

## HORIZONTAL WELL TESTS ANALYSIS USING KAPPA (ECRIN) SOFTWARE

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### ABSTRACT

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Horizontal wells technology has provided motivation for many applications in the Petroleum Industry, in naturally fractured reservoirs, horizontal wells has been used to intersect fractures and drain them and the reservoir effectively. Horizontal wells also allow operators to take advantage of highly heterogeneous layered reservoirs, reservoirs with fractures, reservoir with gas and water coning problems, heavy oil reservoirs water flood and enhanced oil recovery (EOR) application to increase injectivity and improved sweep efficiency. The main objective of this paper is to estimate the three dimensions permeability and skin factor using two different tools first was using Excel sheet by inserting the equation and analysis the flow periods the by using Kappa(ECRIN)software. The results obtained were good matched for two wells and the third well (E38) was hard to be matched in ECRIN but in Excel was analyzed by divided the curves in to three periods, and the other close to each in first and second wells (E37 -E39) when comparison made between Excel sheet and Kappa(ECRIN) software the  $k_y$  over  $k_z$  permeability was estimated as 37.41md (ECRIN39.7md) and to total skin factor-5.15 (ECRIN-7.25) for E37 moreover for well E39 the  $k_y$  over  $k_z$  permeability was estimated at 35.5 md (ECRIN 42.4md) and total skin factor -6.19 (ECRIN -7.01). ECRIN software was very hard and didn't reach to a modelling well E38 because every scattering in pressure derivative, gave permeability 111.3 md in Y dimension in Excel sheet and -1.62 skin factor.

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### 1.0 Introduction

Horizontal wells could turn out to be one of the most important technological developments of the decade. In the last few years, technology to drill horizontal wells has advanced significantly. Where thousands of these well have been drilled successfully all over the world; currently, various commercial techniques are available to drill, complete and test horizontal wells. The first recorded true horizontal oil well, drilled near Texon, Texas, was completed in 1929. Another was drilled in 1944 in the Franklin Heavy Oil Field, Venango County, Pennsylvania. However, little practical application occurred until the early 1980's.

Starting in the early 1980s, horizontal wells have been extremely popular in the oil industry; therefore, nowadays they are more often exercised in developing oil and gas fields. The rapid increase in the applications of horizontal-well technology brought a massive development of the procedures to evaluate the performances of horizontal wells.

Horizontal wells have a higher productivity and pay contact per well than vertical wells, thereby reducing the number of wells required to drain the reservoir. Horizontal wells allow operators to take advantage of highly heterogeneous or layered reservoirs, reservoirs with fractures, reservoir with gas and water coning problems, heavy oil reservoirs waterflood and enhanced oil recovery (EOR) application to increase injectivity and improved sweep efficiency. An important consideration is the well completion scheme. One can either have an open hole, insert a slotted liner, insert a liner with external casing packers, or case the hole and perforate the casing, depending upon local completion needs and experience. The type of completion affects horizontal well performance and certain types of completions are possible with certain types of drilling techniques and in certain formations. Well length, the well's physical location in the reservoir, the tolerance in drilling location, and the type of completion that can be achieved strongly affect well performance. Therefore, it is very important for reservoir engineers to understand different drilling and completion techniques and their advantages and disadvantages.

## 2.0 Materials and Methods

The interpretation of well tests from horizontal wells is much more difficult than interpretation of those from vertical wells because of a considerable wellbore storage effect, the three-dimensional nature of the flow geometry and lack of radial symmetry. The objective of well test interpretation is to estimate the reservoir/well parameters such as: wellbore storage coefficient, vertical and horizontal permeabilities, effective flowing length and mechanical skin factor.

The analysis of individual flow regimes provides relevant information about important reservoir and well characteristics. The durations of these flow regimes and the pertinent equations for calculating reservoir and well parameters. There are two methods to the interpretation of horizontal well test data; the Segmental Analysis Approach, and the Integrated Model Approach. In this section, we will discuss both methods, followed by the advantages and disadvantages of each of which.

Segmental Analysis Approach. In this method, two steps should be followed in the interpretation of horizontal well test data, Fluid Flow Regime Identification, and Reservoir and Well Parameters Estimation. The horizontal well tests are best interpreted using a log-log representation of the pressure-time data ( $\Delta p$  vs.  $\Delta t$ ) in conjunction with the derivative curve ( $d p / d (\log \Delta t)$  vs.  $\Delta t$ ) to identify whether the wellbore storage is affecting the early time readings or not, and to diagnose the characteristic behavior of the system and identify specific flow regimes as shown in the Figure (1).

Figure (1) illustrates the character of the log-log plot in relation to the flow regimes under ideal conditions. The wellbore storage will result in unit (1) slope on a log-log plot of the pressure-time data curve. The early-time radial flow regime is characterized by the flattening of the derivative curve (i.e., zero slopes). However, in many systems, the duration of early-time radial flow could be relatively short and can be easily masked by wellbore storage effects. During the early-time linear flow regime, if develops, the linear flow regime is characterized by a positive half-slope "trend" on the derivative curve, theoretically located as a constant slope line between

the early and the late time radial flow regimes. The late-time radial flow regime is also characterized by the flattening of the derivative curve. If the test is continued for a long time, a second "Late-time" linear flow regime will be recognized in case of parallel faults with the horizontal well perpendicular to them. After the flow regimes are identified in the previous step. Then the specialized plots such as semi-log, square root, etc, must be used to extract the effective reservoir /well parameters of each flow regime, typically permeability and skin factor.

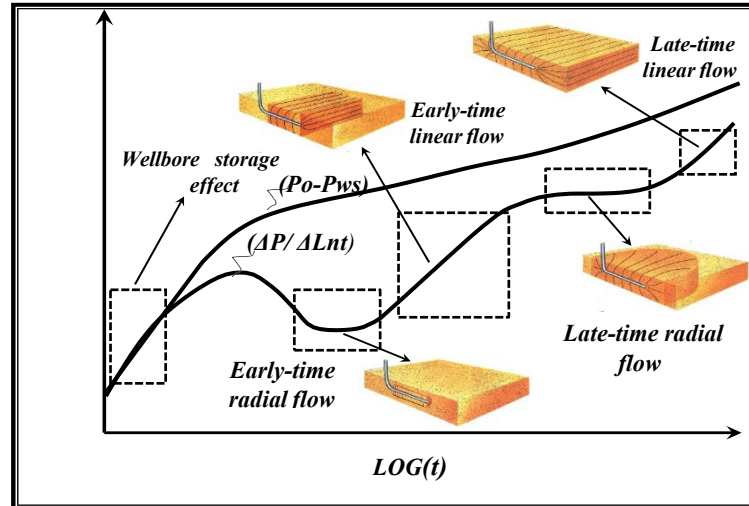


Figure 1: Transient pressure performance in a horizontal well

### 3.0 Theory and Calculation

Mathematical First Radial Flow Period:

Babu and Odeh (6) derived an equation Eq.(1) describes the flow behavior of a horizontal well producing at a constant rate during this period as the following:

$$P_i - P_{wf} = \left( \frac{162.6q \mu B_o}{\sqrt{k_x k_z} L} \right) \left[ \log \left( \frac{t \sqrt{k_x k_z}}{\phi \mu c_t r_w^2} \right) - 3.23 + 0.87 S_m \right] \quad (1)$$

A plot of  $p_{wf}$  vs.  $t$  for draw down test data and plot of  $p_{ws}$  vs.  $(tp+\Delta t)/\Delta t$  for build up test data on semi-log paper gives a straight line with slope  $m_{1r}$ , from this slope can be calculate the geometric average permeability  $\sqrt{k_x k_z}$  and the mechanical skin  $S_m$  as the following:

$$\sqrt{k_x k_z} = \frac{162.6q \mu B_o}{m_{1r} L} \quad (2)$$

$$S_m = 1.151 \left[ \frac{\Delta P_{1hr}}{m_{1r}} - \log \left( \frac{\sqrt{k_x k_z}}{\phi \mu c_t r_w^2} \right) + 3.23 \right] \quad (3)$$

Where:  $\Delta p_{1hr} = (p_i - p_{1hr})$  for drawdown test, and  $\Delta p_{1hr} = (p_{\Delta t=1} - p_{wfo})$  for buildup test.

First Linear Flow Period:

A requirement of L for this early linear flow period to occur is given by the following equation:

$$L > 3.33D_z \sqrt{\frac{k_y}{k_z}}; \text{ Where: } D_z = \max(z_o, h - z_o)$$

Babu and Odeh derived an equation Eq.(4) describes the flow behavior of a horizontal well producing at a constant rate during this period as the following:

$$p_i - p_{wf} = \left( \frac{8.13q \mu B_o}{L h} \right) \left( \sqrt{\frac{t}{\phi \mu c_t k_x}} + \frac{17.37 h}{\sqrt{k_x k_v}} (S_z + S_m) \right) \quad (4)$$

A plot of p<sub>wf</sub> vs. t for drawdown test data and p<sub>ws</sub> vs.  $(\sqrt{t_p + \Delta t} - \sqrt{\Delta t})$  for buildup test data on linear paper should result in a straight line with a slope mL1, from this slope the horizontal permeability in x-direction k<sub>x</sub> can be calculated by using Eq.(5), and the mechanical skin from Eq.(6).

$$k_x = \left( \frac{8.13q \mu B_o}{m_{1L} L h} \right)^2 / \phi \mu c_t \quad (5)$$

$$S_m = \left( \frac{L \sqrt{k_x k_z}}{141.2 q \mu B_o} \right) \Delta P_{0hr} - S_z \quad (6)$$

Where:  $\Delta p_{0hr} = (p_i - p_{0hr})$  for drawdown test, and  $\Delta p_{0hr} = (p_{\Delta t=0} - p_{wfo})$  for buildup test.

S<sub>z</sub> is the pseudo skin may be visualized as the skin resulting from partial penetration in the vertical direction, given by:

$$S_z = \ln\left(\frac{h}{r_w}\right) + 0.25 \times \ln\left(\frac{k_x}{k_v}\right) - \ln\left(\sin\frac{180^\circ(d_z)}{h}\right) - 1.838 \quad (7)$$

### Second Radial Flow Period:

For this period to occur, the penetration ratio should be  $L/b < 0.45$ . Babu and Odeh derived the following equation Eq.(8) to describe the flow in this period:

$$p_i - p_{wf} = \left( \frac{162.6q \mu B_o}{h \sqrt{k_x k_y}} \right) \left[ \log\left(\frac{k_y t}{\phi \mu c_t L^2}\right) - 1.76 + 0.87 \sqrt{\frac{k_y}{k_v}} \frac{h}{L} (S_z + S_m) \right] \quad (8)$$

A plot of p<sub>wf</sub> vs. t for the drawdown test data and p<sub>ws</sub> vs.  $(t_p + \Delta t) / \Delta t$  for buildup test data on semi-log paper gives a straight line with slope mr2, from this slope can be calculate the geometric average permeability  $\sqrt{k_x k_y}$  in horizontal plane and the mechanical skin S<sub>m</sub> as the following:

$$\sqrt{k_x k_y} = \frac{162.6q \mu B_o}{m_{2r} h} \quad (9)$$

$$S_m = \left( 1.151 \sqrt{\frac{k_z L}{k_y h}} \right) \left[ \frac{\Delta P_{1hr}}{m_{2r}} - \log\left(\frac{k_y}{\phi \mu c_t L^2}\right) + 1.76 \right] - S_z \quad (10)$$

Where:  $\Delta p_{1hr} = (p_i - p_{1hr})$  for drawdown test, and

$\Delta p_{1hr} = (p_{\Delta t=1} - p_{wfo})$  for buildup test.

$S_z$  as in Eq.(7).

Second Linear Flow Period:

Babu and Odeh derived the following equation Eq.(11) to describe the flow in this period:

$$P_i - P_{wf} = \left( \frac{8.13q \mu B_o}{b h} \right) \left( \sqrt{\frac{t}{\phi \mu c_t k_x}} + \frac{17.37 h}{\sqrt{k_x k_z}} (S_z + S_t) \right) \quad (11)$$

A plot of pwf vs. t for drawdown test data and pws vs.  $(\sqrt{t_p + \Delta t} - \sqrt{\Delta t})$  for buildup test data on linear paper should result in a straight line with a slope mL2, from which the horizontal permeability in x-direction  $k_x$  can be calculated and also the total skin  $S_t$  as the following:

$$k_x = \left( \frac{8.13q \mu B_o}{m_{2L} b h} \right)^2 / \phi \mu c_t \quad (12)$$

$$S_t = \left( \frac{L \sqrt{k_x k_z}}{141.2 q \mu B_o} \right) \Delta P_{ohr} - S_z \quad (13)$$

This is the only flow period that reflects the total skin,  $S_t$  Where:

$$S_t = S_m \left( \frac{b}{L} \right) + S_R \quad (14)$$

Where:

$S_R$  = Skin due to partial penetration in all directions.

$S_z$  as in Eq.(9).

To calculate the  $S_m$ , we need calculate  $S_R$  as shown below, once  $S_R$  is calculated, then

$$S_m = (L/b) (S_t - S_R).$$

Calculation of  $S_R$  :

As known,  $S_R = 0$  when  $L = b$ . If  $L < b$ , then the value of partial penetration skin factor  $S_R$  depends upon the following two conditions:

Case (a):

$$S_R = PXYZ + P'XY \quad (15)$$

The PXYZ Component is a result of the degree of penetration ( $L/b$ ), and the P'XY component is a result of the location of the well in x-y plane. The skin component resulting from the z location is negligible.

$$P_{XYZ} = \left( \frac{b}{L} - 1 \right) \left[ \ln \left( \frac{h}{r_w} \right) + 0.25 \ln \left( \frac{k_x}{k_z} \right) - \ln \left( \sin \frac{180^\circ z_o}{h} \right) - 1.84 \right] \quad (16)$$

$$P'_{XY} = \left( \frac{2b^2}{Lh} \sqrt{\frac{k_z}{k_y}} \right) \left[ F\left(\frac{L}{2b}\right) + 0.5 \left[ F\left(\frac{4y_{mid}+L}{2b}\right) - F\left(\frac{4y_{mid}-L}{2b}\right) \right] \right] \quad (17)$$

Where pressure computations are made at  $y_{mid} = (y_1+y_2)/2$ . (i.e. the midpoint along the well length).

$$F\left(\frac{L}{2b}\right) = -\left(\frac{L}{2b}\right) \left[ 0.145 + \ln\left(\frac{L}{2b}\right) - 0.137\left(\frac{L}{2b}\right)^2 \right] \quad (18)$$

The evaluation of  $F[(4y_{mid}+L)/2b]$  and  $F[(4y_{mid}-L)/2b]$  depends on their arguments; i.e.  $(4y_{mid}+L)/2b$  and  $(4y_{mid}-L)/2b$ . If the argument  $< 1$ , Eq.(18) is used. In this case,  $(L/2b)$  is replaced by  $(4y_{mid}+L)/2b$  and/or  $(4y_{mid}-L)/2b$ . On the other hand, if the argument  $> 1$ , then the following equation is used:

$$F(x) = (2-x) \left[ 0.145 + \ln(2-x) - 0.137(2-x)^2 \right] \quad (19)$$

Where  $F(x)$  = Function used to describe effects of well location in horizontal plane,  $x = (4y_{mid}+L)/2b$  or  $(4y_{mid}-L)/2b$ , with  $x > 1$ .

Case (b):

$$SR = P_{XYZ} + P_Y + P_{XY} \quad (20)$$

The  $P_{XYZ}$  Component is given by Eq.(16).

$$P_Y = \left( \frac{6.28b^2}{ah} \right) \left( \frac{\sqrt{k_x k_z}}{k_y} \right) \left[ \left( \frac{1}{3} - \frac{y_{mid}}{b} + \frac{y_{mid}^2}{b^2} \right) + \frac{L}{24b} \left( \frac{L}{b} - 3 \right) \right] \quad (21)$$

$$P_{XY} = \left( \frac{b}{L} - 1 \right) \left( \frac{6.82a}{h} \sqrt{\frac{k_z}{k_x}} \right) \left( \frac{1}{3} - \frac{x_o}{a} + \frac{x_o^2}{a^2} \right) \quad (22)$$

### 3.1 Mathematical Expressions and Symbols

This study includes three horizontal wells which are analysis by buildup test using ECRIN software and Excel sheet to confirm the results to estimate the permeability, skin factor and reservoir pressure. This chapter focused on analysis, it will be analysed to determine permeability, skin factor and reservoir pressure.

3.1.1 Buildup Analysis (Well -E37)

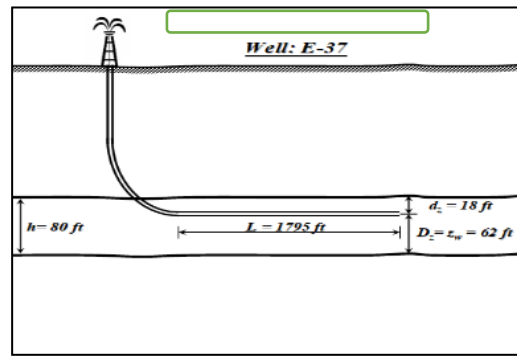


Figure 2: Horizontal well location in the vertical plane well E37

Step (1): General Data Required for the Test Analysis:

Table 1: Input Data for Buildup Test well E37

Field Name	103E.
Well Orientation	Horizontal
Well Completion	Open Hole
Last Oil Production Rate, $q$	1313 STB/day
Producing Time, $t_p$	54 hrs
Well Drilling Length, $L$	1795 ft
Well Radius, $r_w$	0.354 ft
Vertical Well Location, $z_w$	62 ft
Nearest Upper or Lower Boundary, $d_z$	18 ft
Shortest Distance Between Well and x-Boundary, $d_x$	1450 ft
Shortest Distance Between Tip of Well and y-Boundary, $d_y$	553 ft
Longest Distance Between Tip of Well and y-Boundary, $D_y$	553 ft
Longest Distance Between Well and z-Boundary, $D_z$	62 ft
Vertical Section Spacing, $A$	104 acres
Layer Net Thickness, $h$	80 ft

Layer Porosity, $\phi$	25.0 %
Oil Formation Volume Factor, B	1.3 res bbl/STB
Total Compressibility, $C_t$	$12.0 \times 10^{-6}$ /psi

The well “E37” was producing at a rate of about 1313 STB/day oil, a producing time of 54 hours was calculated since the well was opening produce

Step (2): Prepare the general data required for the analysis:

The pressure data versus time data (i.e.,  $P_{ws}$  vs.  $\Delta t$ ) as collected from company and Read in the pressure test data (i.e.,  $P_{ws}$  vs.  $\Delta t$ ) and for each data point calculate the corresponding value of  $(P_{ws}-P_{wfo})$ ,  $(d(P_{ws})/d(\log \Delta t))$ ,  $(\sqrt{tp + \Delta t} - \sqrt{\Delta t})$ ,  $((tp+\Delta t)/\Delta t)$  : Horner time),  $(d(P_{ws})/d(\log ((tp+\Delta t)/ \Delta t)))$ ,  $(d(P_{ws})/d(\sqrt{tp + \Delta t} - \sqrt{\Delta t}))$ .

Step (3): Identification of Wellbore Plotting the pressure drop and pressure derivative versus time to indicate the radial flowregion. (Figure 3) shows radial flow.

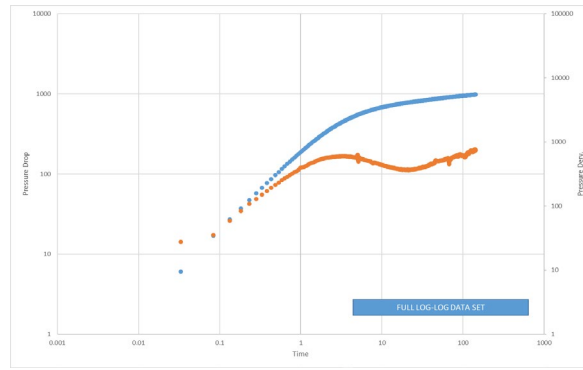


Figure 3: Pressure Drop and Derivative for E37

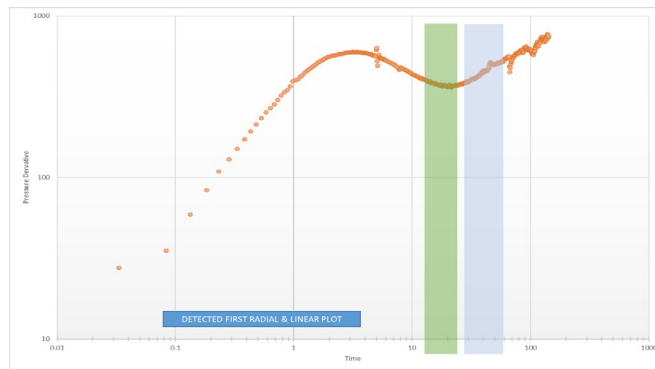


Figure 4: Detect the radial and linear periods for E37

Step (4): Analysis of the First Radial Flow Period by Plotting pressure data versus Horner time function,  $[Pws \text{ vs. } ((t+\Delta t)/ \Delta t)]$  on semi-log paper as shown in figure (4). The slope of the semi-log plot should also be shown on the same graph.

Step (5): The semi-log plot of  $[Pws \text{ vs. } ((t+\Delta t)/ \Delta t)]$  and of its slope, shows clearly that the Horner time from  $(tH= 4.086)$  to  $(tH =3.16)$  can be fitted to a semi-log straight line

Step (6): Read the slope directly from the plot,  $mr1 = 368.48 \text{ psi/cycle}$ .

Step (7): clearly that the From this flow period the equivalent permeability in vertical plane (x-z directions),  $\sqrt{k_x k_y}$  can be calculated:

$$\sqrt{k_x k_y} = 162.6 \left( \frac{q \mu B_o}{m_2 r h} \right) \sqrt{k_x k_y} = 0.56 \text{ m}$$

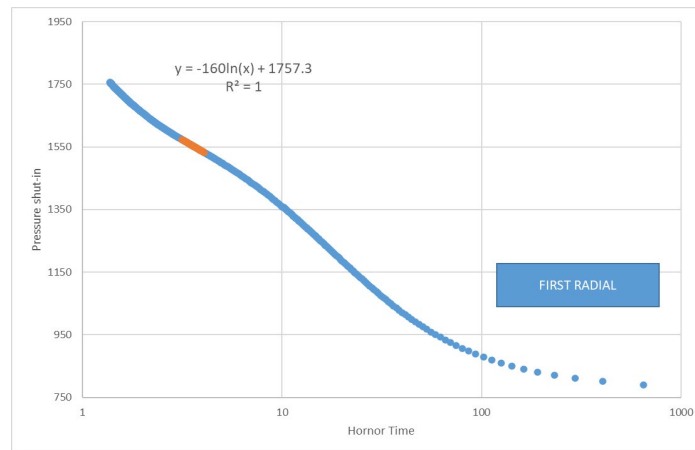


Figure 5: First Radial Pressure Analysis for E37

Step (8): Analysis of the First Linear Flow Period by plotting pressure data versus  $(\sqrt{t_p + \Delta t} - \sqrt{\Delta t})$  on linear paper as shown in figure (5).

The linear plot of  $[P_{ws}$  vs.  $(\sqrt{t_p + \Delta t} - \sqrt{\Delta t})]$ , shows clearly that the square root time from  $[(\sqrt{t_p + \Delta t} - \sqrt{\Delta t}) = 3.688]$  to  $[(\sqrt{t_p + \Delta t} - \sqrt{\Delta t}) = 2.83]$  can be fitted to a linear straight line as shown in figure (5). This could be interpreted as the effect of an early-time linear flow. (i.e., First linear flow period)

Step (9): Read the slope directly from the plot,  $m_{L1} = 102.81$  psi/hr<sup>0.5</sup>.

Step (10): From this flow period the horizontal permeability in x-directions ( $k_x$ ), can be calculated:

$$k_x = \left( \frac{8.13 q \mu B_o}{m_{L1} L h} \right)^2 \left( \frac{1}{\phi \mu c_t} \right) = 0.39 \text{ md.}$$

Step (11): Combining results of the analysis of the early-time radial flow and early-time linear flow,  $k_x = 0.39$  md, and  $\sqrt{k_x k_v} = 0.56$  md.  $\therefore k_v = 0.81$  md

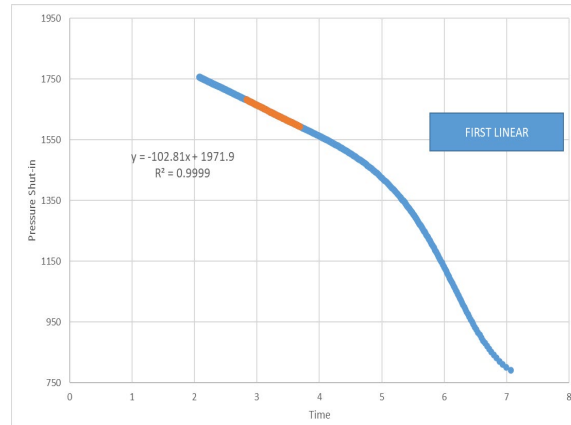


Figure 6: First Linear Pressure Analysis for E37

Step (11) : Estimation of the Permeability in y-direction ( $k_y$ ). A maximum value for ( $k_y$ ) can be estimated by substituting the last time reading on the linear straight line in the duration equation of the end early-time linear flow as Read the last time on the linear straight line from log-log plot as shown in figure (6). ( $t_{E1}=66$  hrs).

Step (12) : Substituting the last time in the duration time of end of first linear flow we calculate the value of  $k_y = 30.31$  md.

The following table summarized the permeability estimation from each flow period.

**Table 3:** summarized the permeability estimation from each flow period

Flow Period	Permeability Estimation	Result	Unit
First Radial Flow	$\sqrt{k_x k_v}$	0.56	md
First Linear Flow	$k_x$	0.39	md
	$k_v$	0.81	md
Late-time Pseudo-Radial Flow	$\sqrt{k_x k_y}$	30.31	md
	$k_y$	0.56	md

Step (13): Skin Factor Calculations: Calculate the pseudo-skin caused by partial penetration in the vertical direction.

$$S_z = \ln\left(\frac{h}{r_w}\right) + 0.25 \times \ln\left(\frac{k_x}{k_v}\right) - \ln\left(\sin\frac{180^\circ(d_z)}{h}\right) - 1.838$$

$S_z = 3.58$

Step (14): Evaluate the mechanical skin using the early-time radial results by Extrapolate the straight line in figure (6) to  $\Delta t=1$  hour and read,  $P_{ws}(1hr)$ , and then calculate  $\Delta P_{1hr}$

$$P_{ws}(1hr) = 1114 \text{ psi, and } P_{wfo} = 773 \text{ psi } \Delta P_{1hr} = P_{ws}(1hr) - P_{wfo} = 1114 - 773 = 343 \text{ psi}$$

$$S_m = 1.151 \frac{L}{h} \sqrt{\frac{k_v}{k_y}} \left[ \frac{\Delta P_{1hr}}{m_{r2}} - \log \left( \frac{k_y}{\phi \mu c_t L^2} \right) + 1.76 \right] - S_z$$

Sm = - 5.15

### 3.1.2 Buildup Test by ECRIN Software (Well E37)

Step (1): Plot pressure and production profile for well to identify the production and shut in periods.

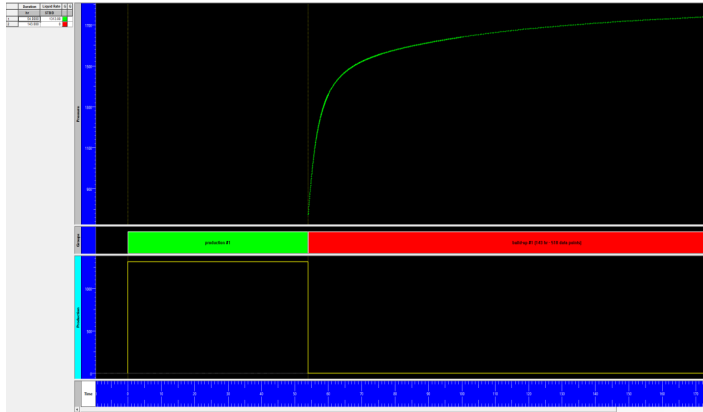


Figure 7: Pressure and Production Profile for E37

Step (2): Plot log-log plot to determine regions of flow to analysis and run the model to have the matching for plot of test.

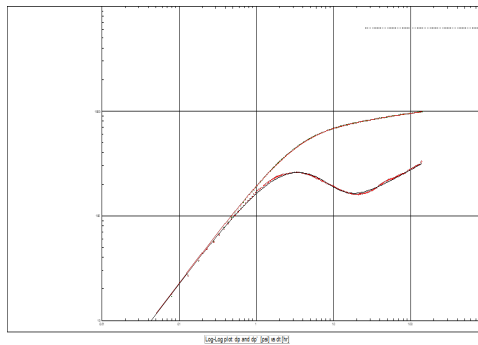


Figure 8: Log-Log plot of pressure drop and pressure derivative vs time by ECRIN

ECRIN software used several techniques to perform the matching and gives results in order to use these results for any reservoir engineering applications, (Figure 8) illustrates matching.

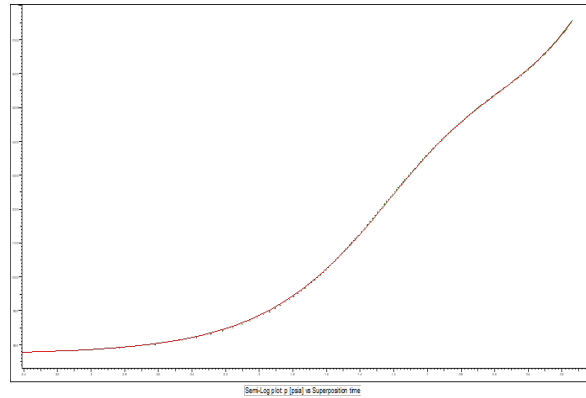


Figure 9: Semi-Log plot of pressure versus superposition time

The results of build-up test analysis for well E37 was summarized in tables below:

Table 4: summarized Buildup Test Results (ECRIN)

Name	Value	Unit	Name	Value	Unit
<b>Selected Model</b>			C	0.294	bb/psi
Model Option	Standard Model		Skin	0.0331	--
Well	Horizontal		Geometrical S	-7.27	--
Reservoir	Radial composite		well length	2095.85	ft
Boundary	Infinite		Zw	62	ft
<b>Main Model Parameters</b>			<b>Reservoir &amp; Boundary parameters</b>		
TMatch	0.0242	[hr] <sup>-1</sup>	h	80	ft
PMatch	9.99E-5	[psia] <sup>-1</sup>	Pi	1935.94	psia
C	0.294	bb/psi	k.h	31.3	md.ft
Total Skin	-7.23	--	k	0.391	md
k.h, total	31.3	md.ft	kz/kr	39.7	--
k, average	0.391	md	Ri	1500	ft
Pi	1935.94	psia	M	1	--
<b>Model Parameters</b>			D	1	--
<b>Well &amp; Wellbore parameters (Tested well)</b>			<b>Derived &amp; Secondary Parameters</b>		
C	0.294	bb/psi	Delta P (Total)	-72419.2	psi
Skin	0.0331	--	Delta P Ratio (	-73.9857	Fraction

The analysis interpretations for the Well E-37, summarized as follows:

- The well testing data quality for the well E-37 was good, for each relevant data quality has low problems and good matched was done.
- ECRIN software was very hard to reach to model because not clearly zone in first radial and first linear, but in Excel sheet were zoom in and estimated by Excel.
- The reservoir permeability is low and as average permeability 0.39 md in x dimension and 30.31 md in y dimension using excel and ECRIN.
- The skin factor was negative which indicates a stimulation process was done before running the buildup test. Average reservoir pressure was 1935 psi using ECRIN.

Table 4: shows summary of Results.

Parameters	Excel Sheet	ECRIN Software

Kx, (md)	0.39	0.316
S Total	-5.15	-7.25
Kz/kr	37.41	39.7

#### 4.0 Conclusion

Comparison between Kappa (ECRIN) software and Excel sheet (hand calculations) shows close results in some stages in first and second wells (E37, E39) i.e permeability (X, Y and Z). However, the third well (E38) was hard to match in ECRIN but in Excel was analyzed by dividing the curves into three periods. The average permeability estimated in both wells are similar even if the horizontal wells are different in length (1795 ft and 1949 ft). The ECRIN software was very hard and didn't reach to a model in well E38 because very scattering in pressure derivative, but in Excel sheet were zoomed and filtered by point and estimated by Excel and obtained results. The permeability ( $k_y$  over  $k_z$ ) was estimated as 37.41 md (ECRIN 39.7md) and total skin factor -5.15 (ECRIN -7.25) for E37, Well E39 the estimated  $k_y$  over  $k_z$  permeability was 35.5 md (ECRIN 42.4 md) and total skin factor -6.19 (ECRIN -7.01). Well E38 estimated the permeability 47.36 md with total skin -1.62 using Excel sheet analysis. The average reservoir pressure was close for the wells around 1930 psi.

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