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Gringarten et.al Type Curve, Interpretation Method

The interpretation method consists of the following steps

1- Plot the measured pressure drop i.e

$$\Delta P_j = P_{wf}(\Delta t=0) - P_{wf_j} \quad \text{Vs. } t\,(hr)\ (\text{Drawdown})$$

or

$$\Delta P_j = P_{ws_j} - P_{ws}(\Delta t=0) \quad \text{Vs. } \Delta t_e \ (\text{Buildup})$$

where Δt_e = Equivalent Shut in time or Agarwal effective time, and

$$\Delta t_e = \frac{\Delta t}{1 + \frac{\Delta t}{t_p}} \quad (hr.)$$

also $\Delta t_e \simeq \Delta t$ for $\Delta t \ll t_p$

on tracing paper lying on the type curve using the type curve of ~~the~~ (Fig. 5.2a)

2- Look for the portion of an underlying type curve matching the data best (Fig 2-a b); only translation are allowed during this step, keeping the two grids parallel.

3- Note the specifications of the type curve where the measured points match; they corresponding to a value of $C_D e^{2s'}$

4- pick a Match point M, whose coordinates can be ~~measured~~ read in both the type curve system of axis $(P_D, \frac{t_D}{C_D})$ as well as in the field data system $(\Delta P_j, \Delta t_j)$ or $(\Delta P_j, \Delta t_{ej})$, the match point M can be chosen anywhere on the plot, not necessarily on the curve (Fig 5.2 c), Read the following: $(P_D)_M$, $(\Delta P)_M$, $(\Delta t \text{ or } \Delta t_e)_M$

$\left(\frac{t_D}{C_D}\right)_M$ and $(C_D e^{2s'})_M$

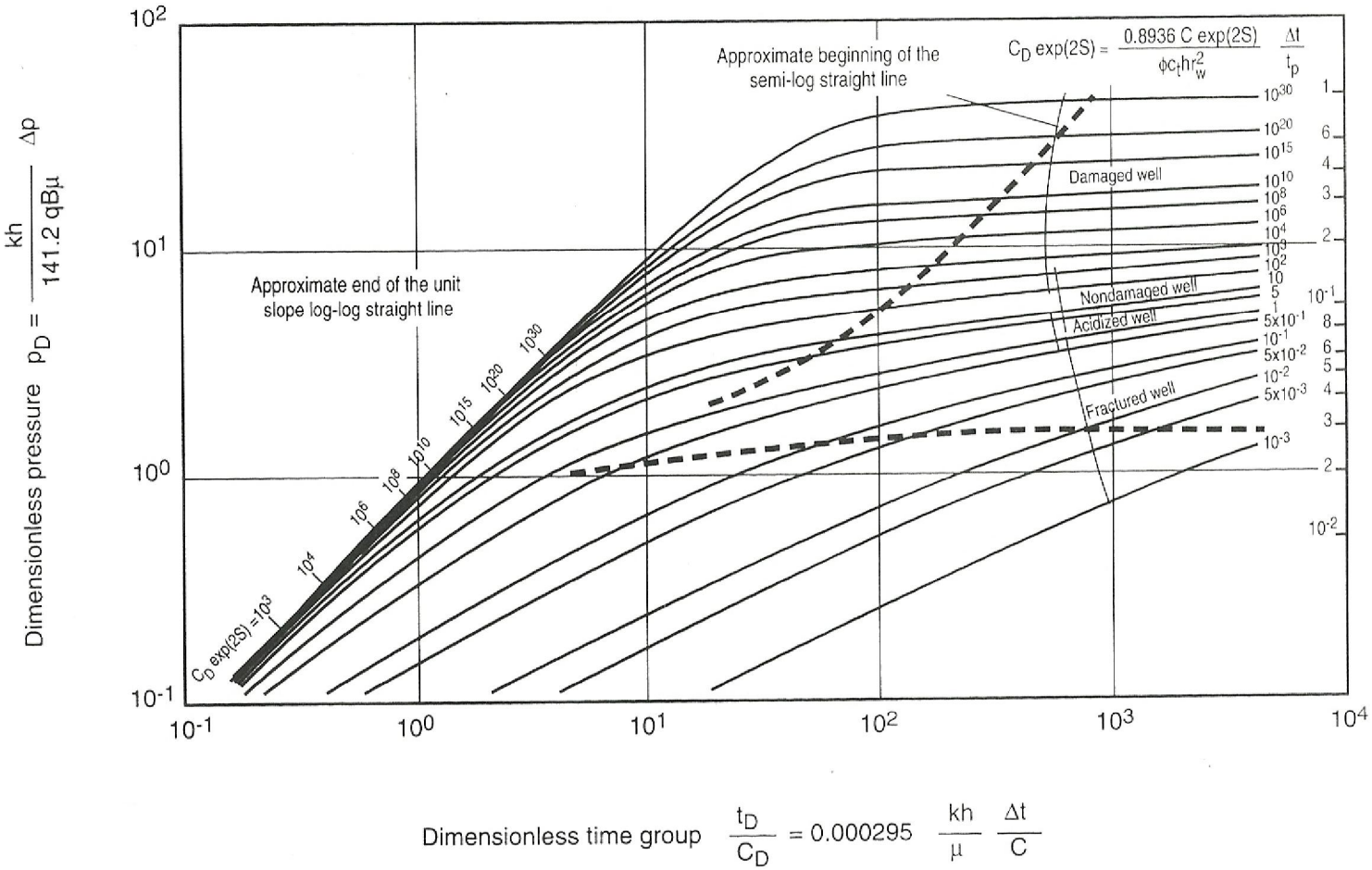

Fig. 5.1 Type curves for a well with wellbore storage and skin (infinite homogeneous reservoir)

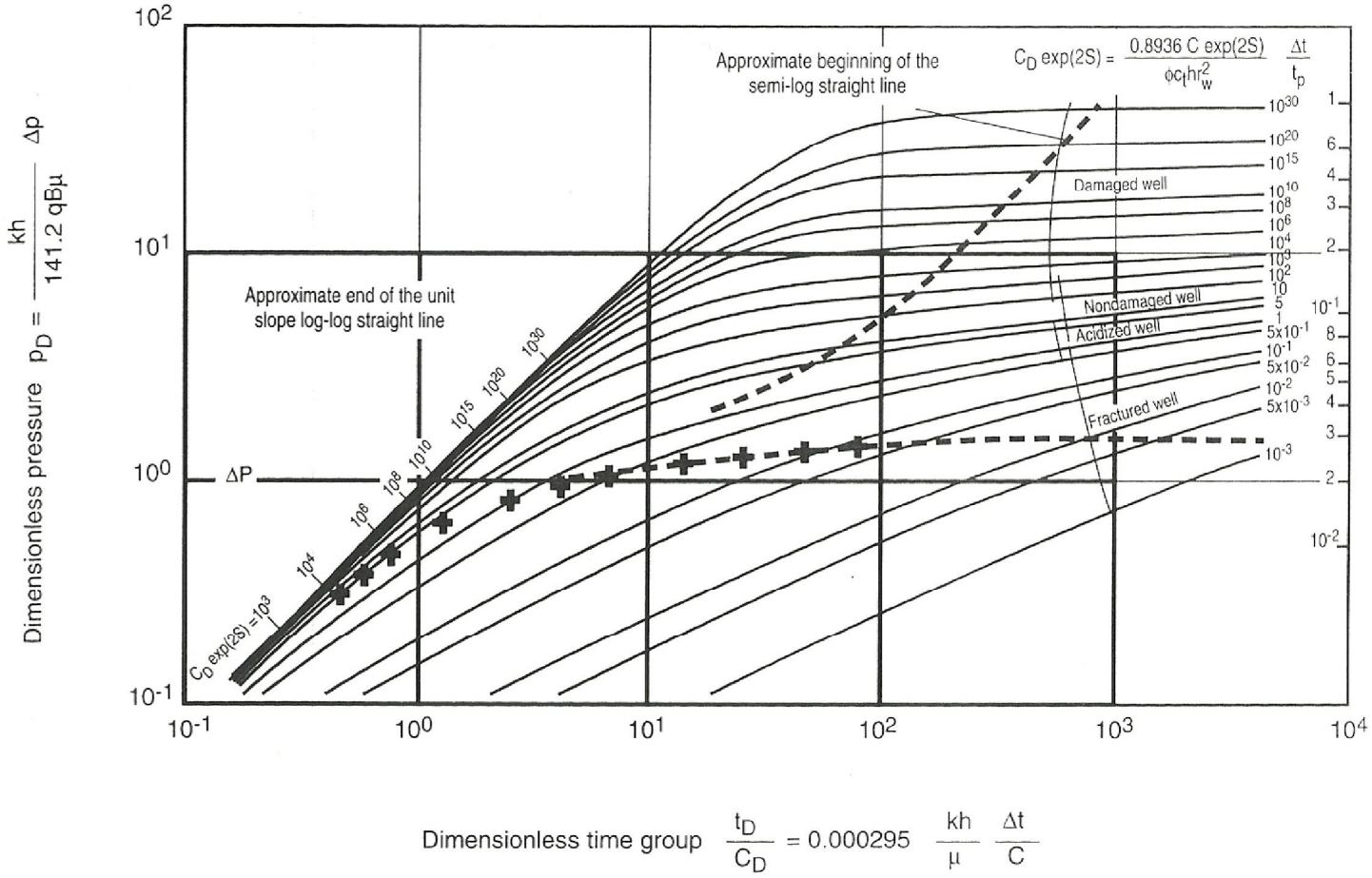
Approximate beginning of the semi-log straight line
$C_D \exp(2S) = \frac{0.8936\, C \exp(2S)}{\phi c_t h r_w^2} \frac{\Delta t}{t_p}$
Damaged well
Nondamaged well
Acidized well
Fractured well
Approximate end of the unit slope log-log straight line
ΔP
$C_D \exp(2S) = 10^3$
Dimensionless pressure $p_D = \frac{kh}{141.2\, qB\mu} \Delta p$
Dimensionless time group $\frac{t_D}{C_D} = 0.000295 \frac{kh}{\mu} \frac{\Delta t}{C}$

Fig. 5.2a

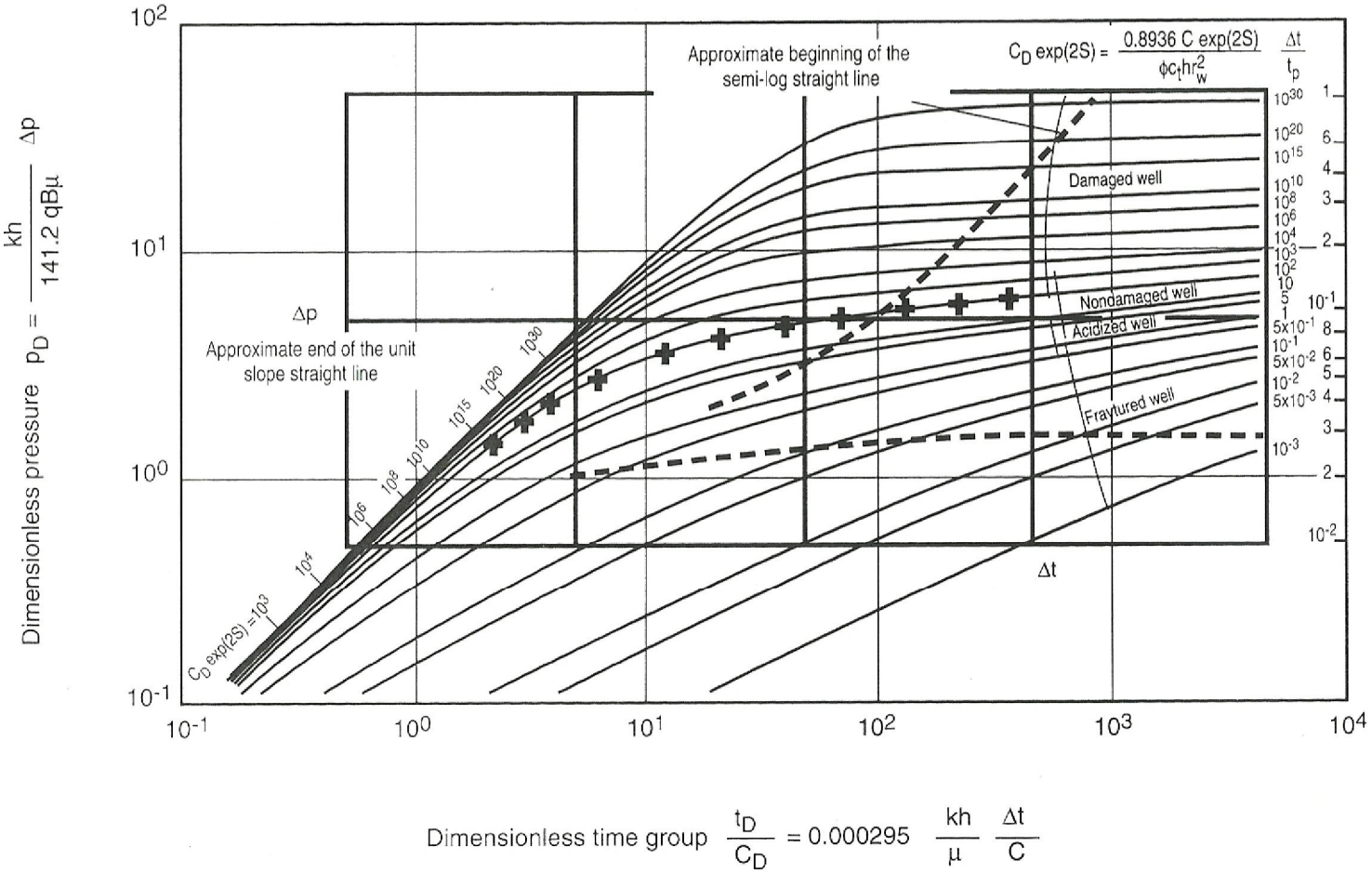
Approximate beginning of the semi-log straight line
$C_D \exp(2S) = \frac{0.8936\, C \exp(2S)}{\phi c_t h r_w^2}$
$\frac{\Delta t}{t_p}$
Damaged well
Nondamaged well
Acidized well
Fractured well
Δp
Approximate end of the unit slope straight line
Δt
$C_D \exp(2S) = 10^3$
Dimensionless pressure $p_D = \frac{kh}{141.2\, qB\mu} \Delta p$
Dimensionless time group $\frac{t_D}{C_D} = 0.000295 \frac{kh}{\mu} \frac{\Delta t}{C}$

Fig. 5.2b

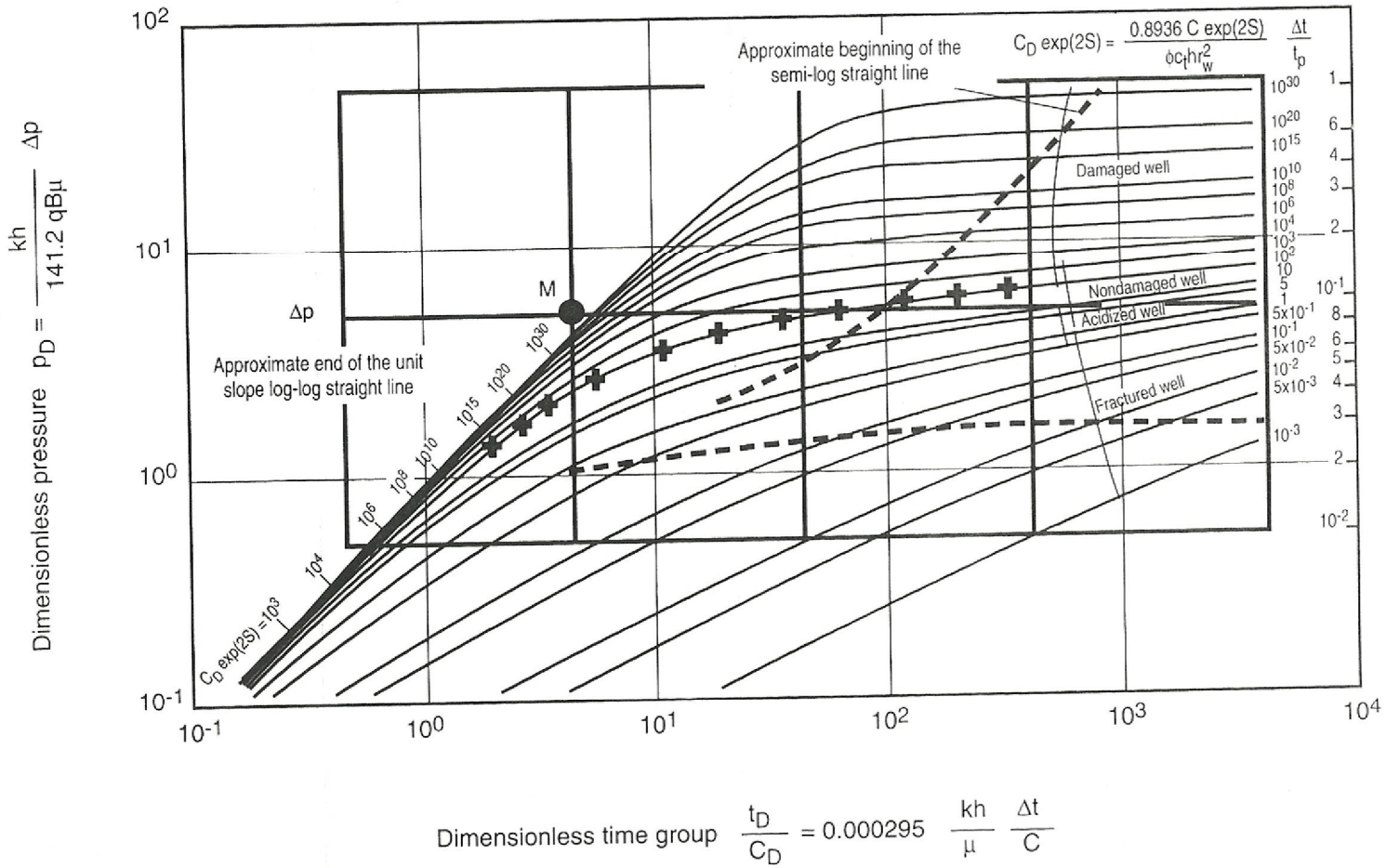
Dimensionless pressure $p_D = \frac{kh}{141.2\,qB\mu}\,\Delta p$
Dimensionless time group $\frac{t_D}{C_D} = 0.000295\,\frac{kh}{\mu}\,\frac{\Delta t}{C}$
$C_D\exp(2S) = \frac{0.8936\,C\exp(2S)}{\phi c_t h r_w^2}\,\frac{\Delta t}{t_p}$
Approximate beginning of the semi-log straight line
Approximate end of the unit slope log-log straight line
Δp
M
Damaged well
Nondamaged well
Acidized well
Fractured well
$C_D\exp(2S) = 10^3$
10^4
10^6
10^8
10^{10}
10^{15}
10^{20}
10^{30}
10^{30}
10^{20}
10^{15}
10^{10}
10^8
10^6
10^4
10^3
10^2
10
5
1
5×10^{-1}
10^{-1}
5×10^{-2}
10^{-2}
5×10^{-3}
10^{-3}
10^{-1}
10^{-2}
10^2
10^1
10^0
10^{-1}
10^{-1}
10^0
10^1
10^2
10^3
10^4

Fig. 5.2c

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Calculations

1- Calculate the reservoir capacity Kh (md.ft)

$$Kh = 141.2\, q_o B_o \mu_o \frac{(P_D)_M}{(\Delta P)_M}$$

2- Calculate the dimensionless wellbore storage C_D

$$C_D = \frac{0.0002637\, K}{\phi \mu_o C_t r_w^2} \left(\frac{t \text{ or } \Delta t_e}{t_D / C_D} \right)_M$$

Note: If a unit slop line is present on the test data at early times, Calculate the dimensionless wellbore storage Coefficient C_D with a data point $(t \text{ or } \Delta t_e, \Delta P)_{USL}$

$$\cancel{C_D = 0.0002637K} \quad C_D = \frac{0.03723\, q_o B_o}{h \phi C_t r_w^2} \left(\frac{t \text{ or } \Delta t_e}{\Delta P} \right)_{USL}$$

If desired, calculate the storage coefficient C, with the Same point from the USL

$$C = \frac{q_o B_o}{24} \left(\frac{t \text{ or } \Delta t_e}{\Delta P} \right)_{USL}$$

the values of C_D should be Comparable, In cosistencies between the two values indicates possible errors in the analysis.

3- Calculate the skin factor, s, with the type curve Correlating parameter $C_D e^{2s}$

$$s = 0.5 \ln \left(\frac{C_D e^{2s}}{C_D} \right)$$

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Prob.:- Formation and fluid properties are:-

$h = 78$ ft., $\mu = 1$ cp., $q_o = 600$ STB/D, $P_{wf} = 250$ psia, $t_p = 1400$ hours, $\phi = 0.2$, $\bar{P} = 2447$ psia, $r_w = 0.365$ ft, $B_o = 1.1$ RB/STB, $C_t = 1.61 \times 10^{-5}$ psi^{-1}, Type of Test Pressure Build up. Test Data are given in Table 1 and Table 2, Apply Gringarten Type-Curve Analysis.

Results of Matching:-

1. From Unit Slop line $(\Delta t_e)_{USL} = 10^{-3}$ hr, $\Delta P = 40.29$ psia
2. Match point:-

$C_D e^{2S} = 10^{10}$ $\quad (\Delta P)_M = 120$ psia $\quad (P_D)_M = 1$

$(\Delta t_e)_M = 28$ hr $\quad \frac{t_D}{C_D} = 10\,000$

Results: a- Calculate C_D and C from USL data

$$C_D = 0.03723 \frac{(600)(1.1)}{(78)(0.2)(1.61 \times 10^{-5})(0.365)^2} \left(\frac{10^{-3}}{40.29}\right)$$

$$C_D = 18.2$$

$$C = \frac{(600)(1.1)}{24} \left(\frac{10^{-3}}{40.29}\right) \Rightarrow C = 6.84 \times 10^{-4} \text{ RB/psi}$$

b- Calculate Kh

$$Kh = \frac{(141.2)(600)(1.1)(1)}{120}$$

$$\boxed{\left(\frac{P_D}{\Delta P}\right)_M = \frac{1}{120}}$$

$Kh = 776.6$ md.ft and $K = 9.96$ md

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TABLE 1.7—PRESSURE-BUILDUP-TEST DATA FOR EXAMPLE 4.3

Δt (hours)	p_{ws} (psi)	Δt (hours)	p_{ws} (psi)
0	250	1.71	2,043.1
0.0001	254.09	2.73	2,072.1
0.0002	258.16	4.36	2,100.7
0.0005	270.30	6.50	2,124.9
0.0008	282.33	10.5	2,153.7
0.0010	290.29	15.1	2,175.4
0.0030	367.39	20.0	2,192.0
0.0050	440.40	25.0	2,205.2
0.0080	542.99	30.0	2,215.9
0.0100	607.11	35.0	2,225.0
0.0160	780.68	40.0	2,232.8
0.0255	1,005.1	45.0	2,239.6
0.0406	1,263.2	50.0	2,245.7
0.0649	1,515.6	55.0	2,251.2
0.104	1,714.0	60.0	2,256.2
0.165	1,837.0	65.0	2,260.8
0.264	1,907.4	70.0	2,265.0
0.421	1,950.0	72.0	2,266.6
0.672	1,983.2	80.0	2,272.6
1.07	2,013.5		

TABLE 2.8—PLOTTING FUNCTIONS FOR GRINGARTEN TYPE-CURVE ANALYSIS, EXAMPLE 4.3

Δt_e (hours)	Δp (psi)	Δt_e (hours)	Δp (psi)
—	—	1.7079	1,793.1
0.0001	4.0900	2.7247	1,822.1
0.0002	8.1600	4.3465	1,850.7
0.0005	20.300	6.4700	1,874.9
0.0008	32.330	10.422	1,903.7
0.0010	40.290	14.939	1,925.4
0.0030	117.39	19.718	1,942.0
0.0050	190.40	24.561	1,955.2
0.0080	292.99	29.371	1,965.9
0.0100	357.11	34.146	1,975.0
0.0160	530.68	38.889	1,982.8
0.0255	755.10	43.599	1,989.6
0.0406	1,013.2	48.276	1,995.7
0.0649	1,265.6	52.921	2,001.2
0.1040	1,464.0	57.534	2,006.2
0.1650	1,587.0	62.116	2,010.8
0.2640	1,657.4	66.667	2,015.0
0.4209	1,700.0	68.478	2,016.6
0.6717	1,733.2	75.676	2,022.6
1.0692	1,763.5		

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c. From Match point Calculate C_D and S'

$$C_D = \frac{(0.0002637)(9.96)}{(0.2)(1)(1.61\times10^{-6})(0.365)^2}\left(\frac{28}{10\,000}\right)$$

$C_D = 17.14$ << consistent with $C_D = 18.2$ Calculated from USL >>

$$S' = 0.5\ln\left(\frac{10^{10}}{17.1}\right) \Rightarrow S' = 10.1 \text{ Sever Damage}$$