Advanced Well Test Analysis

HW #4

Azar 1401

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University of Technology

1. A well test operation was carried out in a vertical oil well (r_w=0.3 ft) drilled in a two-layer reservoir (h_1= h_2 = 15ft). The obtained data are given in the *HW4_Q1.xlsx* file. Please interpret the data using the Saphir and report the achieved parameters. The values of the required parameters are the defaults of the Saphir.

Duration (hr)	Flow rate (STB/D)
6000	1000
2400	0

2. The results of well test operation in three analogous reservoirs of A, B, and C (with similar rock and fluid properties) are given in *HW4_Q2A.txt*, *HW4_Q2B.txt*, and *HW4_Q2C.txt* files, respectively. The well and reservoir conditions are as follows:

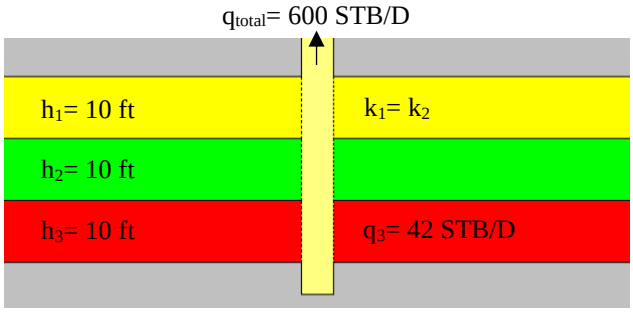
Number of layers	2
Crossflow	Yes
Well	Vertical
Wellbore model	No wellbore storage
$Skin_1$= $Skin_2$	0
h_1= h_2	15ft

The draw-down was implemented with the rate of 800 STB/D for 72 hours.

(a) Import the data of A, B, and C in Saphir and find the best models.
(b) Report the values of the permeability for two layers.
(c) Report the value of the leakage factor.

The rest of the parameters are the defaults of Saphir.

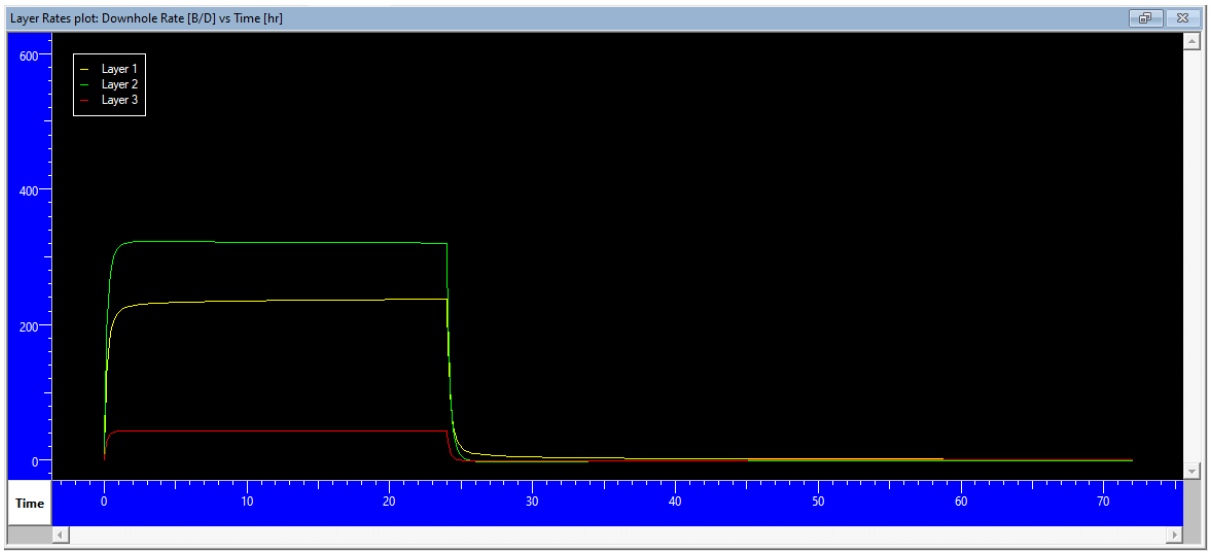
3. The results of a well test in a three-layer reservoir are given in the *HW4_Q3.txt* file.



Duration (hr)	Total flow rate (STB/D)
24	600
48	0

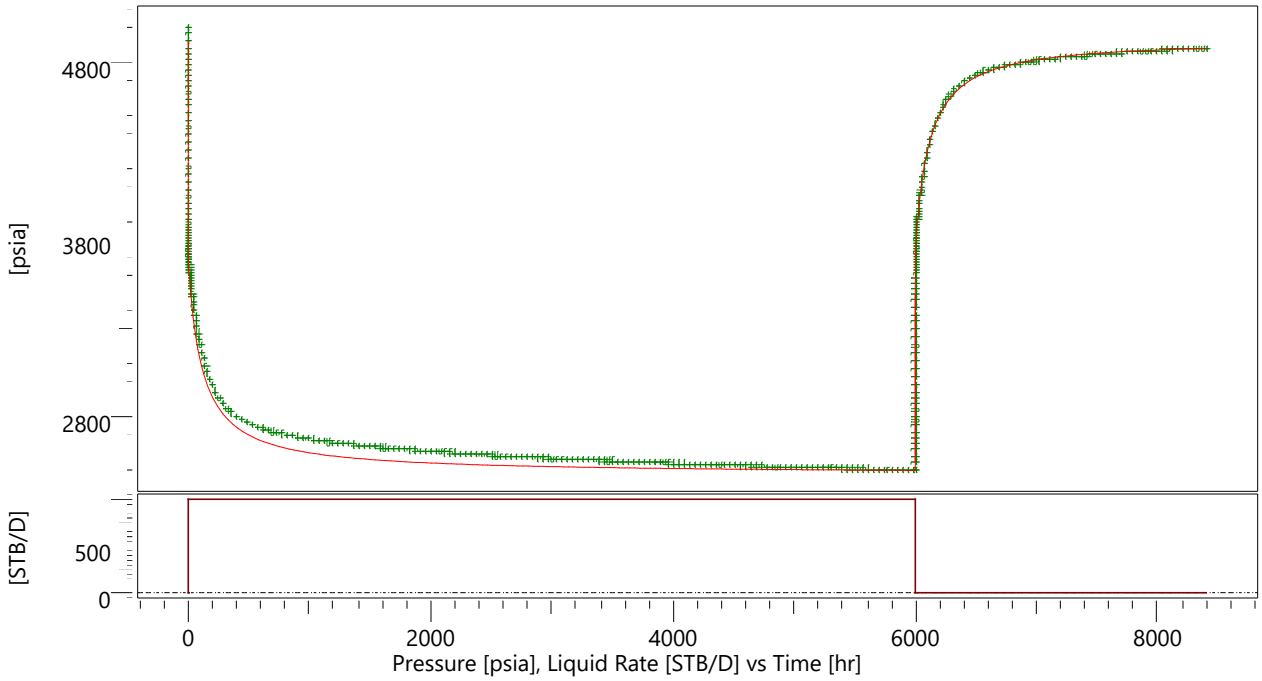
(a) Find the best model matching the data.
(b) Report the values of permeability and skin for each layer.

The required parameters are the defaults of the Saphir. The contribution of each layer in production is shown in the following figure.



Hussein Mohammadi - 401134020 - HW#4 - well test

1. First we make a standard analytical model of a vertical well with Constant WBS in a two layer reservoir. In order to model the second hump we first draw $\frac{dp}{dt}$ to see if it becomes ascending or not. Since it is always descending we can infer that we don't have pss fractured reservoir the second hump is due to a constant pressure parallel fault.



Pressure build-up #1

Rate	0 STB/D
Rate change	1000 STB/D
P@dt=0	2496.86 psia
Pi	4917.34 psia
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Parallel faults

Main Model Parameters

TMatch	4.72 [hr]-1
PMatch	8.52E-4 [psia]-1
C	0.00752 bbl/psi
Total Skin	-5.24
k.h, total	120 md.ft
k, average	4.01 md
Pi	4917.34 psia

Model Parameters

Well & Wellbore parameters (Tested well)

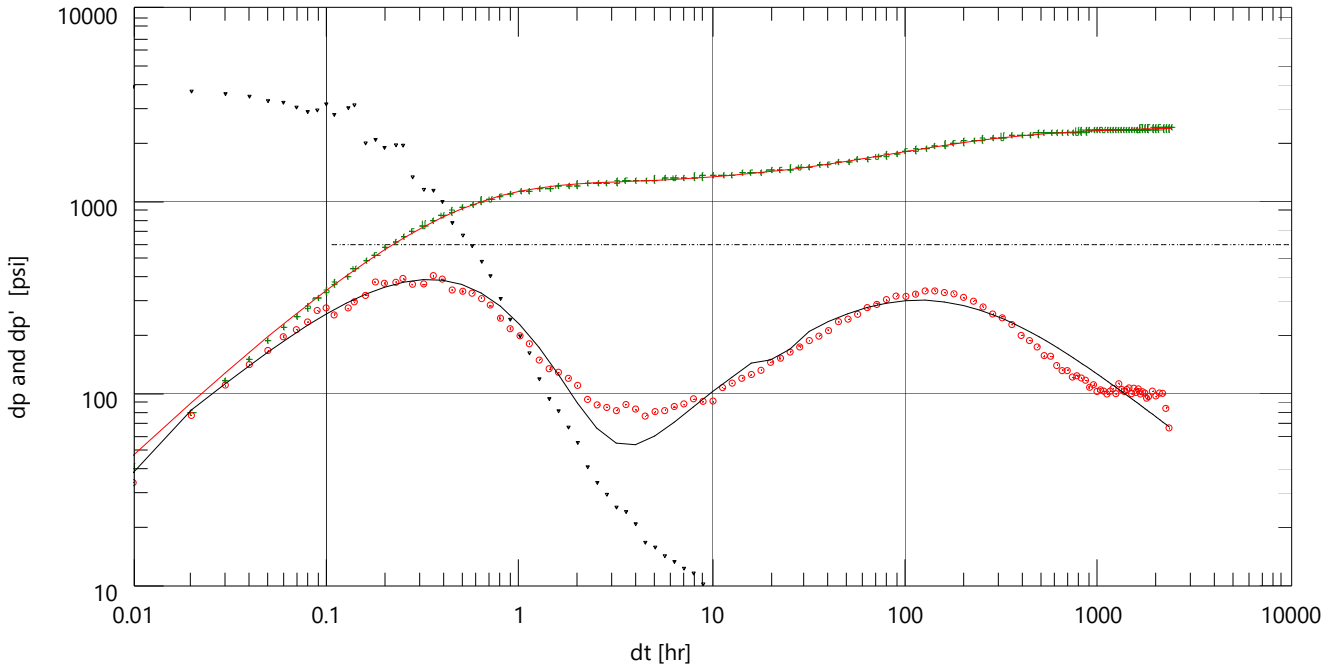
C	0.00752 bbl/psi
Skin1	-2.56
Skin2	-6.95

Reservoir & Boundary parameters

Pi	4917.34 psia
k.h	120 md.ft
k	4.01 md
Omega	0.989
Lambda	5.6E-7
Kappa	0.39
S - Constant P.	15400 ft
N - Constant P.	961 ft

Derived & Secondary Parameters

Delta P (Total Skin)	-6151.18 psi
Delta P Ratio (Total Skin)	-2.58159 Fraction



Pressure build-up #1

Rate	0 STB/D
Rate change	1000 STB/D
P@dt=0	2496.86 psia
Pi	4917.34 psia
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Parallel faults

Main Model Parameters

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PMatch	8.52E-4 [psia]-1
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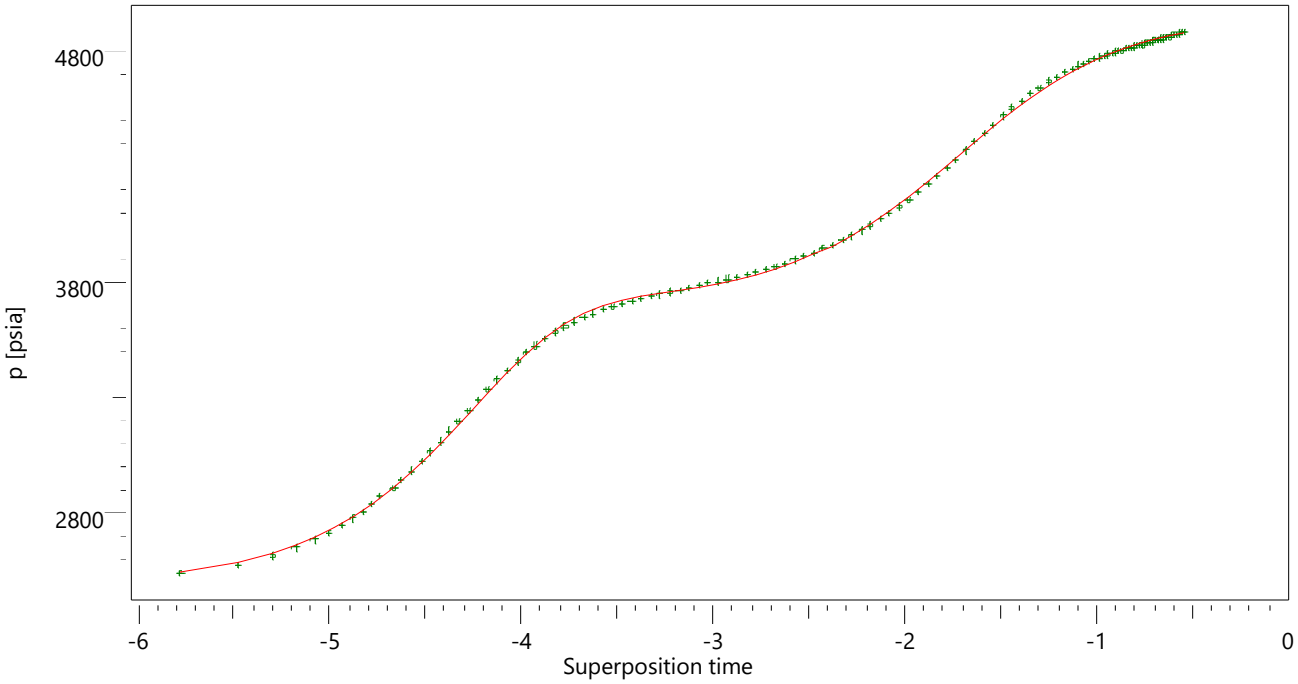

Pressure build-up #1

Rate	0 STB/D
Rate change	1000 STB/D
P@dt=0	2496.86 psia
Pi	4917.34 psia
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Parallel faults

Main Model Parameters

TMatch	4.72 [hr]-1
PMatch	8.52E-4 [psia]-1
C	0.00752 bbl/psi
Total Skin	-5.24
k.h, total	120 md.ft
k, average	4.01 md
Pi	4917.34 psia

Model Parameters

Well & Wellbore parameters (Tested well)

C	0.00752 bbl/psi
Skin1	-2.56
Skin2	-6.95

Reservoir & Boundary parameters

Pi	4917.34 psia
k.h	120 md.ft
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Omega	0.989
Lambda	5.6E-7
Kappa	0.39
S - Constant P.	15400 ft
N - Constant P.	961 ft

Derived & Secondary Parameters

Delta P (Total Skin)	-6151.18 psi
Delta P Ratio (Total Skin)	-2.58159 Fraction

Test date / time	
Formation interval	
Perforated interval	
Gauge type / #	
Gauge depth	
TEST TYPE	Standard
Porosity Phi (%)	10
Well Radius rw	0.3 ft
Pay Zone h	30 ft
Form. compr.	3E-6 psi-1
FLUID TYPE	Oil
Volume Factor B	1 B/STB
Viscosity	1 cp
Total Compr. ct	3E-6 psi-1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Parallel faults

Main Model Parameters

TMatch	4.72 [hr]-1
PMatch	8.52E-4 [psia]-1
C	0.00752 bbl/psi
Total Skin	-5.24
k.h, total	120 md.ft
k, average	4.01 md
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Model Parameters

Well & Wellbore parameters (Tested well)

C	0.00752 bbl/psi
Skin1	-2.56
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Reservoir & Boundary parameters

Pi	4917.34 psia
k.h	120 md.ft
k	4.01 md
Omega	0.989
Lambda	5.6E-7
Kappa	0.39
S - Constant P.	15400 ft
N - Constant P.	961 ft

Derived & Secondary Parameters

Delta P (Total Skin)	-6151.18 psi
Delta P Ratio (Total Skin)	-2.58159 Fraction

Hussein Mohammadi - 40134020 - HW# 4 - well test

2. Well A :

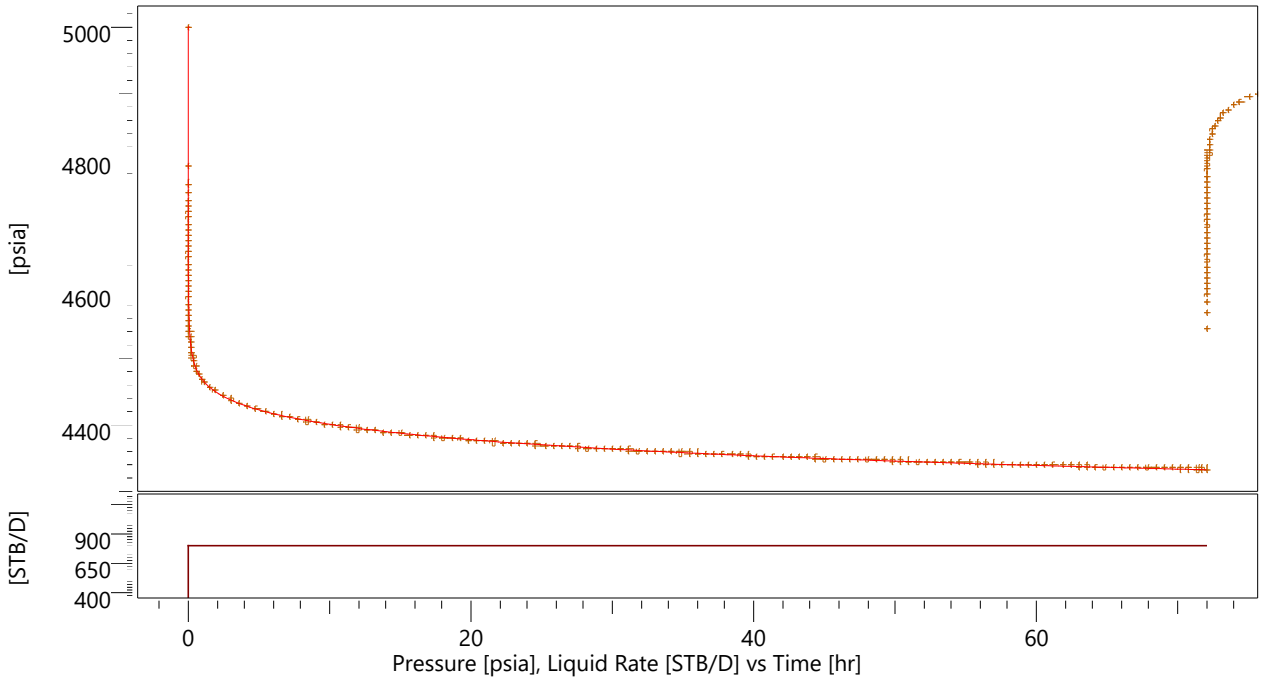
This well is completed in a two Layer reservoir with Cross flow. The vally indicates the effect of the Cross flow.

Well B :

This well is in the same reservoir. If we want to model it we must increase the skin of one layer to a high value to make the well partially Limited

Company
Well Tested well

Field
Test Name / # Well A



HW4_Q2A #2 production #1

Rate	800 STB/D
Rate change	800 STB/D
P@dt=0	4999.85 psia
Pi	4999.85 psia
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Infinite

Main Model Parameters

TMatch	96100 [hr]-1
PMatch	0.0137 [psia]-1
Total Skin	0.065
k.h, total	1550 md.ft
k, average	51.8 md
Pi	4999.85 psia

Model Parameters

Well & Wellbore parameters (Tested well)

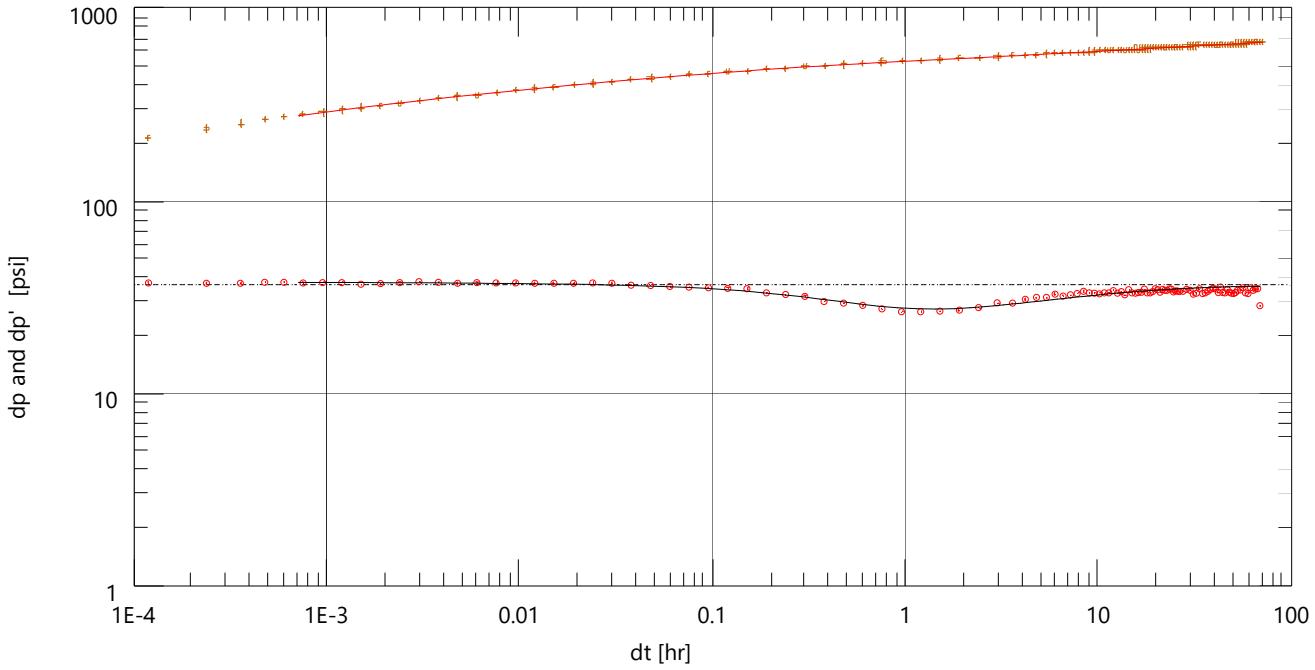
Skin1	0.0496
Skin2	0.0797

Reservoir & Boundary parameters

Pi	4999.85 psia
k.h	1550 md.ft
k	51.8 md
Omega	0.0219
Lambda	1E-7
Kappa	0.49

Derived & Secondary Parameters

Delta P (Total Skin)	4.72418 psi
Delta P Ratio (Total Skin)	0.00707767 Fraction



HW4_Q2A #2 production #1

Rate	800 STB/D
Rate change	800 STB/D
P@dt=0	4999.85 psia
Pi	4999.85 psia
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Infinite

Main Model Parameters

TMatch	96100 [hr]-1
PMatch	0.0137 [psia]-1
Total Skin	0.065
k.h, total	1550 md.ft
k, average	51.8 md
Pi	4999.85 psia

Model Parameters

Well & Wellbore parameters (Tested well)

Skin1	0.0496
Skin2	0.0797

Reservoir & Boundary parameters

Pi	4999.85 psia
k.h	1550 md.ft
k	51.8 md
Omega	0.0219
Lambda	1E-7
Kappa	0.49

Derived & Secondary Parameters

Delta P (Total Skin)	4.72418 psi
Delta P Ratio (Total Skin)	0.00707767 Fraction

Test date / time	
Formation interval	
Perforated interval	
Gauge type / #	
Gauge depth	
TEST TYPE	Standard
Porosity Phi (%)	10
Well Radius rw	0.3 ft
Pay Zone h	30 ft
Form. compr.	3E-6 psi-1
FLUID TYPE	Oil
Volume Factor B	1 B/STB
Viscosity	1 cp
Total Compr. ct	3E-6 psi-1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Infinite

Main Model Parameters

TMatch	96100 [hr]-1
PMatch	0.0137 [psia]-1
Total Skin	0.065
k.h, total	1550 md.ft
k, average	51.8 md
Pi	4999.85 psia

Model Parameters

Well & Wellbore parameters (Tested well)

Skin1	0.0496
Skin2	0.0797

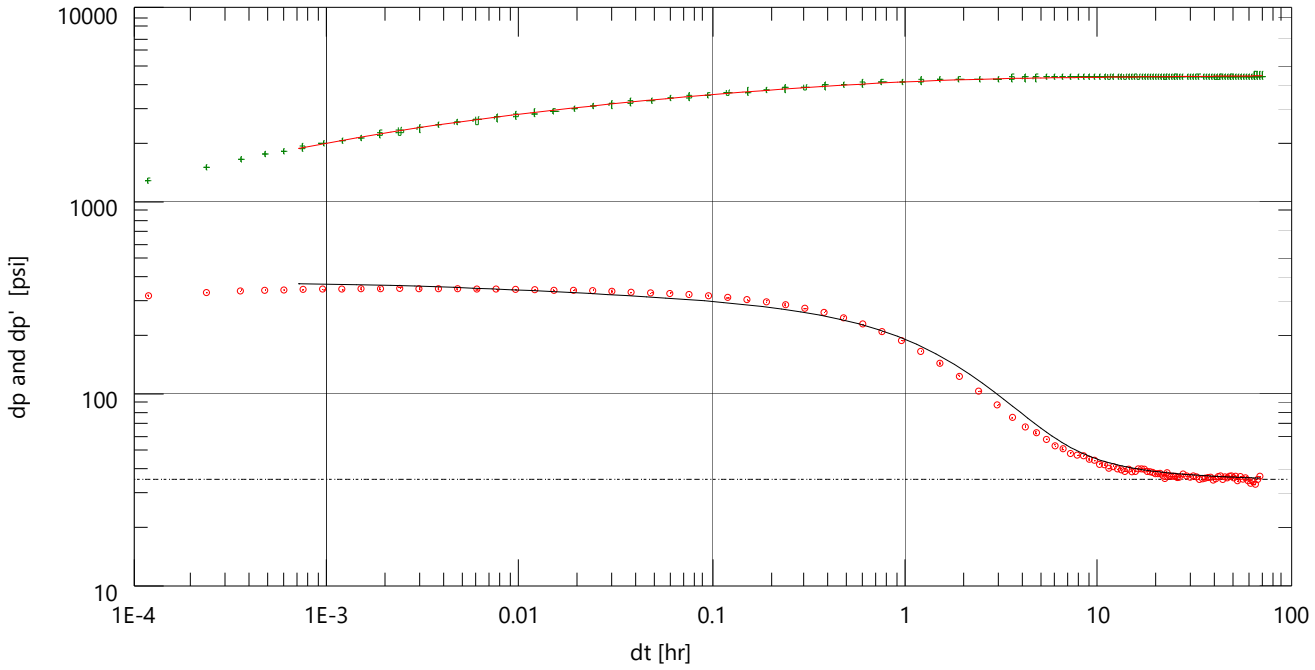
Reservoir & Boundary parameters

Pi	4999.85 psia
k.h	1550 md.ft
k	51.8 md
Omega	0.0219
Lambda	1E-7
Kappa	0.49

Derived & Secondary Parameters

Delta P (Total Skin)	4.72418 psi
Delta P Ratio (Total Skin)	0.00707767 Fraction

Log-Log plot	Analysis 1
Company Well Tested well	Field Test Name / # well B



HW4_Q2B production #1

Rate	800 STB/D
Rate change	800 STB/D
P@dt=0	5000.2 psia
Pi	5000.2 psia
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Infinite

Main Model Parameters

TMatch	3.41E+5 [hr]-1
PMatch	0.0142 [psia]-1
Total Skin	204
k.h, total	1610 md.ft
k, average	53.5 md
Pi	5000.2 psia

Model Parameters

Well & Wellbore parameters (Tested well)

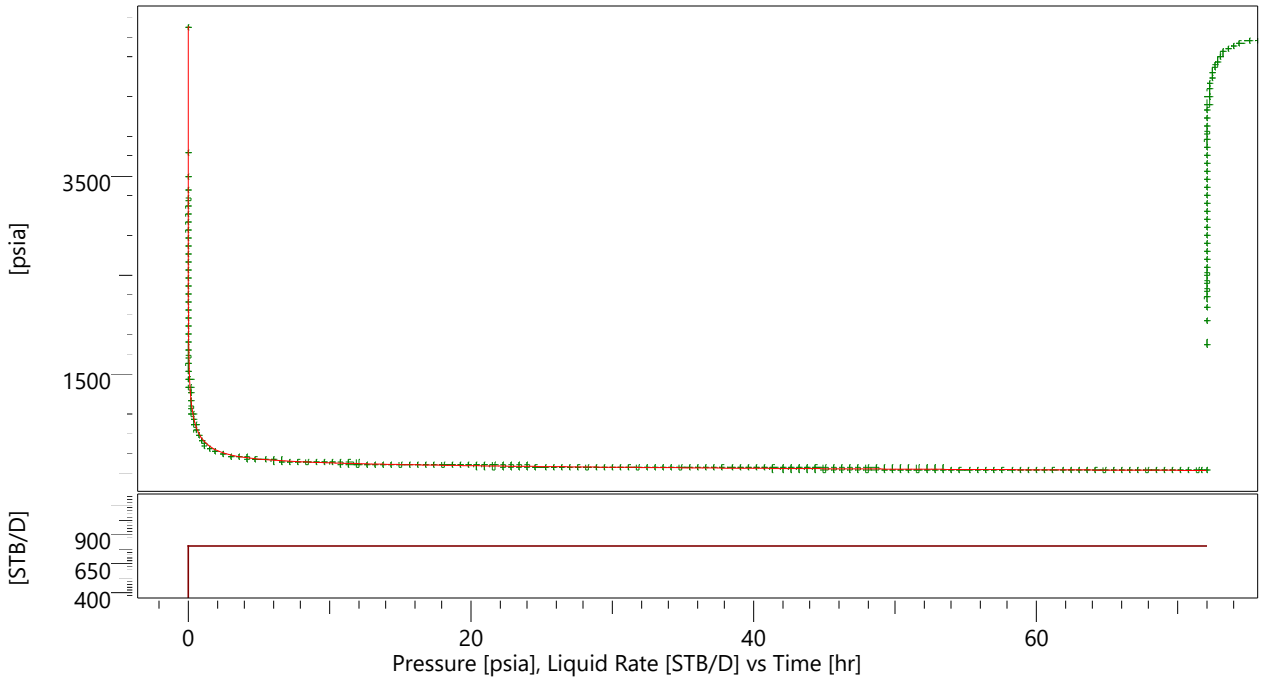
Skin1	-0.802
Skin2	220

Reservoir & Boundary parameters

Pi	5000.2 psia
k.h	1610 md.ft
k	53.5 md
Omega	0.198
Lambda	1.76E-7
Kappa	0.0705

Derived & Secondary Parameters

Delta P (Total Skin)	14378.9 psi
Delta P Ratio (Total Skin)	3.21736 Fraction



HW4_Q2B production #1

Rate	800 STB/D
Rate change	800 STB/D
P@dt=0	5000.2 psia
Pi	5000.2 psia
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Infinite

Main Model Parameters

TMatch	3.41E+5 [hr]-1
PMatch	0.0142 [psia]-1
Total Skin	204
k.h, total	1610 md.ft
k, average	53.5 md
Pi	5000.2 psia

Model Parameters

Well & Wellbore parameters (Tested well)

Skin1	-0.802
Skin2	220

Reservoir & Boundary parameters

Pi	5000.2 psia
k.h	1610 md.ft
k	53.5 md
Omega	0.198
Lambda	1.76E-7
Kappa	0.0705

Derived & Secondary Parameters

Delta P (Total Skin)	14378.9 psi
Delta P Ratio (Total Skin)	3.21736 Fraction

Test date / time	
Formation interval	
Perforated interval	
Gauge type / #	
Gauge depth	
TEST TYPE	Standard
Porosity Phi (%)	10
Well Radius rw	0.3 ft
Pay Zone h	30 ft
Form. compr.	3E-6 psi-1
FLUID TYPE	Oil
Volume Factor B	1 B/STB
Viscosity	1 cp
Total Compr. ct	3E-6 psi-1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Infinite

Main Model Parameters

TMatch	3.41E+5 [hr]-1
PMatch	0.0142 [psia]-1
Total Skin	204
k.h, total	1610 md.ft
k, average	53.5 md
Pi	5000.2 psia

Model Parameters

Well & Wellbore parameters (Tested well)

Skin1	-0.802
Skin2	220

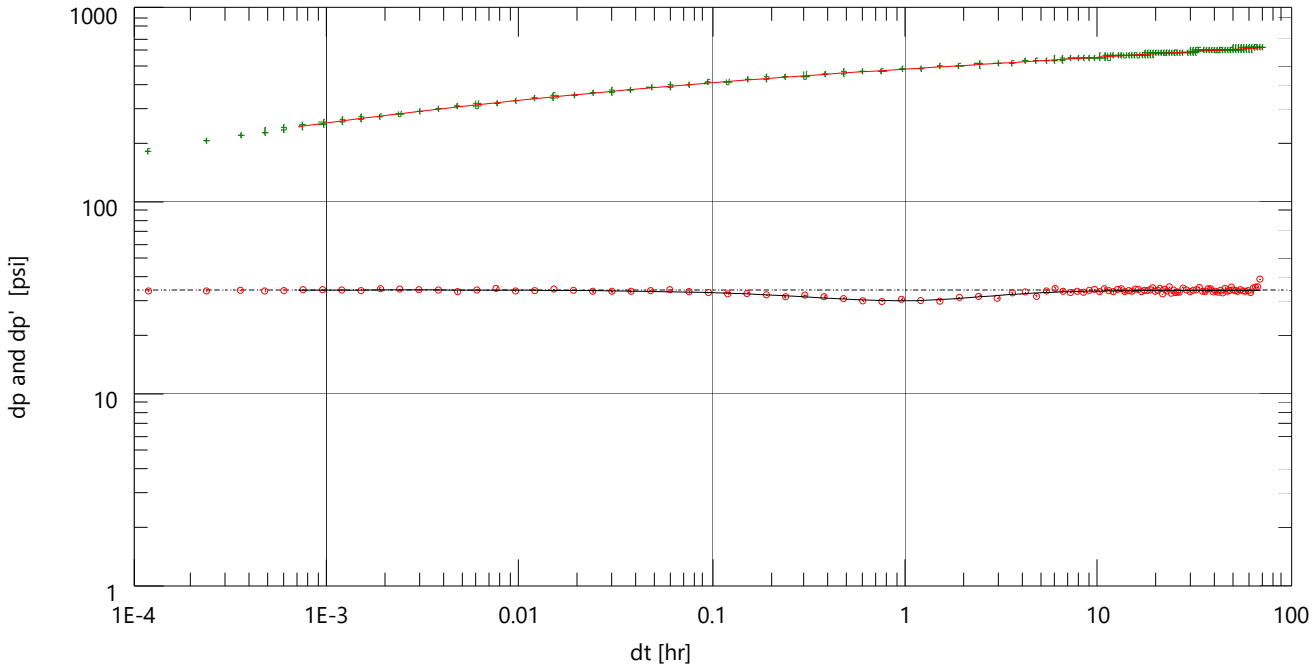
Reservoir & Boundary parameters

Pi	5000.2 psia
k.h	1610 md.ft
k	53.5 md
Omega	0.198
Lambda	1.76E-7
Kappa	0.0705

Derived & Secondary Parameters

Delta P (Total Skin)	14378.9 psi
Delta P Ratio (Total Skin)	3.21736 Fraction

Log-Log plot	Analysis 1
Company	Field well C
Well Tested well	Test Name / #



HW4_Q2C production #1

Rate	800 STB/D
Rate change	800 STB/D
P@dt=0	5000.12 psia
Pi	5000.12 psia
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Infinite

Main Model Parameters

TMatch	84700 [hr]-1
PMatch	0.0146 [psia]-1
Total Skin	-0.00124
k.h, total	1650 md.ft
k, average	55 md
Pi	5000.12 psia

Model Parameters

Well & Wellbore parameters (Tested well)

Skin1	0.0525
Skin2	-0.0191

Reservoir & Boundary parameters

Pi	5000.12 psia
k.h	1650 md.ft
k	55 md
Omega	0.685
Lambda	7.24E-7
Kappa	0.25

Derived & Secondary Parameters

Delta P (Total Skin)	-0.084735 psi
Delta P Ratio (Total Skin)	-1.35376E-4 Fraction

Test date / time	
Formation interval	
Perforated interval	
Gauge type / #	
Gauge depth	
TEST TYPE	Standard
Porosity Phi (%)	10
Well Radius rw	0.3 ft
Pay Zone h	30 ft
Form. compr.	3E-6 psi-1
FLUID TYPE	Oil
Volume Factor B	1 B/STB
Viscosity	1 cp
Total Compr. ct	3E-6 psi-1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Infinite

Main Model Parameters

TMatch	84700 [hr]-1
PMatch	0.0146 [psia]-1
Total Skin	-0.00124
k.h, total	1650 md.ft
k, average	55 md
Pi	5000.12 psia

Model Parameters

Well & Wellbore parameters (Tested well)

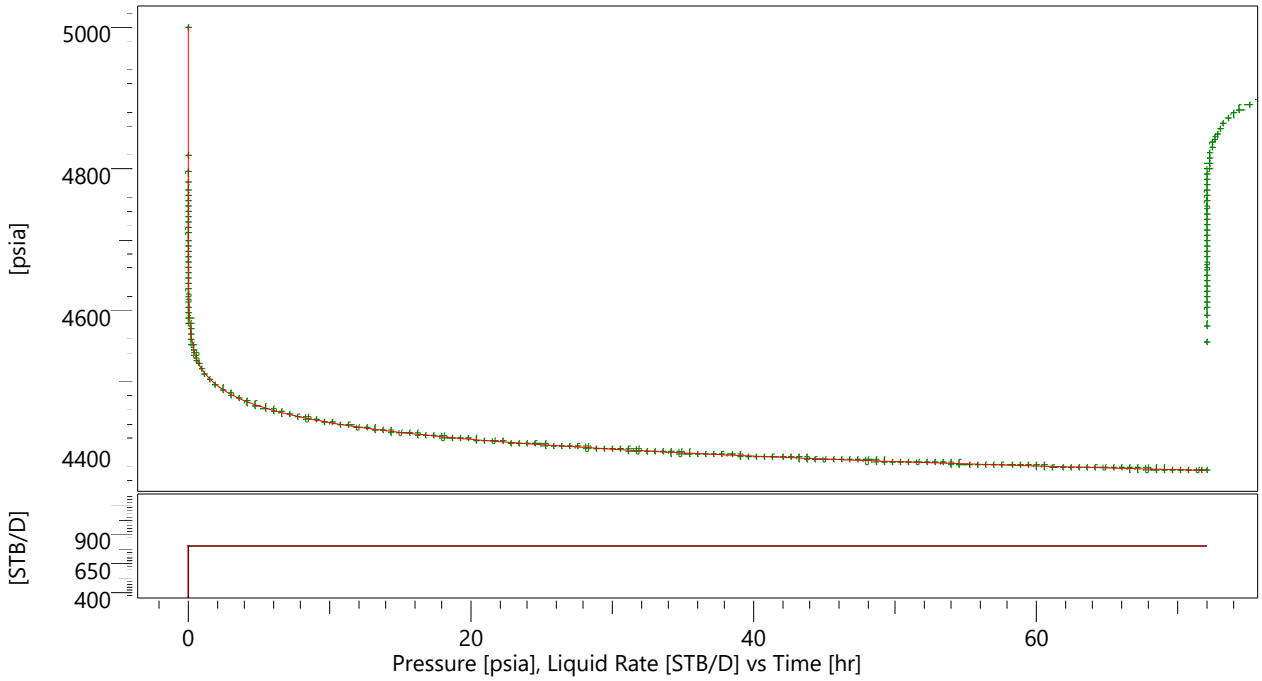
Skin1	0.0525
Skin2	-0.0191

Reservoir & Boundary parameters

Pi	5000.12 psia
k.h	1650 md.ft
k	55 md
Omega	0.685
Lambda	7.24E-7
Kappa	0.25

Derived & Secondary Parameters

Delta P (Total Skin)	-0.084735 psi
Delta P Ratio (Total Skin)	-1.35376E-4 Fraction



HW4_Q2C production #1

Rate	800 STB/D
Rate change	800 STB/D
P@dt=0	5000.12 psia
Pi	5000.12 psia
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Two layers
Boundary	Infinite

Main Model Parameters

TMatch	84700 [hr]-1
PMatch	0.0146 [psia]-1
Total Skin	-0.00124
k.h, total	1650 md.ft
k, average	55 md
Pi	5000.12 psia

Model Parameters

Well & Wellbore parameters (Tested well)

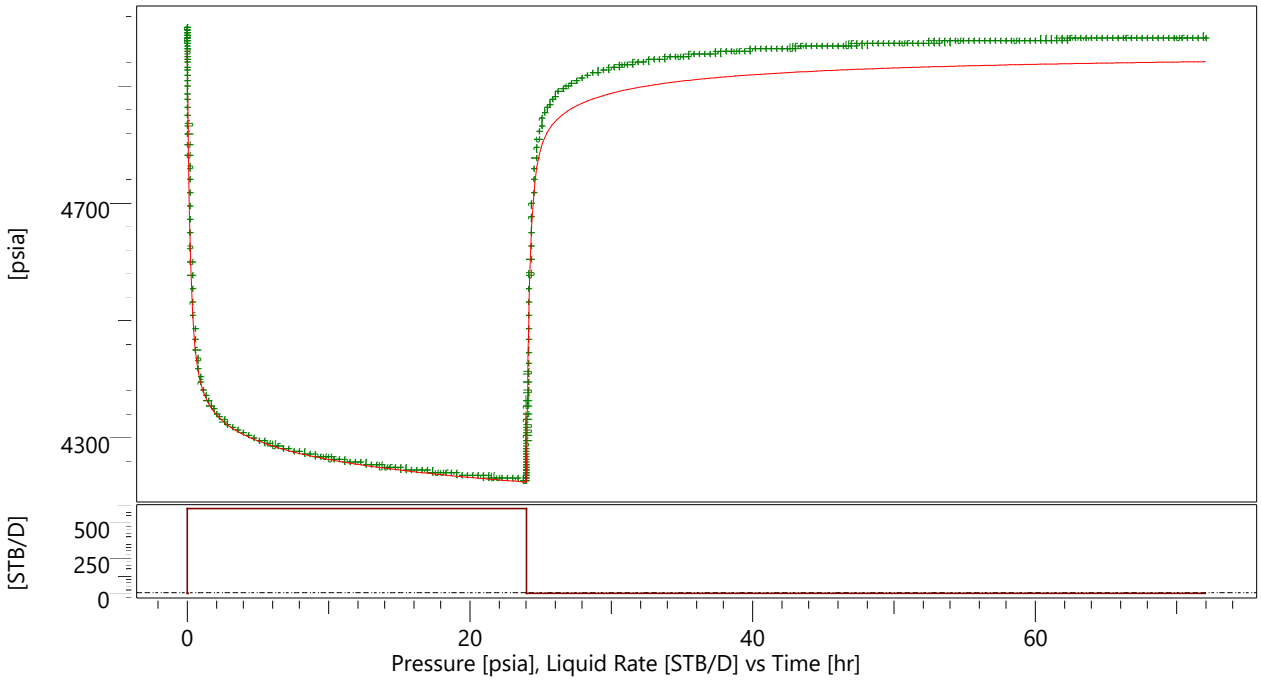
Skin1	0.0525
Skin2	-0.0191

Reservoir & Boundary parameters

Pi	5000.12 psia
k.h	1650 md.ft
k	55 md
Omega	0.685
Lambda	7.24E-7
Kappa	0.25

Derived & Secondary Parameters

Delta P (Total Skin)	-0.084735 psi
Delta P Ratio (Total Skin)	-1.35376E-4 Fraction



HW4_Q3 build-up #1

Rate	0 STB/D
Rate change	600 STB/D
P@dt=0	4227.95 psia
Pi	4959.17 psia
Smoothing	0.1

Selected Model

Model Option	Multi-Layer, Commingled
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters

TMatch	32 [hr]-1
PMatch	0.0118 [psia]-1
C	0.00921 bbl/psi
Total Skin	0
k.h, total	999 md.ft
k, average	33.3 md
Pi	4959.17 psia

Model Parameters

Layer 1

Vertical - Homogeneous - Infinite

Skin	0
k	5 md
h	10 ft
Phi	0.1

Layer 2

Vertical - Homogeneous - Infinite

Skin	0
k	90.9 md
h	10 ft
Phi	0.1

Layer 3

Vertical - Homogeneous - Infinite

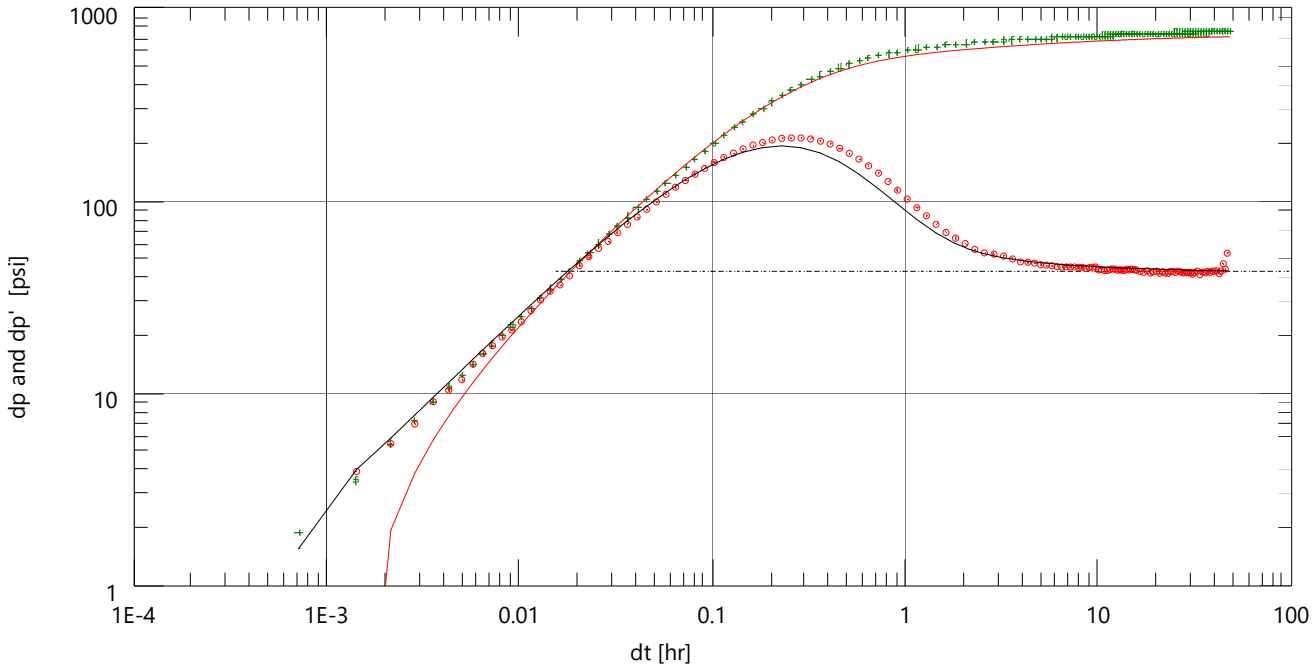
Skin	0
k	4 md
h	10 ft
Phi	0.1

Wellbore & other reservoir parameters

Pi	4959.17 psia
C	0.00921 bbl/psi

Derived & Secondary Parameters

Delta P (Total Skin)	0 psi
Delta P Ratio (Total Skin)	0 Fraction



HW4_Q3 build-up #1

Rate	0 STB/D
Rate change	600 STB/D
P@dt=0	4227.95 psia
Pi	4959.17 psia
Smoothing	0.1

Selected Model

Model Option	Multi-Layer, Commingled
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters

TMatch	32 [hr]-1
PMatch	0.0118 [psia]-1
C	0.00921 bbl/psi
Total Skin	0
k.h, total	999 md.ft
k, average	33.3 md
Pi	4959.17 psia

Model Parameters

Layer 1

Vertical - Homogeneous - Infinite

Skin	0
k	5 md
h	10 ft
Phi	0.1

Layer 2

Vertical - Homogeneous - Infinite

Skin	0
k	90.9 md
h	10 ft
Phi	0.1

Layer 3

Vertical - Homogeneous - Infinite

Skin	0
k	4 md
h	10 ft
Phi	0.1

Wellbore & other reservoir parameters

Pi	4959.17 psia
C	0.00921 bbl/psi

Derived & Secondary Parameters

Delta P (Total Skin)	0 psi
Delta P Ratio (Total Skin)	0 Fraction

Test date / time	
Formation interval	
Perforated interval	
Gauge type / #	
Gauge depth	
TEST TYPE	Standard
Porosity Phi (%)	10
Well Radius rw	0.3 ft
Pay Zone h	30 ft
Form. compr.	3E-6 psi-1
FLUID TYPE	Oil
Volume Factor B	1 B/STB
Viscosity	1 cp
Total Compr. ct	3E-6 psi-1

Selected Model

Model Option	Multi-Layer, Commingled
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters

TMatch	32 [hr]-1
PMatch	0.0118 [psia]-1
C	0.00921 bbl/psi
Total Skin	0
k.h, total	999 md.ft
k, average	33.3 md
Pi	4959.17 psia

Model Parameters

Layer 1

Vertical - Homogeneous - Infinite

Skin	0
k	5 md
h	10 ft
Phi	0.1

Layer 2

Vertical - Homogeneous - Infinite

Skin	0
k	90.9 md
h	10 ft
Phi	0.1

Layer 3

Vertical - Homogeneous - Infinite

Skin	0
k	4 md
h	10 ft
Phi	0.1

Wellbore & other reservoir parameters

Pi	4959.17 psia
C	0.00921 bbl/psi

Derived & Secondary Parameters

Delta P (Total Skin)	0 psi
Delta P Ratio (Total Skin)	0 Fraction