Universitetet i Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

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

DATE: February 11, 2011

DURATION: 4 hours

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

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

Problem 1

A 5 days drawdown test at a rate of 5200 STB/D in a fractured oil well was followed by a 15 hours buildup test to determine fracture and flow properties. Due to technical problems during the drawdown, data were only obtained from the last 4 days. Use input parameters from Table 1, available drawdown data from Table 2 (reduced), buildup data from Table 3 (reduced), and plots on the last three pages to answer the questions and carry out the analyses below.

a) Fig. 1 shows a combined loglog plot of drawdown and buildup data. What flow regimes can be identified in these data sets?

b) Fig. 2 shows a semilog plot of the drawdown data with $\log(\Delta t)$ on the horizontal axis. Use representative data points from the tables below to determine kh, k, S and Δp_S.

c) Fig. 3 shows a simple square-root-of-time plot of the buildup data. Use representative data points from the tables below and information from the preceding points to determine the fracture half-length x_f. Based on the half-length x_f and skin value S, what fracture type is most likely?

d) The drawdown after 5 days production at 5200 STB/D is quite high. Make a best possible estimate of what it would have been with half the rate (2600 STB/D) and double fracture length.

e) How long drawdown would be required to verify a drainage area of 120 acres based on a circular model? (Note: 1 acre = 43560 ft^2.) With the parameters from (b), what rate would generate a drawdown of 2000 psi at the end of the infinite-acting period for a circular model with an area of 120 acres and the well at the center.

Table 1 – Input parameters for Problem 1

Formation thickness, h	=	62	ft
Porosity, ϕ	=	0.23	
Viscosity, μ	=	3.8	cp
Total compressibility, c_t	=	$2.8\text{x}10^{-5}$	psi^{-1}
Volume factor, B	=	1.14	RB/STB
Wellbore radius, r_w	=	0.354	ft
Initial pressure, p_i	=	5000	psia

Table 2 – Drawdown data

Elapsed Time (hrs)	Pressure (psia)	Elapsed Time (hrs)	Pressure (psia)
24.128	2788.32	74.528	1686.00
27.728	2661.57	78.128	1637.12
31.328	2547.73	81.728	1590.26
34.928	2444.34	85.328	1545.26
38.528	2349.70	88.928	1501.99
42.128	2262.56	92.528	1460.33
45.728	2181.81	96.128	1420.17
49.328	2106.48	99.728	1381.41
52.928	2035.81	103.328	1343.95
56.528	1969.27	106.928	1307.72
60.128	1906.46	110.528	1272.63
63.728	1847.02	114.128	1238.61
67.328	1790.71	117.728	1205.60
70.928	1737.12	120.000	1185.25

Table 3 – Buildup data

Elapsed Time (hrs)	Pressure (psia)	Elapsed Time (hrs)	Pressure (psia)
0.0022	1207.49	0.8158	1610.47
0.0050	1219.20	1.2929	1718.23
0.0082	1228.43	2.0492	1852.53
0.0129	1239.58	3.2477	2019.52
0.0205	1253.61	4.6877	2180.41
0.0325	1271.25	6.1277	2315.00
0.0515	1293.42	7.5677	2431.44
0.0816	1321.28	9.0077	2534.22
0.1293	1356.26	10.448	2626.16
0.2049	1400.17	11.888	2709.28
0.3248	1455.22	13.328	2785.04
0.5147	1524.19	15.000	2865.24

Problem 2

A new well is placed at the midpoint between an oil producer and a water injector that have been operating at the same downhole rates over a long time in a developed field with pressure maintenance.

a) If the fluid compressibilities are similar but the effective mobility (permeability/viscosity) of water is higher than that of oil, will the pressure in the new well be higher or lower than the initial pressure?

b) If the compressibility of oil is much higher than that of water but the effective mobilities similar, will the pressure in the new well be higher or lower than the initial pressure?

Problem 3

The following data have been taken from an isochronal test of a gas well with low static pressure at 1903 psia and the last flow period stabilized.

q_{sc} (Mscf/d)	p_{wf} (psia)
15000	1818.9
19400	1772.5
23800	1714.4
27250	1660.8
23040	1633.2

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

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

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

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

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

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

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

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

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

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

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

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

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

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)

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

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

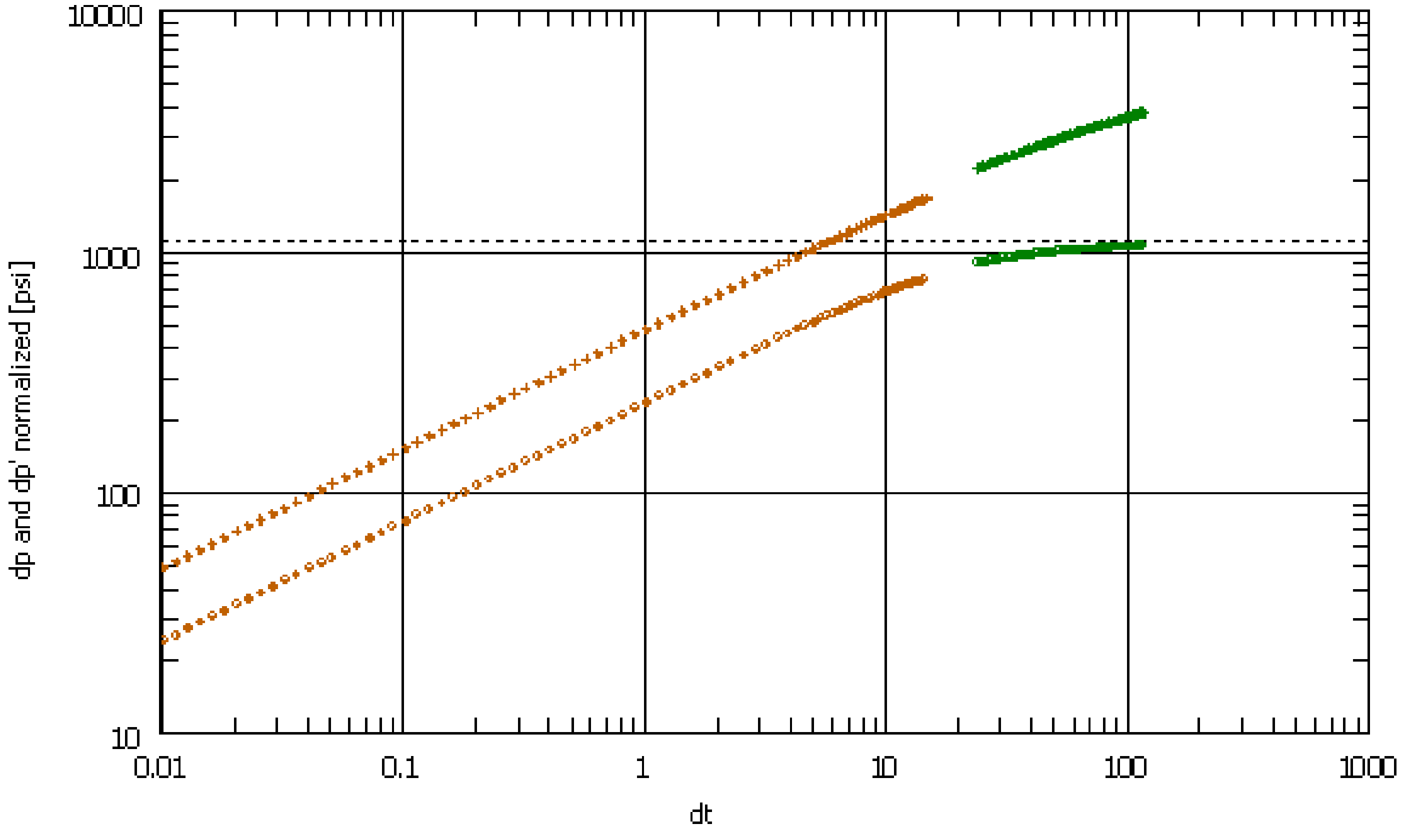
10000
1000
100
10
0.01
0.1
1
10
100
1000
dt
dp and dp' normalized [psi]

Fig. 2

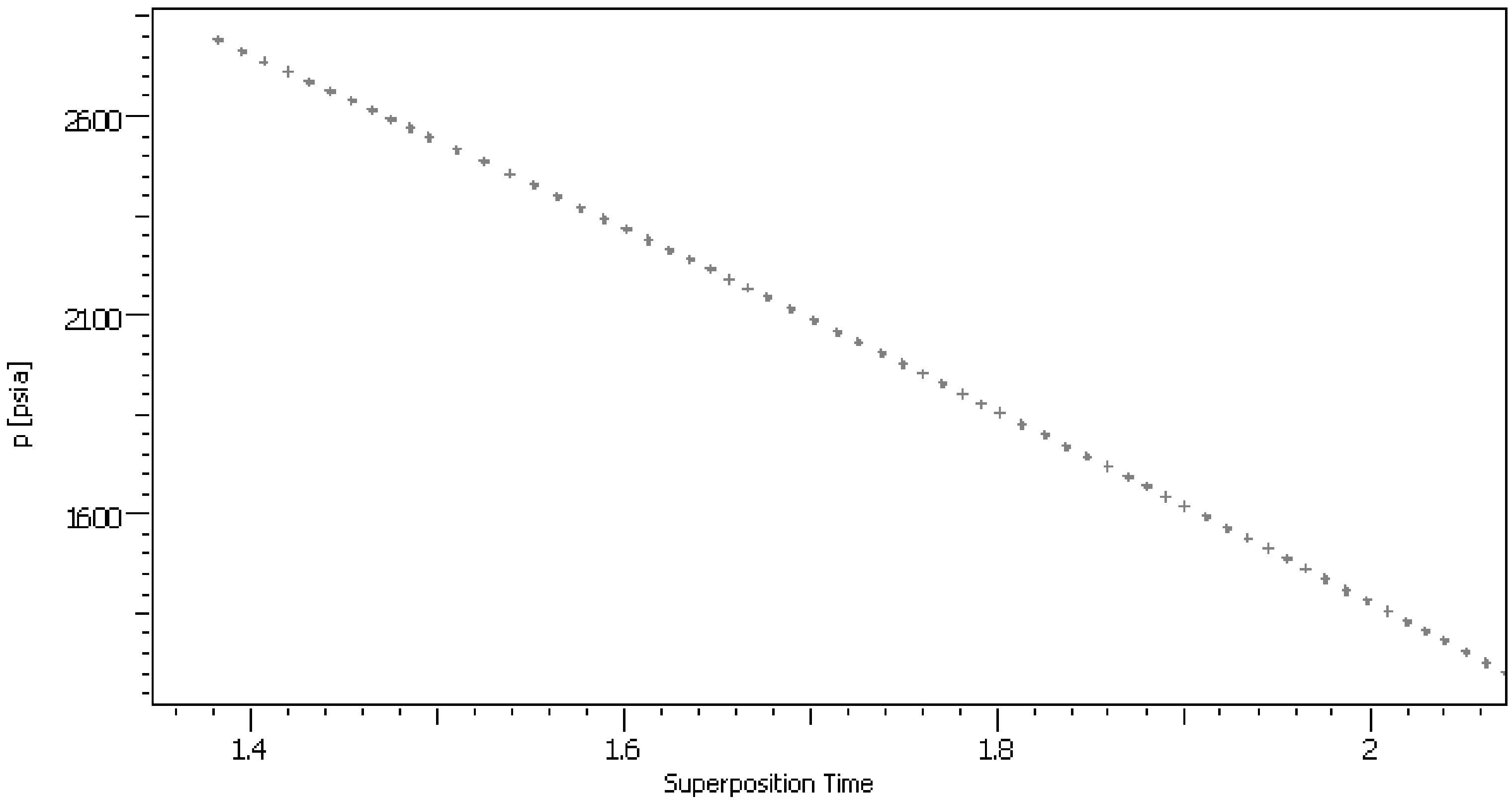

Fig. 3