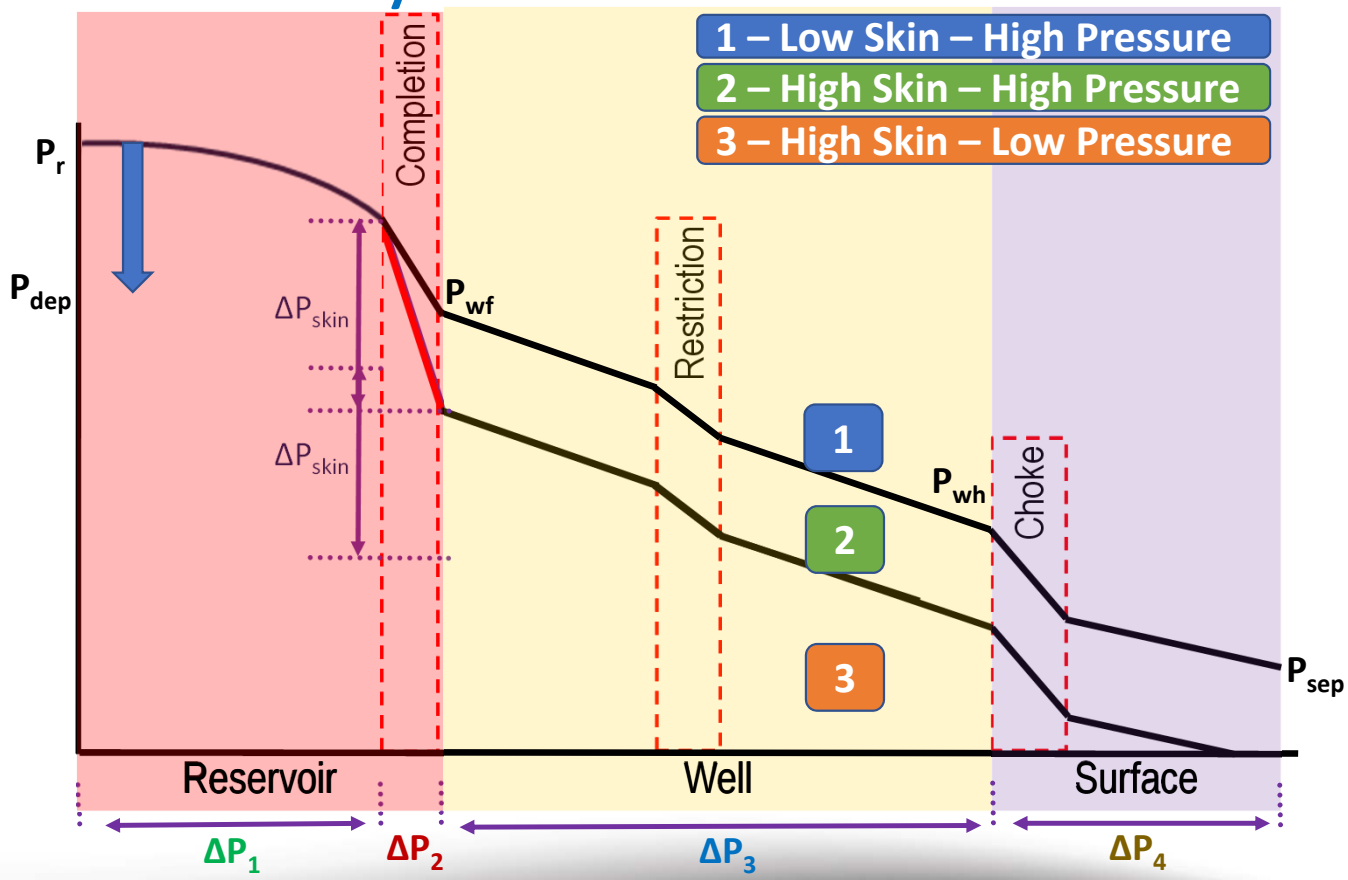


Selection of perforation technique for brown fields: A novel approach

Pressure across production system

Big Picture .....





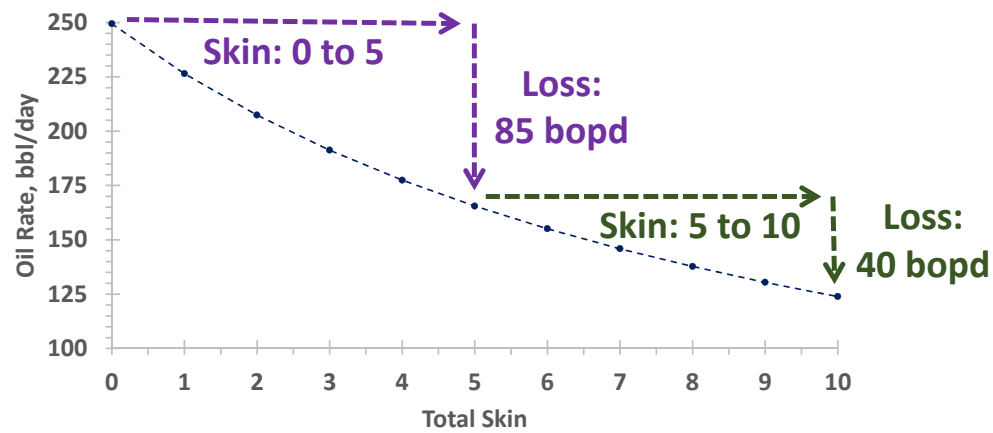
Role of Perforation

Influence of Perforation on Darcy Flow Equation

Where we stand .....

$$Q_o = \frac{0.00708\, k\, h\, (\overline{p}_r - pwf)}{\mu_o B_0 \left[ln \frac{r_e}{r_w}\right] - 0.75 + SKIN_{Total}}$$

$$P.I = \frac{Q_o}{\overline{p}_r - pwf} \propto \left(\frac{1}{SKIN_{Damage} + SKIN_{Perforation}} \right)$$



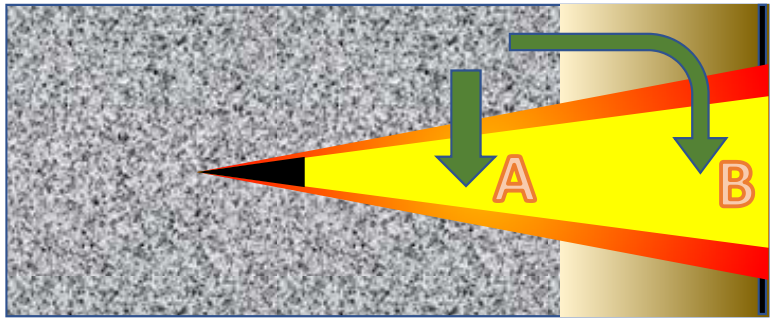
Skin vs. Production Loss

$$SKIN_{Perforation} = f\begin{pmatrix} Penetration \\ Diameter \\ Efficiency \end{pmatrix} = f\begin{pmatrix} Formation\ Geomechanics \\ Explosive\ type, weight \\ Liner\ type, shape \\ Crushed\ zone, Flow\ area \end{pmatrix}$$

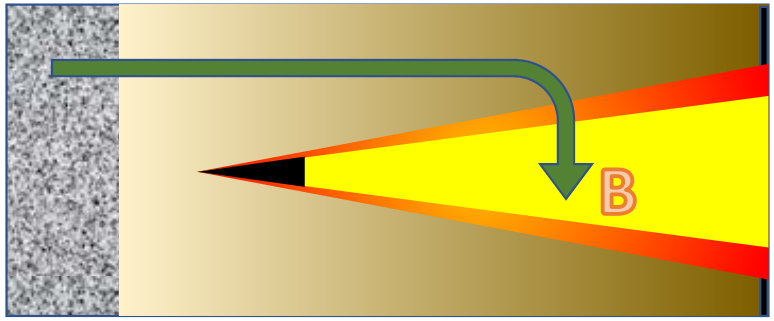
$$Crushed\ zone\ \&\ Flow\ area = f\begin{pmatrix} Overbalanced \\ Static\ Underbalanced \\ Dynamic\ Underbalanced \end{pmatrix}$$

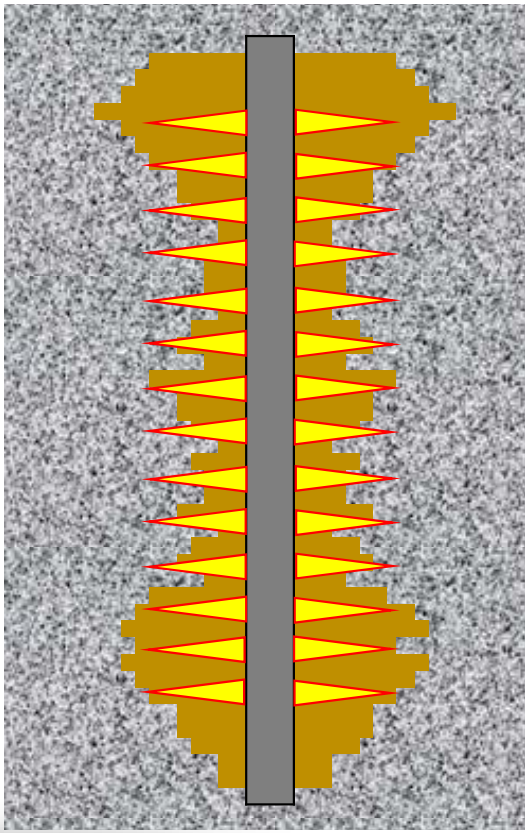
Types of Perforation Tunnels

Penetration > Damage Zone



Penetration < Damage Zone





Path A

Path of least resistance

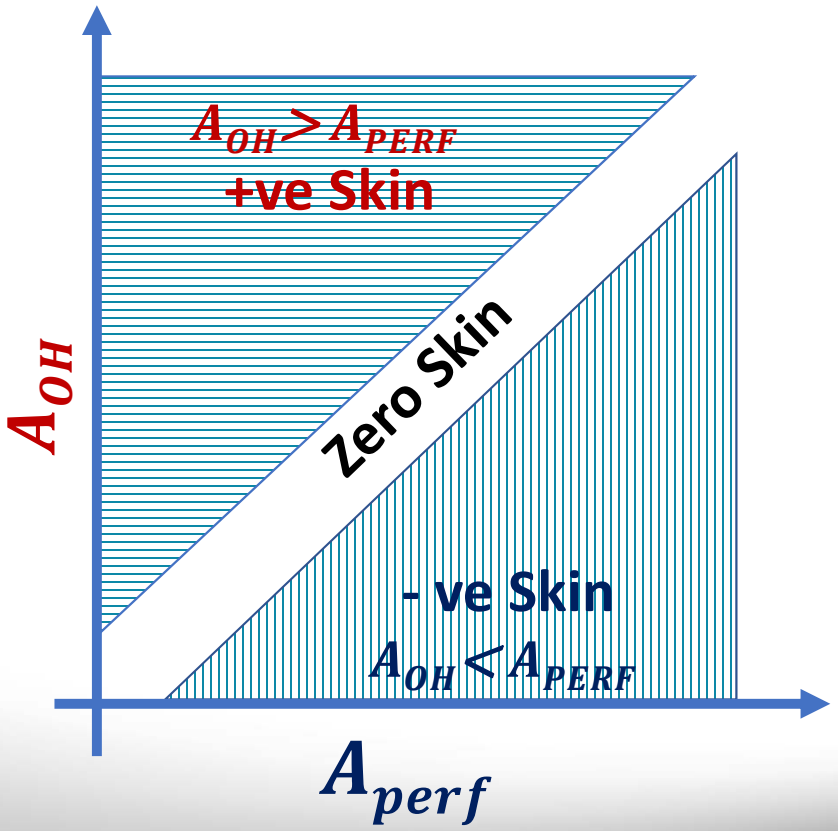
$\Delta P_A = \Delta P_{Crushed\ Zone}$

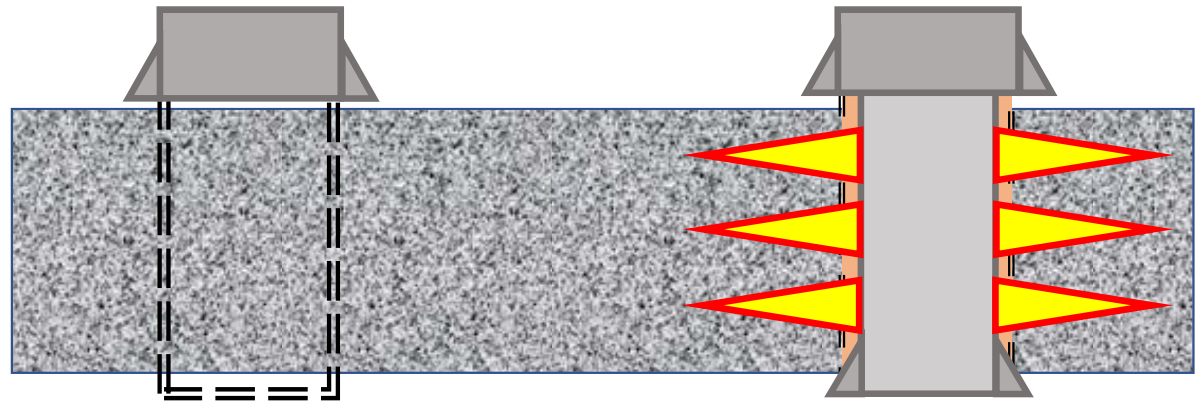
Path B

$\Delta P_B = \Delta P_{Damage} + \Delta P_{Crushed\ Zone}$

Flow Area

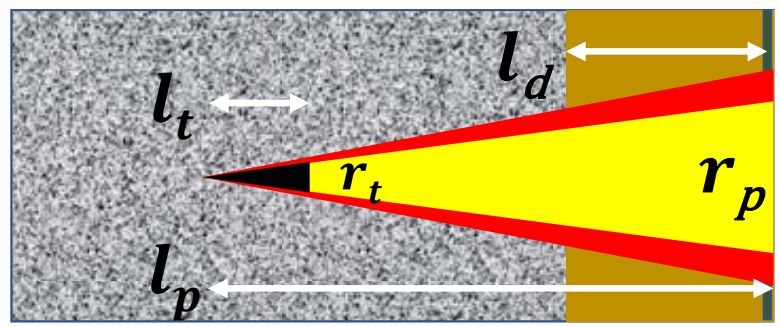
Another way to look at skin..





$$A_{OH} = 2\pi rwh$$

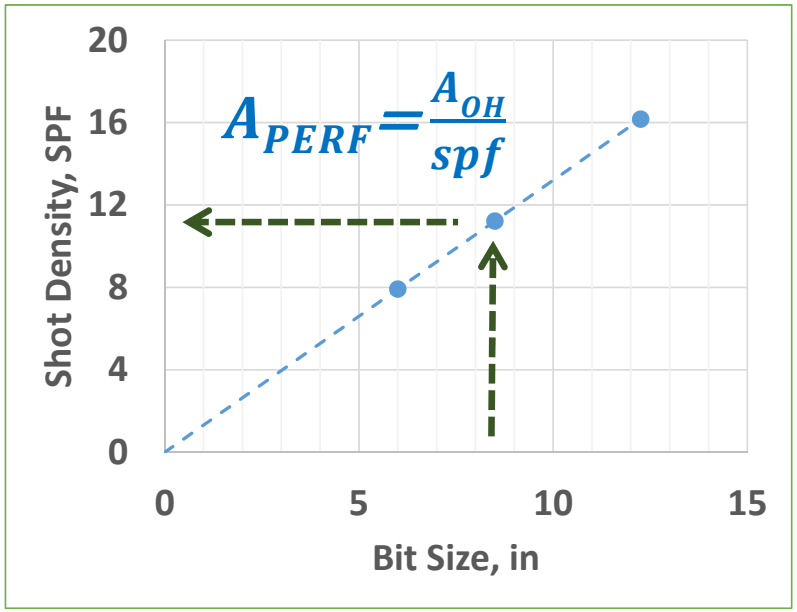
$$A_{PERF} = n\pi rp\sqrt{l_p^{\,2} + r_p^{\,2}}$$



$$A_{PERF} = n\{\pi rp\sqrt{l_p^{\,2} + r_p^{\,2}} - (r_d + rp)l_d - \pi rt\sqrt{l_t^{\,2} + r_t^{\,2}}\}$$

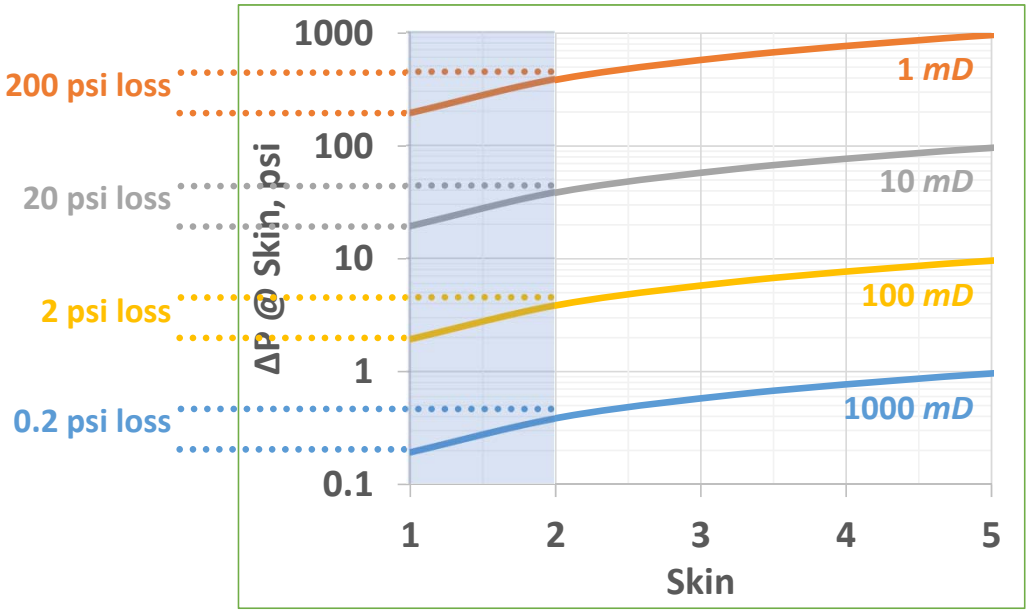
Sensitivity Analysis

Big gun for big hole but what about SPF ??



- SPF should increase with the increase of hole size to achieve larger flow area

Skin acts differently to different permeability



- Skin causes more pressure loss to low k reservoir
- Skin makes more meaning with permeability

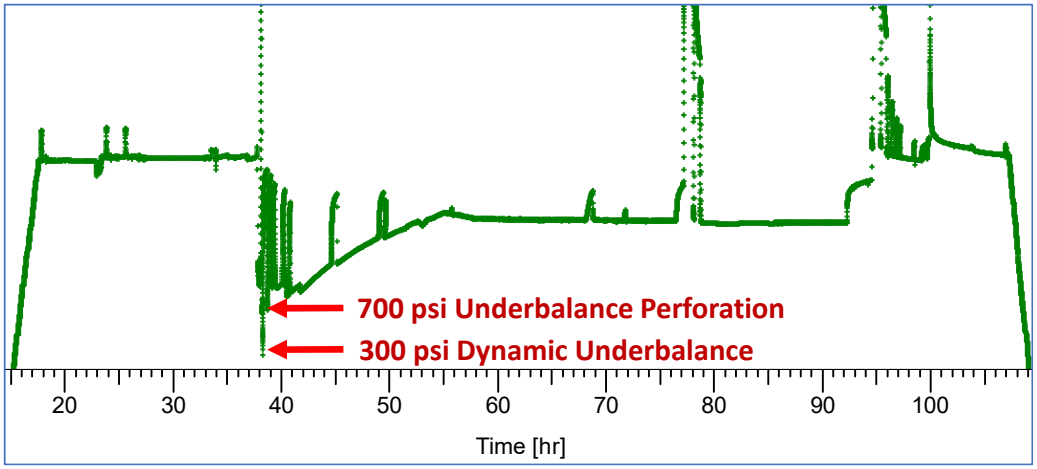
Case Study: Production Well

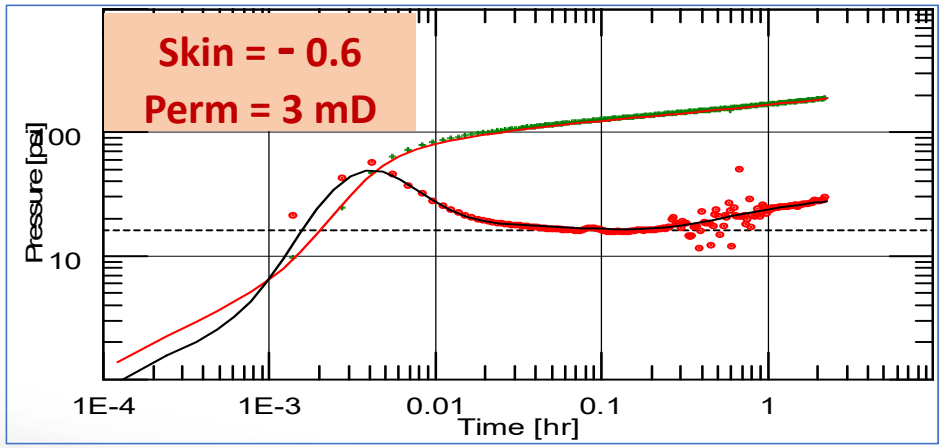
Initial Plan

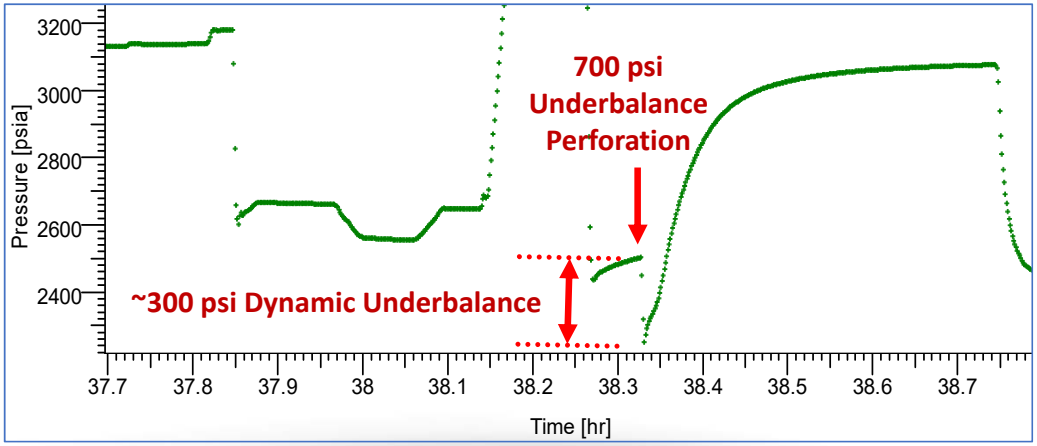
- 500 psi **overbalanced** perforation with W/L
- Perform hydraulic frac job
- Run DST to evaluate zone

Modified Plan

- 700 psi **underbalanced** perforation by TCP + DST string
- Perform flow study

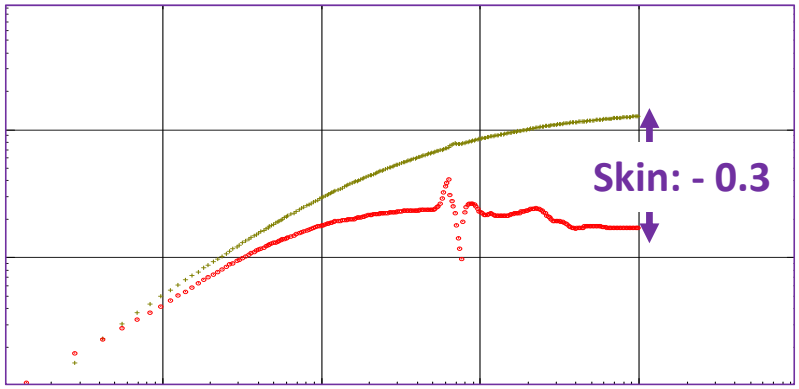


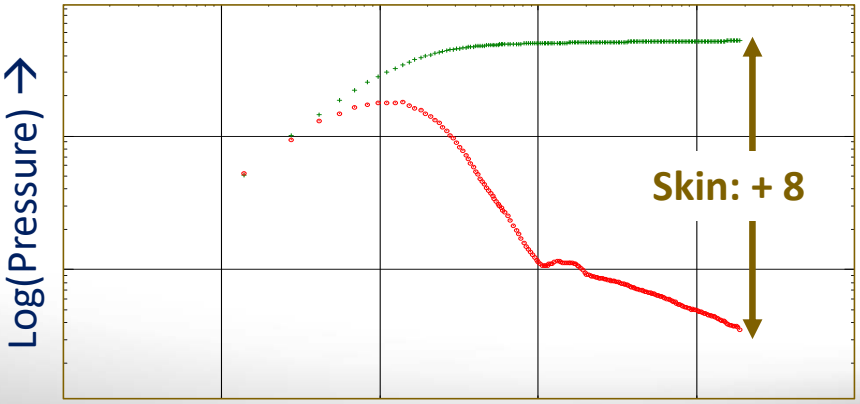




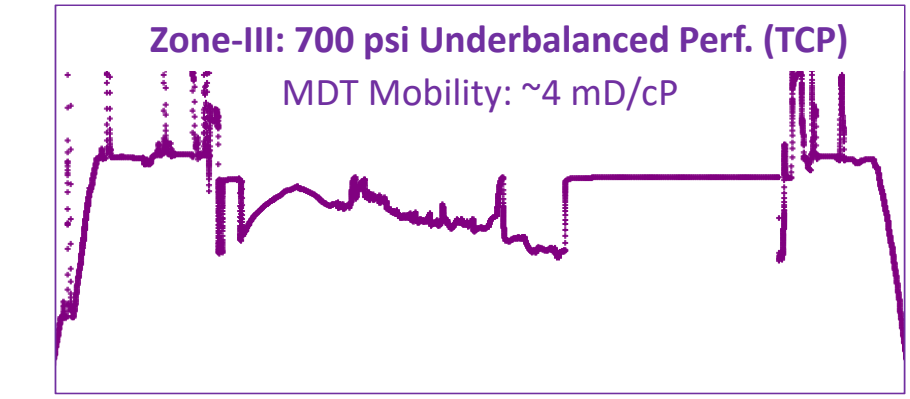
Case Study: Exploration Well

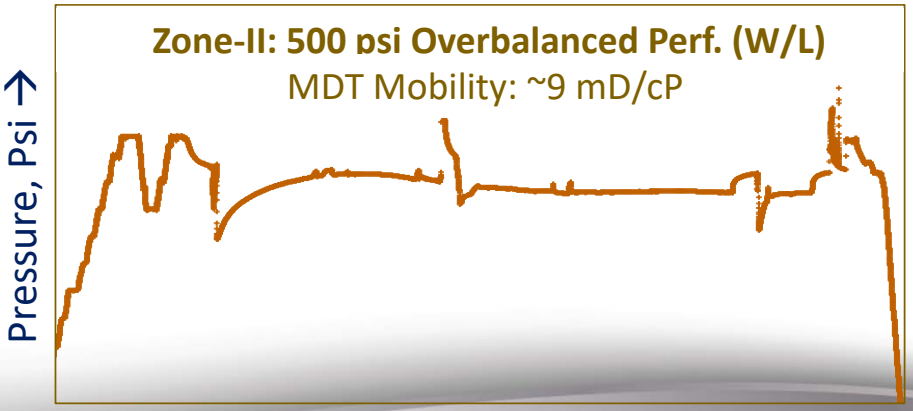
Pressure Derivative Plot

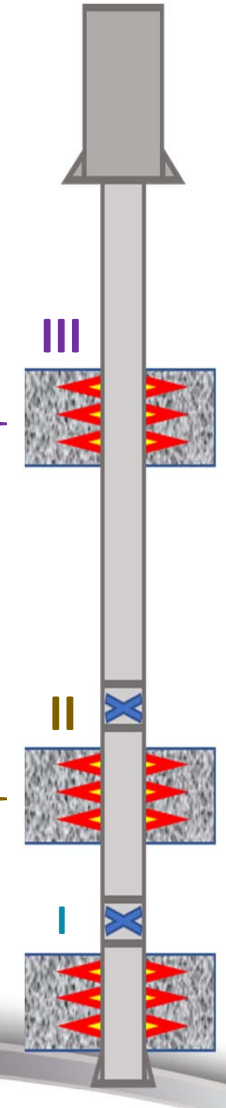




Downhole Pressure-Time Plot

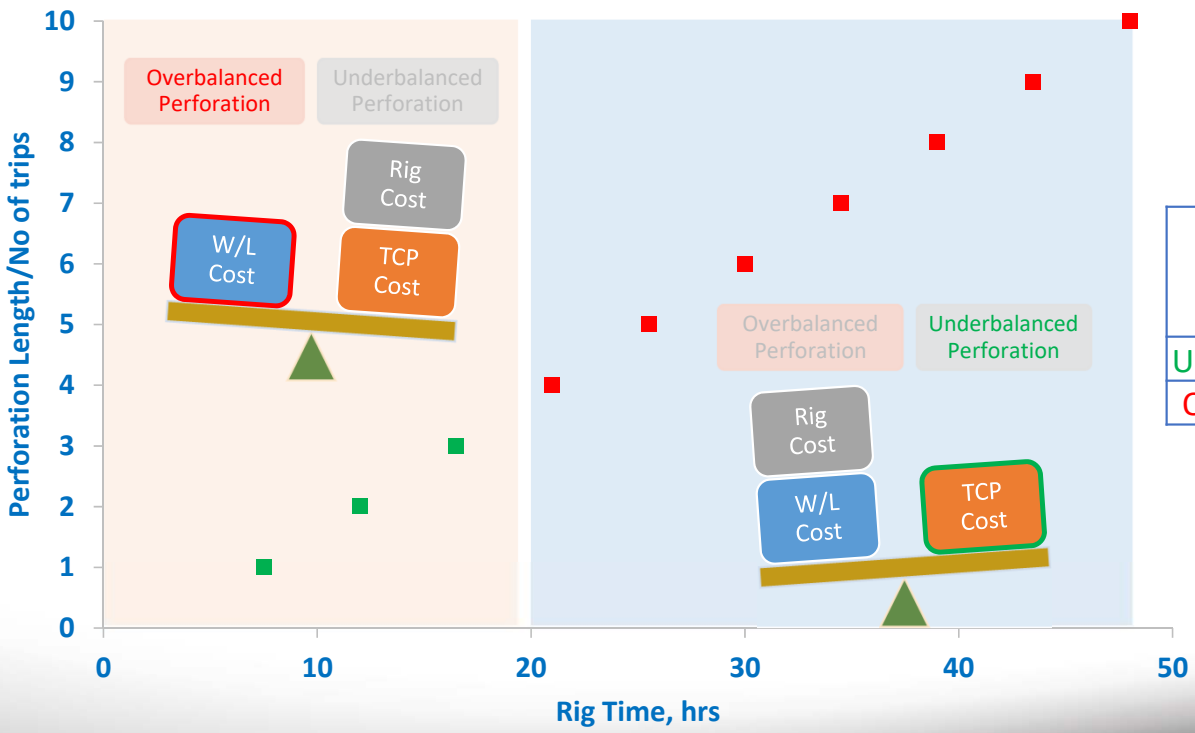






Perforation Economics

Have you considered Skin into the economics?

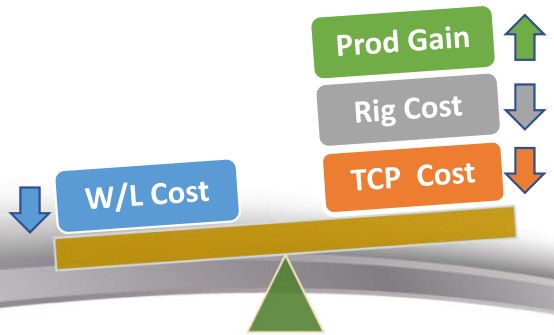


Darcy Flow Equation

$$Q_o = \frac{0.00708\, k\, h\, (\overline{p}_r - pwf)}{\mu_o\, B_0 \left[ln \frac{r_e}{r_w}\right] - 0.75 + SKIN_{Total}}$$

K	10	mD
h	20	m
P_r	3500	psi
P_{wf}	2500	psi
μ_o	0.5	cP
B_0	1.2	RB/STB
r_e	2000	m
r_w	4.25	in

Perforation Technique	Skin	Oil Rate bbl/day	Oil Gain bbl/day	Revenue Gain $/day
Underbalanced	0	903	147	$ 7,344
Overbalanced	1	756		



Conclusion

- Perforation plays a vital role in production
- Lack of knowledge / ignorance are two major factors behind inefficient perforations
- The cost of inefficient perforation is huge
- Each perforation job is unique and needs extensive planning
- Selection of perforation technique should be in favour of reservoir health

QUESTIONS?
THANK YOU!