Horizontal well tests
A horizontal well is one that the wellbore is parallel to the plane of the formation that is produced.

Dimensionless variables used for horizontal wells

\[ p_D = \frac{kh}{141.2qB\mu}(p_i - p) \]

\[ t_D = \frac{0.0002637k}{\theta c_t \mu \left( \frac{L_h}{2} \right) z t} \]

\[ L_D = \frac{L_h}{2h} \sqrt{\frac{k_z}{k}} \]

\[ z_D = \frac{Z}{h} \quad r_{WD} = \frac{r_{w,eq}}{h} \]

\[ r_{w,eq} = \frac{r_w}{2} \left[ \left( \frac{k_y}{k_z} \right)^{.25} + \left( \frac{k_z}{k_y} \right)^{.25} \right] \]

h is the height or thickness of the formation and z is the distance from the wellbore to the nearest boundary.
Flow Regimes for horizontal wells

ERF, early radial flow, At early times the flow toward a horizontal well occurs only in the vertical (y,z) plane normal to the axis of the well. This behavior is exactly like the infinite acting flow in a vertical well. This regime ends when the influence of the top and bottom boundaries is felt or when flow across the tips of the well become significant. If the well is close to one on the boundaries the radial flow may become hemiradial after some time. This regime is usually masked by wellbore storage.

ILF, intermediate linear flow, During ILF, flow is in the direction normal to the well axis (y) in the horizontal plane. This is identical to the early time linear flow in a vertical fractured well. This regime ends when the flow in the x direction (across the tips) becomes considerable.

LRF (pseudoradial), When the flow across the tips becomes significant a 2D flow period in the horizontal (x,y) plane develops. This flow has the same characteristics of a vertical fractured well and the end of this flow is determined by the boundaries in the lateral direction.

Boundary-Dominated Flow When the lateral boundaries influence the well response. If the horizontal well does not penetrate more than half of the reservoir dimension parallel to the well axis the flow characteristics as those of a vertical fractured well. For longer wells the flow may be linear normal to the axis of the well, referred to as late time linear flow.

Calculation of Reservoir Properies

Straight line analysis, Since there are 3 infinite acting regimes for a horizontal well, we can have 3 different straight lines to analyze.
ERF analysis
During the ERF period a plot of $\Delta p$ vs log $t$ should be a straight line with the slope of

$$|m_{er}| = \frac{162.6qB\mu}{\sqrt{k_yk_zL_h}}$$

used to estimate $\sqrt{k_yk_z}$

Estimate skin

$$s = \frac{1.151kh}{\sqrt{k_yk_zL_h}} \left( \frac{\Delta p_{wf}}{|m_{er}|} \log t - \log \left( \frac{\sqrt{k_yk_z}}{\theta c_t\mu r_w^2} + 3.23 \right) \right)$$

ERF period ends

$$t \leq \frac{\theta c_t\mu}{2.637 \cdot 10^{-4}} \min \left\{ \left( \frac{L_h/2}{k_s} \right)^2; \frac{z_w^2}{5k_z}; \frac{(z_w-h)^2}{5k_z} \right\}$$

If ERF is hemiradial the slope is twice by that given by the above equation, the right hand side of the $s$ equation should be multiplied by 2.

ILF analysis
During the ILF period the slope of the log-log plot of $dp'$ vs $t$ should display a straight line with the slope of $\frac{1}{2}$. This can be used to indentify this regime, but in most cases this will be masked by wellbore storage. The Cartesian plot of $p_{wf}$ of $\Delta p$ vs $\sqrt{t}$ should display a straight line with the slope of

$$|m_{il}| = \frac{8.13qB\sqrt{\mu}}{\sqrt{\theta c_tk_yL_h}}$$

used to estimate $k_y$

$$s = \frac{L_h\sqrt{k_yk_z}}{141.2qB\mu} \Delta p_{wf} (t = 0) - s_z$$
\[ s_z = -ln\left(\frac{r_w}{h}\right) + \frac{1}{4} ln\left(\frac{k_y}{k_z}\right) - ln\left(\sin\frac{\pi z_w}{h}\right) - 1.838 \]

ILF exists for

\[ \frac{160 \theta c_t \mu L_h^2}{k_s} \geq t \geq \max \left\{ \frac{1800 z_w^2 \theta c_t \mu}{k_z} ; \frac{1800 (h-z_w)^2 \theta c_t \mu}{k_z} \right\} \]

LFR analysis

During this period the plot of \( \Delta p \) or \( p_{wf} \) vs log of \( t \) should display a straight line with a slope of

\[ |m_{lr}| = \frac{162.6 q B \mu}{\sqrt{k_z k_y h}} \]

Skin

\[ s = 1.151 \left[ \frac{\Delta p_w}{|m_{lr}|} - \log t - \log \frac{\sqrt{k_x k_y}}{\theta c_t \mu r_{weq}^2} + 3.23 \right] \]

The \( \Delta p_{wf} \) is on the straight line at \( t \).

LFR exists for

\[ t \geq \max \left\{ \frac{988 \theta c_t \mu L_h^2}{k_z} ; \frac{2515 \theta c_t \mu h^2}{k_z} \right\} \]

Wellbore Storage

\[ p_{WD} = \frac{t_D}{C_D} \quad \quad C_D = \frac{5.615 C}{2 \pi \theta c_t h \left( L_h/2 \right)^2} \]

\[ p_{wf} = p_i - \frac{q B}{24 C} t \]
On a Cartesian plot of $\Delta p$ vs $t$ should display a straight line with a slope of

$$|m| = \frac{qB}{24C}$$