(2.1) Using eqⁿ 2.4, we get $S = 1.43$ (Example 2.1)

Using eqⁿ 2.3, we get

$$S = 1.151\left(\frac{p_{ws} - p_{wf}}{m}\right) + 1.151\log\left(\frac{1688\,\phi\mu c_t r_w^2}{k\Delta t}\right) + 1.151\log\left(\frac{t_p + \Delta t}{t_p}\right)$$

$$= 1.43 + 1.151\log\left(\frac{72+1}{72}\right)$$

$$= 1.43 + 6.89\times10^{-3}$$

$$= 1.43689$$

$\therefore$ % error $= 0.479\%$

Using $\Delta t = 10$ hrs, $\quad \dfrac{t_p+\Delta t}{\Delta t} = \dfrac{72+10}{10} = 8.2$

from the graph, at $\Delta t = 10$ hrs, $p_{ws} = 1859$ psi

$$\therefore S = 1.151\left(\frac{1859 - 1150}{100}\right) + 1.151\log\left(\frac{1688\times0.2\times1\times20\times10^{-6}\times0.3^2}{48\times10}\right) + 1.151\log\left(\frac{72+10}{72}\right)$$

$$= 8.161 - 6.788 + 0.065$$

$$= 1.438$$

$\therefore$ It hardly makes any difference

ASSUMPTION: Infinite acting reservoir $\Rightarrow r_e = 1233$ ft

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(2.2) We have, $p_{ws} = p_i - 162.6\dfrac{qB\mu}{kh}\log\left(\dfrac{t_p+\Delta t}{\Delta t}\right)$

$$\Rightarrow \underbrace{y}_{p_{ws}} = -\underbrace{m}_{162.6\frac{qB\mu}{kh}}\underbrace{x}_{\log\left(\frac{t_p+\Delta t}{\Delta t}\right)} + \underbrace{c}_{p_i}$$

Let the pressure at one point be p_{ws_1} and pressure after one cycle be p_{ws_2}

$$\therefore p_{ws_2} - p_{ws_1} = -162.6\frac{qB\mu}{kh}\left[\log\left(10\left(\frac{t_p+\Delta t}{\Delta t}\right)_1\right) - \log\left(\frac{t_p+\Delta t}{\Delta t}\right)_1\right]$$

$$\Rightarrow p_{ws_2} - p_{ws_1} = -162.6\frac{qB\mu}{kh}\log\left[10\cancel{\left(\frac{t_p+\Delta t}{\Delta t}\right)_1}\times\cancel{\left(\frac{\Delta t}{t_p+\Delta t}\right)_1}\right]$$

$$\Rightarrow p_{ws_2} - p_{ws_1} = -162.6\frac{qB\mu}{kh}\log 10$$

$$\Rightarrow p_{ws_2} - p_{ws_1} = -162.6\frac{qB\mu}{kh}$$

$$\Rightarrow \boxed{-m = p_{ws_2} - p_{ws_1}}$$ Hence Proved.

for $t_p \gg \Delta t$, we have

$$p_{ws} = p_i - m\left[\log\left(\frac{t_p+\Delta t}{\Delta t}\right)\right]$$

$$\Rightarrow p_{ws} = p_i - m\left[\log(t_p+\Delta t) - \log \Delta t\right]$$

$$\Rightarrow p_{ws} = p_i - m\left[\log t_p - \log \Delta t\right]$$

$$\Rightarrow p_{ws} = (p_i - m\log t_p) + \log\Delta t \, m$$

$\therefore$ we have the same slope m of p_{ws} v/s $\log \Delta t$ graph

Since we expressed the equation as

$$y = c + mx$$

$\therefore$ m is independent of units used in x ($\log \Delta t$)

$\therefore$ Δt can be expressed in any units.

ETR

To

2.8

Δt (hrs)	p_{ws} (psia)	$\frac{t_p+\Delta t}{\Delta t}$
0	709	—
1.97	3,169	151.10
2.95	3,508	101.24
3.94	3,672	76.05
4.92	3772	61.10
5.91	3873	51.03
7.88	3963	38.52
9.86	4026	30.99
14.8	4133	20.98
19.7	4198	16.01
24.6	4245	13.02
29.6	4279	10.99
34.5	4306	9.57
39.4	4327	8.50
44.4	4343	7.66
49.3	4356	6.99
59.1	4375	6.

$$t_p = \frac{12,173 \text{ STB}}{988 \text{ STB/D}} \times 24 \text{ hrs}$$

$$\Rightarrow \boxed{t_p = 295.7 \text{ hrs}}$$

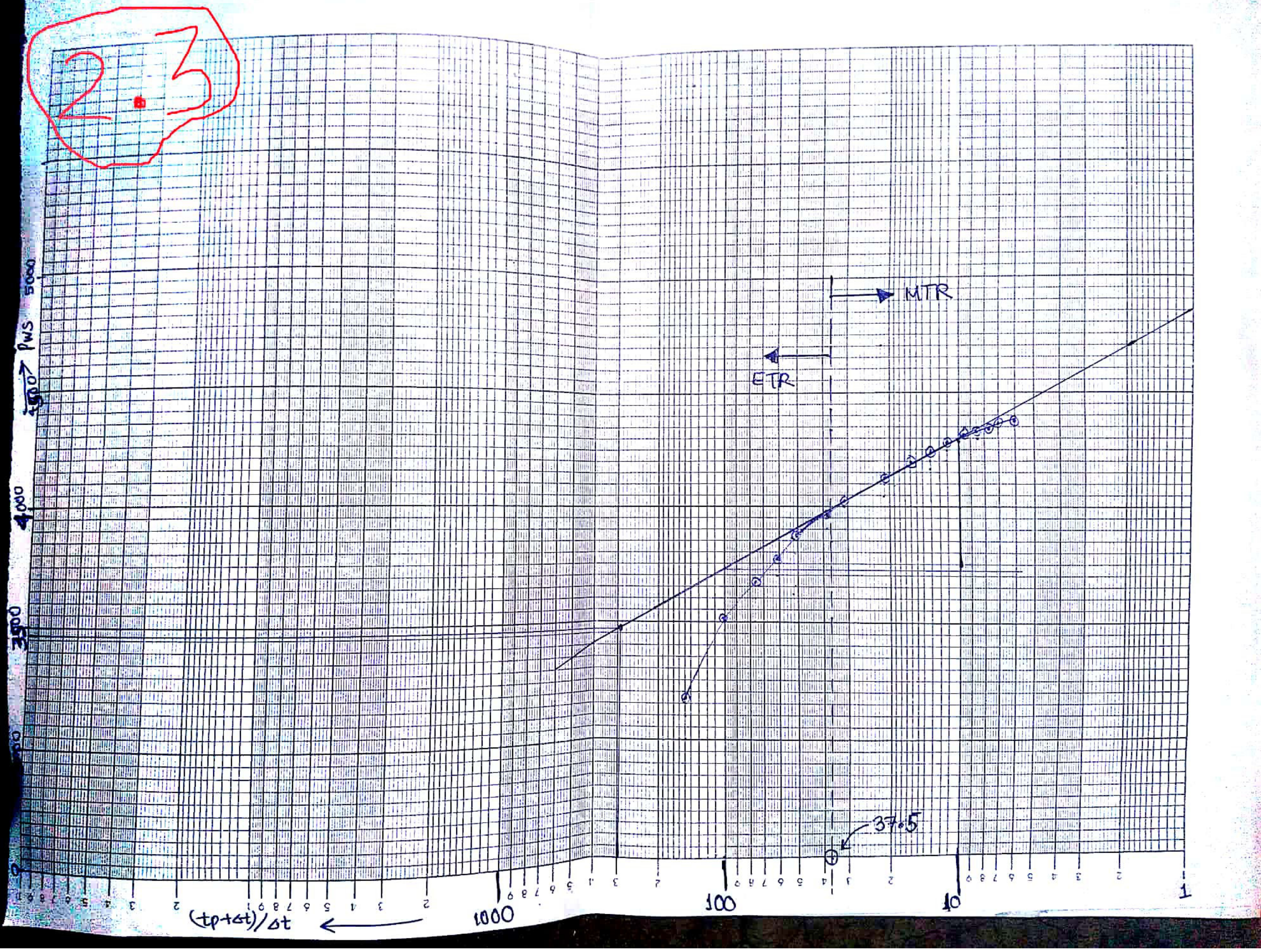
Afterflow ceased distorting the buildup test data as soon as the ETR ended (because well wasn't damaged and the only distortion occurs due to afterflow)

from the graph, ETR ends at $\frac{t_p+\Delta t}{\Delta t} = 37.5$

$$\Rightarrow \frac{295.7+\Delta t}{\Delta t} = 37.5$$

$$\Rightarrow \boxed{\Delta t = 8.1 \text{ hrs}}$$

$\therefore$ Afterflow ceases at 8.1 hours


2.3
Pws
5000
4000
3500
MTR
ETR
37.5
1000
100
10
1
(tp+Δt)/Δt

MTR starts at 8.01 hrs (shown in the graph)

To determine k_1 we use MTR

(2.4) from the graph, $\Delta P_{cycle} = (4300 - 3725)$ psi/cycle

$= 575$ psi/cycle

$$\therefore k = 162.6 \frac{qB\mu}{mh}$$

$$= \frac{162.6 \times 988 \times 1.126 \times 0.55}{575 \times 7} \text{ md}$$

$$\boxed{k_1 = 24.71 \text{ md}}$$

(2.5)

$$s = 1.151 \left[\frac{p_{1hr} - p_{wf}}{m} - \log \frac{k}{\phi \mu c_t r_w^2} + 3.22 \right]$$

$$= 1.151 \left[\frac{3466. - 709}{575} - \log \left(\frac{24.71}{0.14 \times 0.55 \times 16 \times 10^{-6} \times 0.5^2} \right) + 3.23 \right]$$

$$\boxed{S = 0.1386}$$

$$(\Delta P)_s = 141.2 \frac{qB\mu}{kh} S$$

$$= \frac{141.2 \times 988 \times 1.126 \times 0.55 \times 0.1386}{24.71 \times 7} \text{ psi}$$

$$\boxed{(\Delta P)_s = 69.22 \text{ psi}}$$

Flow efficiency, E

$$E = \frac{p^* - p_{wf} - (\Delta P)_s}{p^* - p_{wf}}$$

$$= \frac{4850 - 709 - 69.22}{4850 - 709}$$

$$\boxed{E = 0.9832}$$

$$r_{wa} = r_w e^{-S}$$

$$= 0.5 e^{-0.1386} \text{ ft}$$

$$\boxed{r_{wa} = 0.4352 \text{ ft}}$$

(2.6) Near a single fault, the buildup test equation is given as

$$p_{ws} = p_i - 325.2 \frac{qB\mu}{kh} \log\left[\frac{t_p+\Delta t}{\Delta t}\right]$$

For ideal buildup test, the equation is

$$p_{ws} = p_i - 162.6 \frac{qB\mu}{kh} \log\left[\frac{t_p+\Delta t}{\Delta t}\right]$$

we can see that due to fault, the slope doubled.

for infinite shut in time, $\frac{t_p+\Delta t}{\Delta t} = 1$

$\therefore$ $p_{ws} = p_i$ (in either case)

so, extrapolating LTR to infinite shut in time gives the original reservoir pressure

---

(2.9) slope of MTR = 66 psi/cycle.

$\bar{p} = 3171$ psi $p_{1hr} = 2745$ psi. $p_{wf} = 2486$ psi

Formation permeability, $k = \frac{q_g \mu_i z_i T}{mh}$ (1637)

$= 9.20$ md

skin factor, $s' = 1.151 \left[\frac{p_{1hr} - p_{wf}}{m} - \log\left(\frac{k}{\phi \mu c_t r_w^2}\right) + 3.23\right]$

$\Rightarrow$ $s' = -0.952$

$S_g + S_w = 1.0$

$\Rightarrow$ $S_{g_i} = 1 - S_w = 0.67$

$\Rightarrow$ $S_{g_i} = 0.67$

$c_{t_i} = c_{g_i} S_g + c_w S_w + c_f$

$\approx c_{g_i} S_g$

$c_{t_i} = 2.11 \times 10^{-4}$ psi^{-1}

(2.10) Permeabilities of each phase

$k_o = 162.6 \frac{q_o B_o \mu_o}{mh}$

$= 32.45$ md

$k_w = 162.6 \frac{q_w B_w \mu_w}{mh}$

$= 3.40$ md

$k_g = \frac{162.6\left(q_g - \frac{q_o R_s}{1000}\right) B_g \mu_g}{mh}$

$= 1.17$ md

Total flow rate, q_{Rt}

$$q_{Rt} = q_o B_o + \left(q_g - \frac{q_o R_s}{1000}\right) B_g + q_w B_w$$

$= 964.19$ RB/D

$\therefore$ Total Mobility, $\lambda_t = \frac{162.6 \, q_{Rt}}{mh}$

$\Rightarrow \lambda_t = 80.52$ md/cp

the point to P_{wc} and ...

To calculate skin factor,

$$c_t = S_o c_o + S_g c_g + S_w c_w + c_f$$

$$= 0.56\,c_o + 0.09 \times 0.48\times10^{-3} + 0.35 \times 3.5\times10^{-6} + 3.5\times10^{-6}$$

for calculating c_o,

$$c_o = \frac{B_g}{B_o}\frac{dR_s}{dp} - \frac{1}{B_o}\frac{dB_o}{dp}$$

$$= \frac{1.122}{1.28} \times \frac{0.263}{1000} - \frac{1}{1.28} \times 0.248\times10^{-3}$$

$$= 3.678\times10^{-5}$$

$$\therefore c_t = 6.85\times10^{-5}\ psi^{-1}$$

$$\therefore s = 1.151\left(\frac{p_{1hr} - p_{wf}}{m} - \log\left(\frac{k_t}{\phi \mu c_t r_w^2}\right) + 3.23\right)$$

$$= 1.151\left(\frac{1744 - 1581}{59} - \log\left(\frac{80.52}{0.18 \times 6.85\times10^{-5} \times 0.3^2}\right) + 3.23\right)$$

$$\boxed{s = -2.15}$$

2.11

$p_{ws}-p_{MT}$	p_{MT}	Δt	p_{ws}	$\frac{t_p+\Delta t}{\Delta t}$
–	–	20	1373	108.87
–	–	30	1467	72.91
–	–	40	1533	54.93
–	–	50	1585	44.14
27	1725	100	1752	22.57
85	1855	200	1940	11.78
185	2040	500	2225	5.31
250	2110	800	2360	3.69
284	2150	1000	2434	3.15
340	2205	1500	2545	2.43
371	2245	2000	2616	2.07

$$\boxed{t_p = 2157.4\ hrs}$$

$$k = \frac{162.6\, q B \mu}{m h}$$

$$\boxed{k = 87\ md}$$

Evaluating L at $\Delta t = 100$ hrs, we have

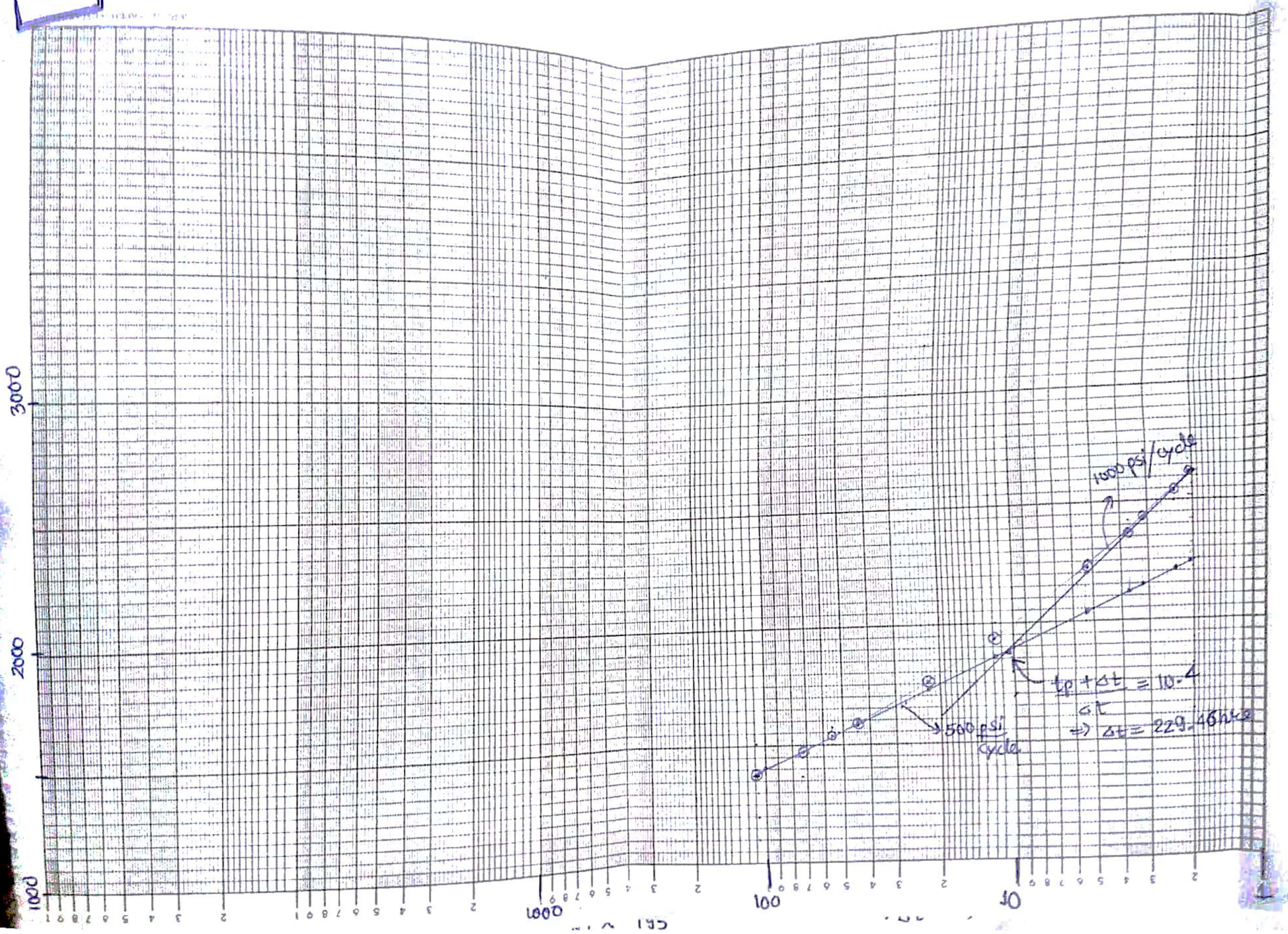
$$\Delta p_{ws}^{*} = -\frac{70.6\, q B \mu}{k h} E_i\left(-\frac{3792\, \phi \mu c_t L^2}{k \Delta t}\right)$$

$$\Rightarrow 27 = -\frac{70.6 \times 940 \times 1.11 \times 50}{87 \times 195} E_i\left(-\frac{3792\, \phi \mu c_t L^2}{k \Delta t}\right)$$

$$\Rightarrow -E_i\left(-\frac{3792\, \phi \mu c_t L^2}{k \Delta t}\right) = 0.124 \Rightarrow -\frac{3792\, \phi \mu c_t L^2}{k \Delta t} = -1.36 \Rightarrow \boxed{L = 63.24\ ft}$$

2.11

$= \frac{1.122}{1.\ldots} \times 0.263$



2.12, Give, $t_p = 10$ days $= 240$ hrs

(a) For infinite acting reservoir,

$$p_{ws} = p_i - \frac{162.6\, qB\mu}{kh} \log\left(\frac{t_p+\Delta t}{\Delta t}\right)$$

$$= 3000 - 25.72 \log\left(\frac{t_p+\Delta t}{\Delta t}\right) \text{ (For } S = 0\text{)}$$

Δt (hrs)	$\left(\frac{t_p+\Delta t}{\Delta t}\right)$	p_{ws}
0	—	—
0.1	2401	2901
1.0	241	2938.7
10	25	2964.05

The p_{ws} v/s $\log\left(\frac{t_p+\Delta t}{\Delta t}\right)$ plot is give.

(b) We have, $r_i = \left(\frac{k\Delta t}{948\phi\mu c_t}\right)^{1/2}$

Δt (hrs)	r_i (ft)
0.1	40.6
1.0	128.4
10.0	406

2.13, Given :- $\bar{p} = 4411$ psi , $A = 6.97 \times 10^6$ sq.ft
for $t_p = 13630$

& $t_{pss} = \left(\dfrac{\phi \mu c_t A}{0.000264\, k}\right)(t_{DA})_{pss}$

$= \dfrac{\phi \mu c_t A}{0.00264 k} = 183$ hrs.

Using t_{pss} instead of t_p,

Δt (hrs)	$\left(\dfrac{t_{pss} + \Delta t}{\Delta t}\right)$	p_{ws}
8	23.88	4354
12	16.25	4366
16	12.44	4376
20	10.15	4382
24	8.63	4388

From the graph, slope of MTR = 68 psi/cycle

And the p^* value in this case = p_1^*

$= 4410$ psig

i.e. $\boxed{p_1^* \approx p^*}$

Thus, p^* value remains the same in both cases