Universitetet i Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

RE-SIT EXAM: MPE 760 Formation Evaluation and Well Testing

DATE: February 15, 2012

DURATION: 4 hours

"TOOLS" ALLOWED: Standard simple calculator (HP30S, Casio FX-82, TI-30 or Citizen SR-270X)

THE SET CONSISTS OF: 3 problems on 9 pages (total)

Problem 1

A 6 days long buildup test was run after just 12 hours production at 3600 STB/D in a fractured oil well to determine fracture and flow properties and possible boundary effects. Use input parameters from Table 1, buildup data from Table 2 (reduced), and plots from the last three pages to answer the questions and carry out the analyses below.

a) Fig. 1 shows a loglog plot of the buildup data. What flow regimes can be identified in the data set?

b) Fig. 2 shows a semilog plot of the buildup data with $\log(\Delta t/(t + \Delta t))$ on the horizontal axis. Use representative data points from Table 2 to determine kh, k, S and Δp_S. Moreover, use either a distance-to-fault analysis or an analysis based on the radius-of-investigation to determine the distance to the nearest boundary.

c) Use the semilog plot in Fig. 2 and data from Table 2 to estimate the reservoir pressure. If the buildup test had been stopped after 12 hours, would it still be possible to get a good estimate of the reservoir pressure? (Explain!)

d) Based on results from the semilog analysis, what is the minimal drainage area determined by the buildup data?

e) Fig. 3 shows a simple square-root-of-time plot of the buildup data based on elapsed time after shut-in. Use representative data points from Table 2 and information from Point (b) to determine the fracture half-length x_f and give a direct estimate of the pressure at shut-in based on early buildup data. Based on the half-length x_f and skin value S, what fracture type is most likely?

Table 1 – Input parameters for Problem 1

Formation thickness, h	=	56	ft
Porosity, ϕ	=	0.11	
Viscosity, μ	=	0.95	cp
Total compressibility, c_t	=	$2.6\text{x}10^{-5}$	psi^{-1}
Volume factor, B	=	1.28	RB/STB
Wellbore radius, r_w	=	0.354	ft
Pressure at shut-in, $p_{wf,s}$	=	3816.89	psia

Table 2 – Buildup data

Buildup time (hrs)	Pressure (psia)	Buildup time (hrs)	Pressure (psia)
0.0014	3822.10	63.728	3953.37
0.0036	3825.13	68.048	3953.74
0.0082	3829.28	72.368	3954.07
0.0129	3832.48	76.688	3954.37
0.0515	3847.36	81.008	3954.64
0.2049	3869.63	85.328	3954.88
0.8158	3894.54	89.648	3955.10
3.2477	3917.41	93.968	3955.31
7.5677	3930.33	98.288	3955.49
11.888	3936.81	102.608	3955.67
16.208	3940.88	106.928	3955.83
20.528	3943.71	111.248	3955.98
24.848	3945.80	115.568	3956.12
29.168	3947.40	119.888	3956.25
33.488	3948.68	124.208	3956.37
42.128	3950.59	128.528	3956.48
46.448	3951.32	132.848	3956.59
50.768	3951.94	137.168	3956.69
55.088	3952.48	139.328	3956.74
59.408	3952.95	144.000	3956.84

Problem 2

To get direct information about flow properties between two wells in a reservoir it is possible to run an interference test between the wells. In such tests there are two main effects one can observe: 1) time to pressure response, and 2) degree of pressure response. Give best possible answers to the questions below.

a) Which parameters are most important for effect 1?

b) Which parameters are most important for effect 2?

Problem 3

The following data have been taken from a modified isochronal test:

q_{sc} (Sm^3/d)	p_{wf} (bar)	
0	352.0	Static pressure
256000	306.2	
0	347.2	
397000	258.4	
0	338.8	
472000	222.5	
0	327.3	
539100	183.3	
463000	220.5	Stabilized period

Use the information above to carry out the analyses below.

a) Determine the deliverability and AOF potential of the well by using LIT analysis and direct computations without plotting (assume the data to be consistent such that computations can be based on any chosen representative data points).

b) Determine the deliverability and AOF potential of the well by using simple loglog analysis (back-pressure equation) and direct computations without plotting (assume the data to be consistent such that computations can be based on any chosen representative data points).

STANDARD EQUATIONS

$$p_D = \frac{kh}{18.66qB\mu}\Delta p$$ (SI units, oil)

$$p_D = \frac{kh}{141.2qB\mu}\Delta p$$ (field units, oil)

$$p_D = \frac{p_r kh}{0.06563q_{sc}Z_r\mu_r T_r}\Delta p$$ (SI units, gas at high pressure)

$$p_D = \frac{p_r kh}{711q_{sc}Z_r\mu_r T_r}\Delta p$$ (field units, gas at high pressure)

$$t_D = \frac{0.000355kt}{\phi\mu c_t r_w^2}$$ (SI units, oil and gas)

$$t_D = \frac{0.000264kt}{\phi\mu c_t r_w^2}$$ (field units, oil and gas)

$$C_D = \frac{C}{2\pi\phi hc_t r_w^2}$$ (SI units, oil and gas)

$$C_D = \frac{5.615C}{2\pi\phi hc_t r_w^2}$$ (field units, oil and gas)

$$\frac{t_D}{C_D} = \frac{0.002232kht}{\mu C}$$ (SI units, oil and gas)

$$\frac{t_D}{C_D} = \frac{0.0002951kht}{\mu C}$$ (field units, oil and gas)

$$C = \frac{qB}{24}\frac{t}{\Delta p} = c_{wb}V_{wb}$$

$$\Delta p = m't = \frac{qB}{24C}t$$

STANDARD EQUATIONS (Contin.)

$$m = \frac{21.49 qB\mu}{kh}$$ (SI units)

$$m = \frac{162.6 qB\mu}{kh}$$ (field units)

$$S = 1.151\left(\frac{p_i - p_{1hr}}{m} - \log\frac{k}{\phi\mu c_t r_w^2} + 3.098\right)$$ (SI units, drawdown data)*

$$S = 1.151\left(\frac{p_{1hr} - p_{wf,s}}{m} - \log\frac{t}{t+1} - \log\frac{k}{\phi\mu c_t r_w^2} + 3.098\right)$$ (SI units, buildup data)*

*) Field units: replace 3.098 by 3.23.

$$\Delta p_S = \frac{m}{1.151} S$$

$$r_{inv} = 0.0286\sqrt{\frac{kt}{\phi\mu c_t}}$$ (SI units)

$$r_{inv} = 0.0246\sqrt{\frac{kt}{\phi\mu c_t}}$$ (field units)

$$d = 0.01412\sqrt{\frac{kt}{\phi\mu c_t}}$$ (SI units)

$$d = 0.01217\sqrt{\frac{kt}{\phi\mu c_t}}$$ (field units)

$$p_i - \overline{p} = \frac{m}{1.151} 2\pi t_{DA}$$

$$p_{ws}(\Delta t) = \overline{p} \quad \text{when} \quad \Delta t_e = \frac{\phi\mu c_t A}{0.000355 k C_A}$$ (SI units)

$$p_{ws}(\Delta t) = \overline{p} \quad \text{when} \quad \Delta t_e = \frac{\phi\mu c_t A}{0.000264 k C_A}$$ (field units)

STANDARD EQUATIONS (Contin.)

Fractured wells:

$$m' = \frac{0.6236qB}{hx_f}\sqrt{\frac{\mu}{k\phi c_t}}$$ (SI units)

$$m' = \frac{4.064qB}{hx_f}\sqrt{\frac{\mu}{k\phi c_t}}$$ (field units)

$$S = \ln\frac{2r_w}{x_f}$$ (fracture with infinite conductivity)

$$S = \ln\frac{er_w}{x_f} = \ln\frac{2.718r_w}{x_f}$$ (fracture with uniform flux)

Reservoir limit analysis:

$$m' = \frac{0.04167qB}{\phi c_t Ah}$$ (SI units)

$$m' = \frac{0.2339qB}{\phi c_t Ah}$$ (field units)

$$p_0 = p_i - \frac{18.66qB\mu}{kh}\left(\frac{1}{2}\ln\frac{4A}{e^{\gamma}C_A r_w^2} + S\right)$$ (SI units)

$$p_0 = p_i - \frac{141.2qB\mu}{kh}\left(\frac{1}{2}\ln\frac{4A}{e^{\gamma}C_A r_w^2} + S\right)$$ (field units)

$$e^{\gamma} = e^{0.57721\ldots} = 1.781\ldots$$

Gas tests:

$$q_{sc} = C(\overline{p}^2 - p_{wf}^2)^n$$ (simplified deliverability, p^2 formulation)

$$\overline{p}^2 - p_{wf}^2 = aq_{sc} + bq_{sc}^2$$ (LIT based deliverability, p^2 formulation)

$$\text{AOF} = \frac{1}{2b}\left(-a + \sqrt{a^2 + 4b\overline{p}^2}\right)$$ (LIT based AOF, p^2 formulation)

Fig. 1

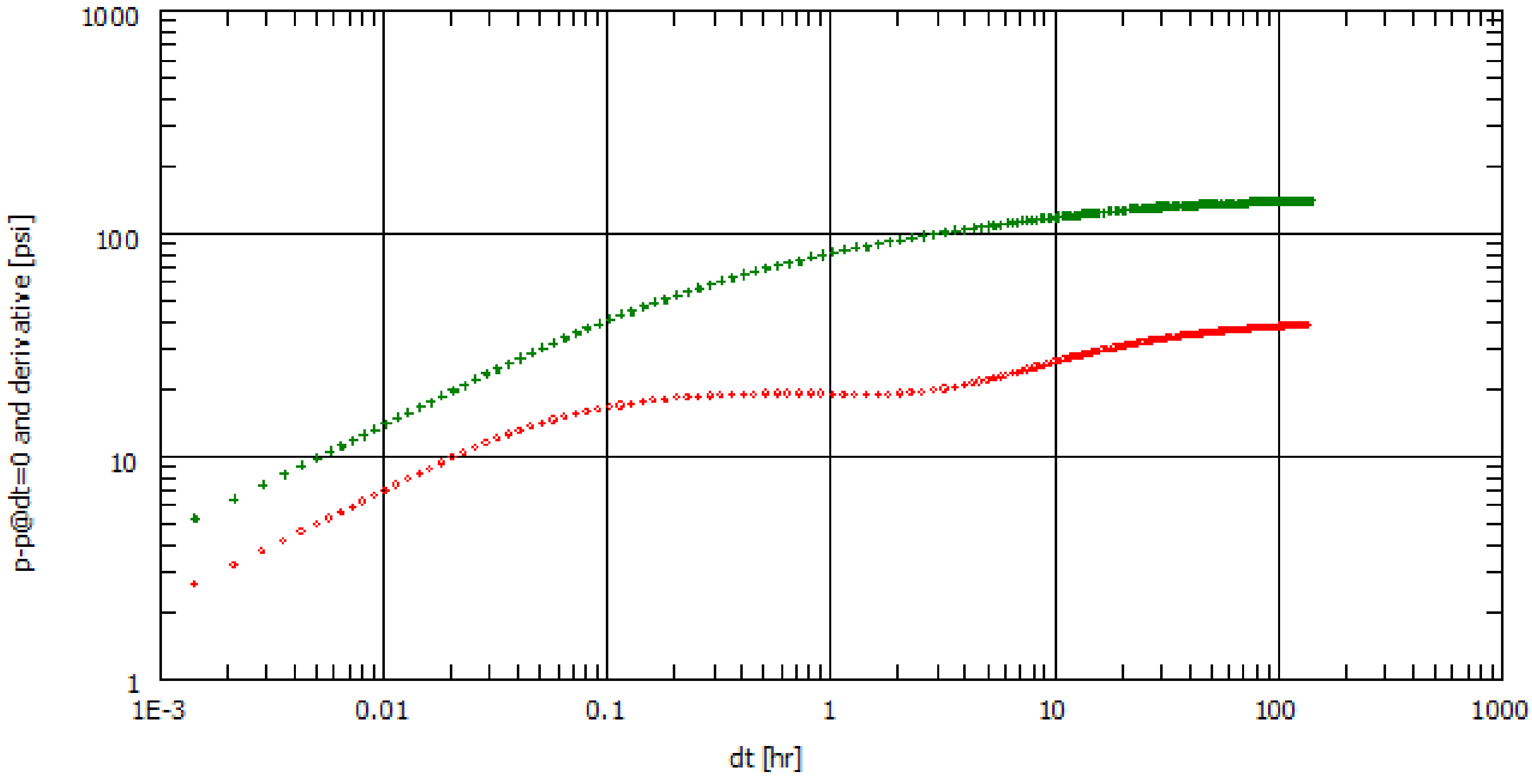
1000
100
10
1
1E-3
0.01
0.1
1
10
100
1000
dt [hr]
p-p@dt=0 and derivative [psi]

Fig. 2

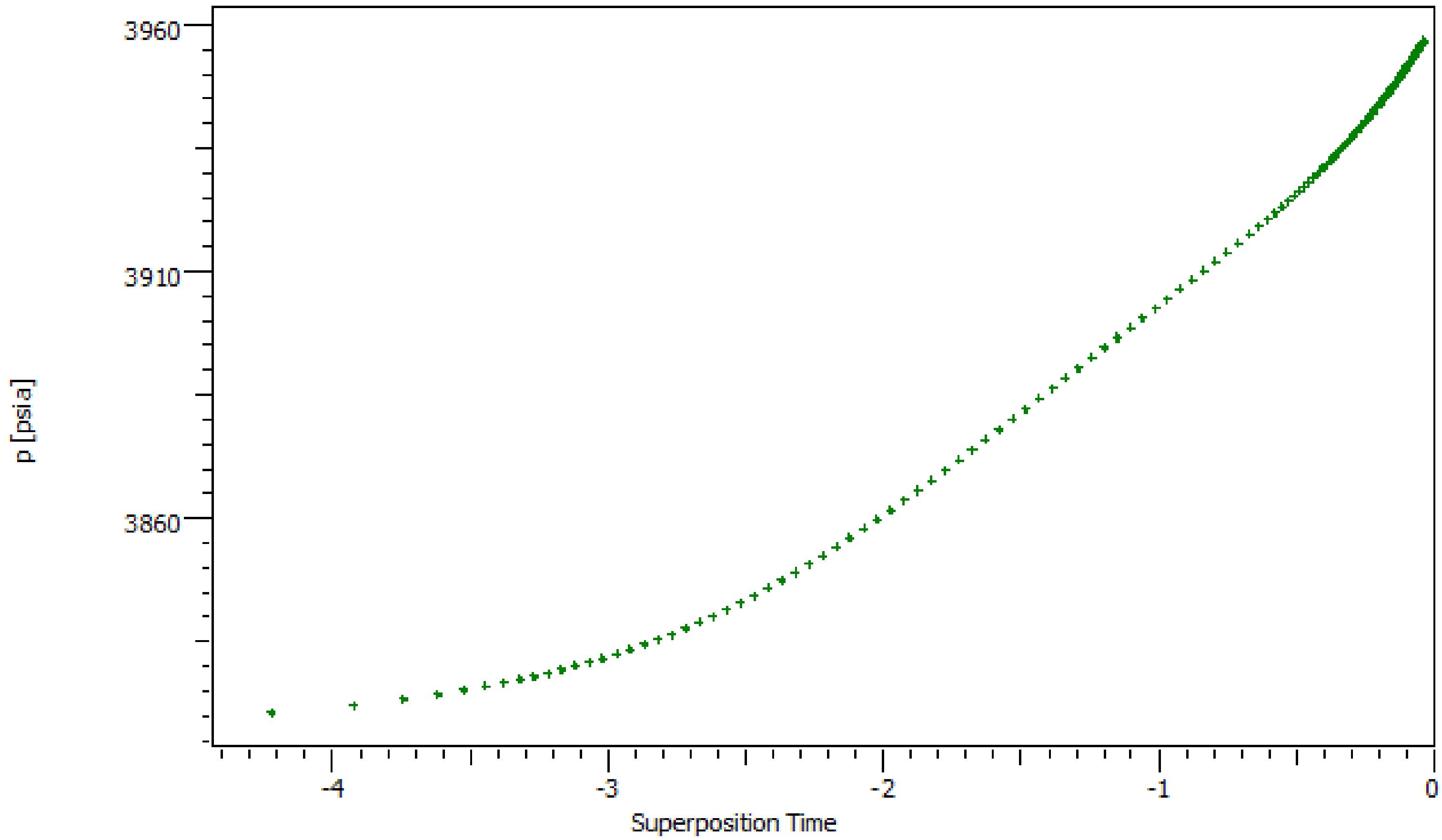

Fig. 3