# Rules of thumb for oil field development

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The Rules of Thumb for oil field development are intended as order of magnitude evaluation of reservoir volumes, productivity and reservoir performance. They are based on a typical undersaturated light oil in moderate to good quality reservoir, but may be scaled to suit the fluid and reservoir properties required. While not replacing more precise evaluation, these allow for rapid estimation as QC on results and/or as a reasonable starting point for further analysis.

STOIIP rule of thumb

The classic STOIIP equation gives the stock tank volume of oil in terms of the net rock volumes and reservoir parameters. Substituting for typical values ϕ_{avg} 25%, S_{oi} 0.8 and B_{oi} 1.3 gives the simple rule of thumb:

$$STOIIP: 1km^2 \text{ area} \times 1m \text{ net} \rightarrow 1MMstb$$
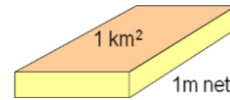
The rule of thumb is modified to give the 'rule' for your field by entering the typical porosity, saturation and shrinkage, usually in the range 0.3 – 1.5:

$$stb/m^3 \leftarrow STOIIP/A.H_{net} = \phi_{avg}.S_{oi}/B_{oi} \times 6.29$$

PI rule of thumb

The classic well inflow equation gives the productivity index for oil in terms of the reservoir permeability, thickness, viscosity, shrinkage and geometric flow factor. Substituting for typical values B_{oi} 1.3, ln r_e / r_w ~ 10

and no skin gives the simple rule of thumb:
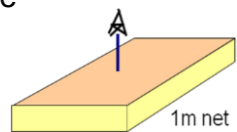
$$PI: 1D.m/cp \rightarrow 2stb/d/psi$$

Completion / damage skin modifies the PI as follows

$$PI \times 1/(1 + S/10)$$

Well count / spacing

In a water injection development the number of wells required can be estimated from basic data. The premise of the 'wash cycle equation' is that a hydrocarbon pore volume should be injected i) at the economically optimal rate, for oil fields typically injecting at ca. 15% pore volume per year; and ii) assuming voidage replacement making a link to oil well performance:

$$N_{prod\ wells} \approx \frac{15\%.HCPV}{365.B_{oi}Q_{oi}}$$

Notes

i. Productivity depends on completion type, e.g. sand control, fraccing.

ii. The rule does not specify injector numbers, only number of producers, but e.g. in a 5-spot pattern the well spacing L depends is given by
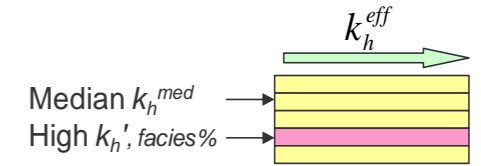
$$L_{inj-prod} = 1/2 \sqrt{N_{prod\ wells}/Area}$$

Horizontal Perm

The presence of a high permeability layer increased horizontal permeability of a reservoir system on the well spacing scale via an arithmetic average:

Additional high perm facies:

$$k_h^{eff} = k_h^{med} + k_h^{high} \times high\ perm\ facies\%$$

k_h^{eff}

Median k_h^{med}
High $k_{h'}$, facies%

Vertical Perm

Principally a function of architecture on the well spacing scale. An unconfined system with little amalgamation has vertical perm from a harmonic average and is dominated by the low perm silts and muds. In a confined system the vertical perm is dominated by the sand-sand connectivity.
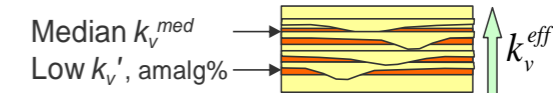
- Layered system: perm is a vertical harmonic average, which is dominated by the lowest perm facies:

$$k_v^{eff} = k_v^{low}/low\ perm\ facies\%$$

Median k_v^{med}
Low $k_{v'}$, facies %
k_v^{eff}
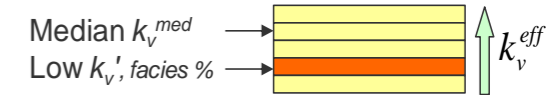
- Amalgamated sands: perm is the median perm times the fraction amalgamated, i.e. sand on sand, flow paths:

$$k_v^{eff} = k_v^{med} \times amalgamated\%$$

Median k_v^{med}
Low $k_{v'}$, amalg%
k_v^{eff}

(In the above, k_h^{med}, k_v^{med} are the median permeabilities, i.e. of the dominant facies; k_v^{low} is the vertical permeability of a low perm heterogeneity facies).

Flooding rule of thumb

The flood front velocity for a stable displacement is proportional to the applied pressure gradient between producers and injectors or aquifer. Typical values μ_w 0.4 cp, k'_{rw} 0.3, B_{oi} 1.3, S_{om} 0.6, gives the simple rule of thumb:

$$FV: 1D \times 1\ psi/km \rightarrow 1\ m/yr$$

where the flooding velocity FV is defined by

$$FV = \frac{k'_{rw}k_{avg}}{\varphi.\mu_w.S_{om}}.\frac{\Delta P}{L}$$

Also of note is how the fluid static gradient $\Delta\rho.g$ ~ 0.15 psi/ft compares to reservoir gradients:

$$0.15\ psi/ft \sim 500\ psi/km \sim 30\ bar/km$$