UNIVERSITI TEKNOLOGI PETRONAS

FINAL EXAMINATION
MAY 2024 SEMESTER

COURSE	**:**	**PEB2063/PFB2063 - PRODUCTION ENGINEERING I**
DATE	**:**	**5 AUGUST 2024 (MONDAY)**
TIME	**:**	**9:00 AM - 12:00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **FOURTEEN (14)** pages in this Question Booklet including the cover page and appendices.

ii. **DOUBLE-SIDED** Question Booklet.

iii. Graph paper (s) will be provided.

3. a. Onshore wells are likely to perform poorly or lower than expected due to low reservoir permeability and wellbore restriction because of formation damage or incomplete perforation. However, a well stimulation could improve its productivity.

i. Explain the indicators of formation damage and discuss **TWO (2)** sources of formation damage during operations.

[10 marks]

ii. Explain critically the working mechanism of matrix acidizing.

[5 marks]

iii. Evaluate the consequences of incorrect choice of matrix stimulation fluids.

[5 marks]

b. An offshore field is classified as a sandstone reservoir and supported by a strong water formation. It has an average reservoir pressure of 4,500 psi and a temperature of 150 ^{o}F. The well testing records showed a stabilized oil flow rate at a flowing bottomhole pressure of 1,550 psi with insignificant skin effect. As the production declines with time, the company have decided to perform an acidizing treatment by injecting mud acid. Before HF/HCl stage penetrates the formation, HCl pre-flush (15% wt.) is injected to dissolve all carbonate minerals within 1.25 ft from the wellbore.

TABLE Q3: Reservoir and hydrocarbon fluid data.

Reservoir type	Sandstone
Formation minerals	10% calcite, 15% quartz, 0.5% clay
Permeability	5 mD
Porosity	18%
Formation thickness	50 ft
Oil viscosity	1.2 cP
Drainage area	400 acres
Wellbore radius	0.428 ft
Formation volume factor	1.1 res bbl/stb
Formation compressibility	3 x10 $^{-6}$ psia^{-1}
GOR	400 ft^3/bbl

Design a successful acid treatment for an offshore reservoir. Show all detailed calculation steps and used equations clearly.

[20 marks]

- END OF PAPER –

APPENDIX I

Radial Inflow Equations for Stabilised Steady-State Conditions (S = 0) Vertical Well

$$PI = \frac{q}{\left(\overline{p} - p_{wf}\right)} = \frac{0.007082\ kh}{\mu B_o\left(\ln\frac{r_e}{r_w} - \frac{1}{2}\right)}$$

Radial Inflow Equations for Stabilised Semi–Steady-State Conditions (S = 0) for Vertical Well.

$$\overline{p} - p_{wf} = \frac{141.2 q\mu B_o}{kh}\left(\ln\frac{r_e}{r_w} - \frac{3}{4}\right)$$

Vogel equations for vertical single oil well (EF=1)

$$q_o = q_{o,max}\left[1 - 0.2\left(\frac{p_{wf}}{p_r}\right) - 0.8\left(\frac{p_{wf}}{p_r}\right)^2\right]$$

$$q_o = q_b + \frac{Jp_b}{1.8}\left[1 - 0.2\left(\frac{p_{wf}}{p_b}\right) - 0.8\left(\frac{p_{wf}}{p_b}\right)^2\right]$$

$$J = \frac{q_{o1}}{(p_r - p_b) + \frac{p_b}{1.8}\left[1 - 0.2\left(\frac{p_{wf1}}{p_b}\right) - 0.8\left(\frac{p_{wf1}}{p_b}\right)^2\right]}$$

$$J = \frac{q_{o1}}{(p_r - p_{wf1})}$$

$$q_b = J(p_r - p_b)$$

$$q_{o,max} = AOF = q_b + \frac{Jp_b}{1.8}$$

$$P_{wf} = 0.125\,\overline{P}\left[\sqrt{81 - 80\left(\frac{q_o}{q_{max}}\right)} - 1\right]$$

Closing pressure of the subsurface safety valve:

$$\boldsymbol{P_{close} = 0.433 \times \rho_f \times H_{max} \times SF}$$

$$\text{Pg (psig/ft)} = \rho\left(\frac{lb}{gal}\right) \times 0.052$$

Gas injection

$$\left(P_{inj}\right)_{downhole} = \left(P_{inj}\right)_{surface} \times \left[1 + \frac{D_{ov}}{40{,}000}\right]$$

$$p_{upstream} = \frac{bq_L R^c}{D_{64}^a}$$

Correlation	a	b	c
Ros	2.00	17.40	0.500
Gilbert	1.89	10.00	0.546
Achong	1.88	3.82	0.650
Ausseens	1.97	3.86	0.680
Baxendell	1.93	9.56	0.546

Height of dead oil in the tubing

$$h = \frac{reservoir\ pressure}{oil\ gradient}$$

$$q_g = q_o\,(GLR_{operating} - GLR_{formation})$$

$$GOR_{operating} = \frac{Lift\ Gas\ Injection\ Rate}{Required\ Oil\ Rate} + Initial\ GOR$$

Acid Injection

$$\beta = \frac{\nu_{mineral} MW_{mineral}}{\nu_{acid} MW_{acid}}$$

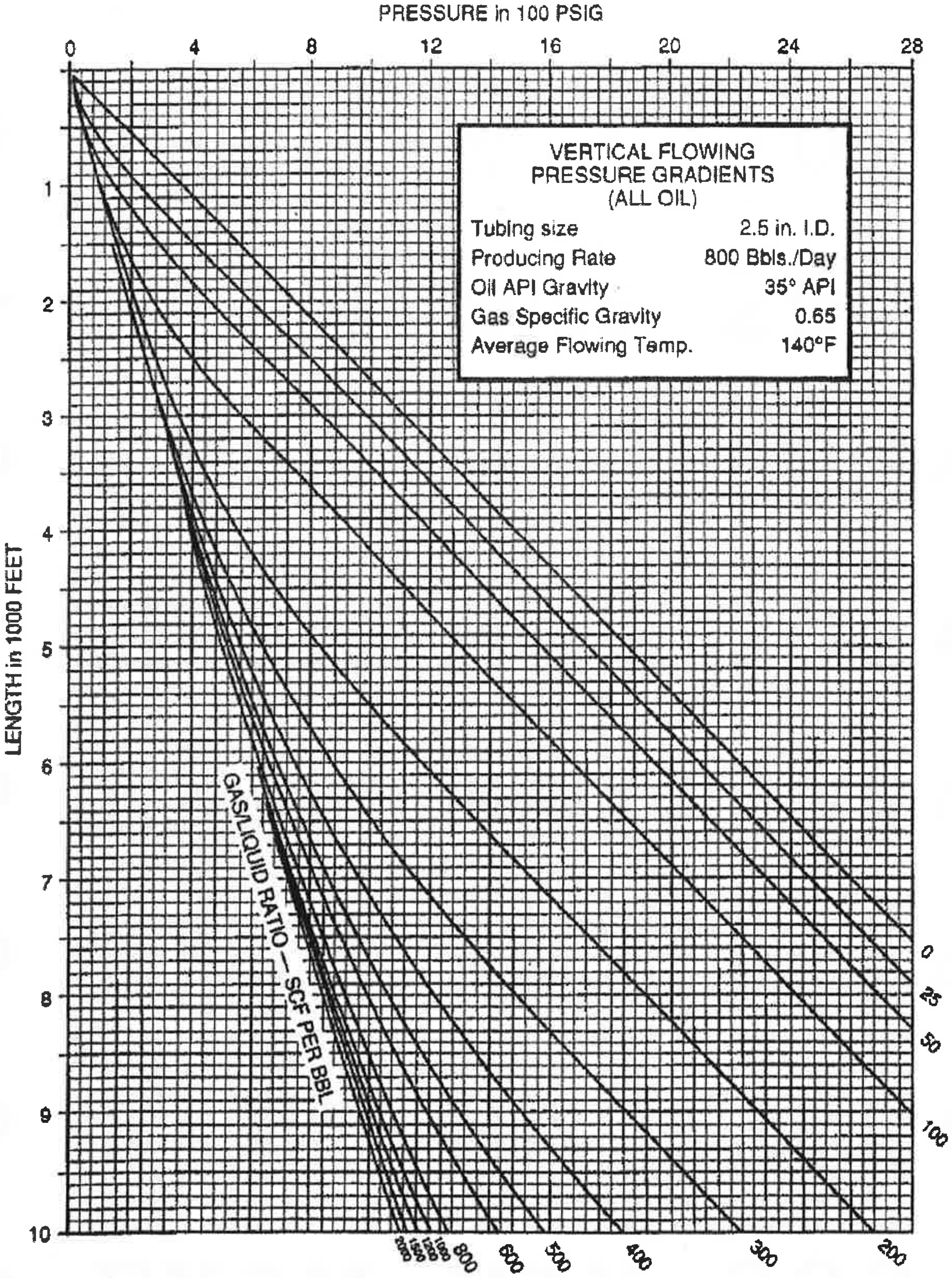
$$X = \beta \frac{\rho_{acid\ solution}}{\rho_{mineral}}$$

$$V_m = \pi\,(r_{HCl}^2 - r_w^2)(1-\phi)\,x_{caco_3}$$

$$V_p = \pi\,(r_{HCl}^2 - r_w^2)\,\phi$$

$$V_d = \frac{V_m}{X}$$

$$V_{acid} = V_p + V_d + V_m$$


PRESSURE in 100 PSIG
0
4
8
12
16
20
24
28
LENGTH in 1000 FEET
1
2
3
4
5
6
7
8
9
10
VERTICAL FLOWING
PRESSURE GRADIENTS
(ALL OIL)
Tubing size 2.5 in. I.D.
Producing Rate 800 Bbls./Day
Oil API Gravity 35° API
Gas Specific Gravity 0.65
Average Flowing Temp. 140°F
GAS/LIQUID RATIO — SCF PER BBL
0
25
50
100
200
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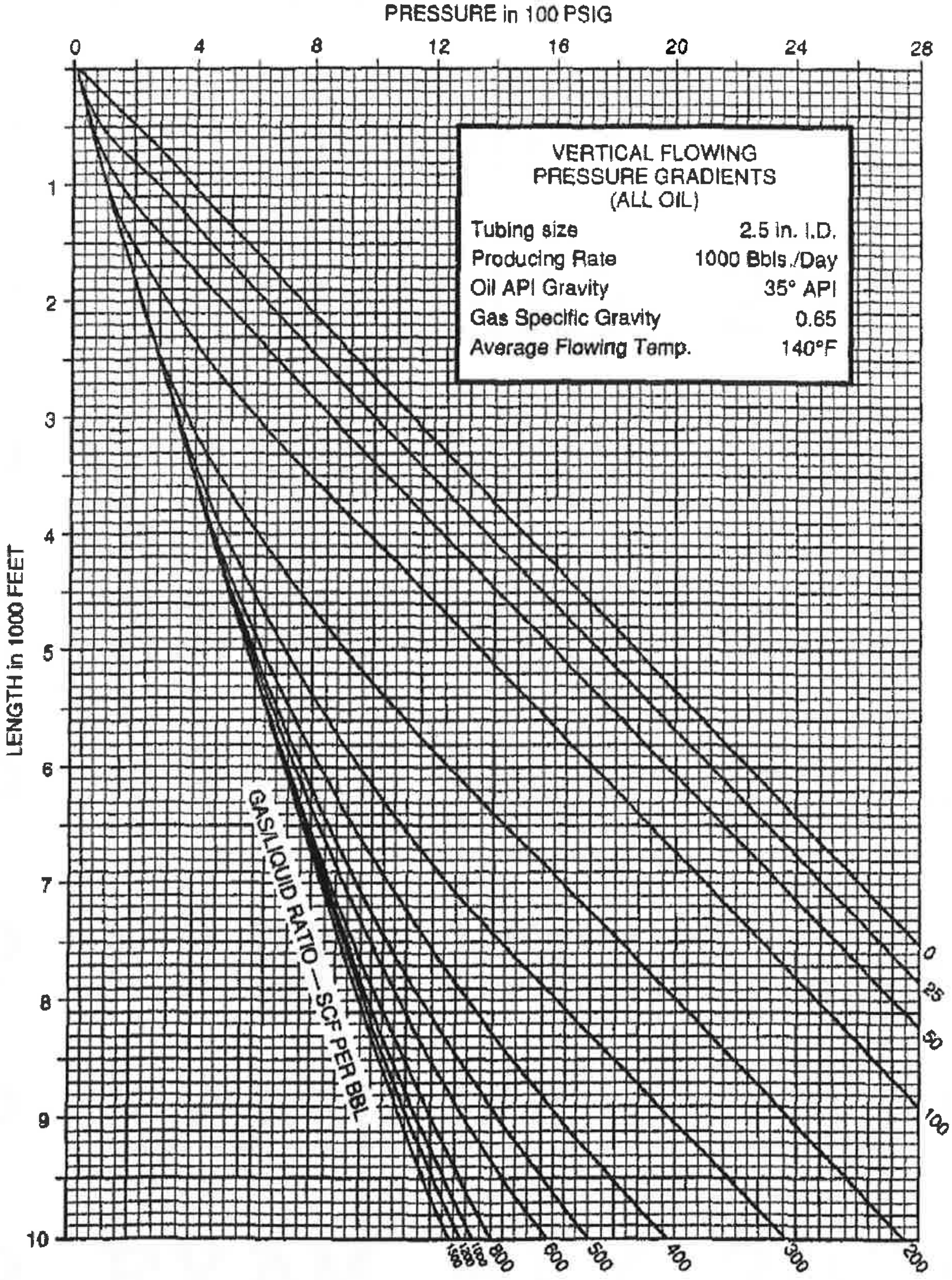
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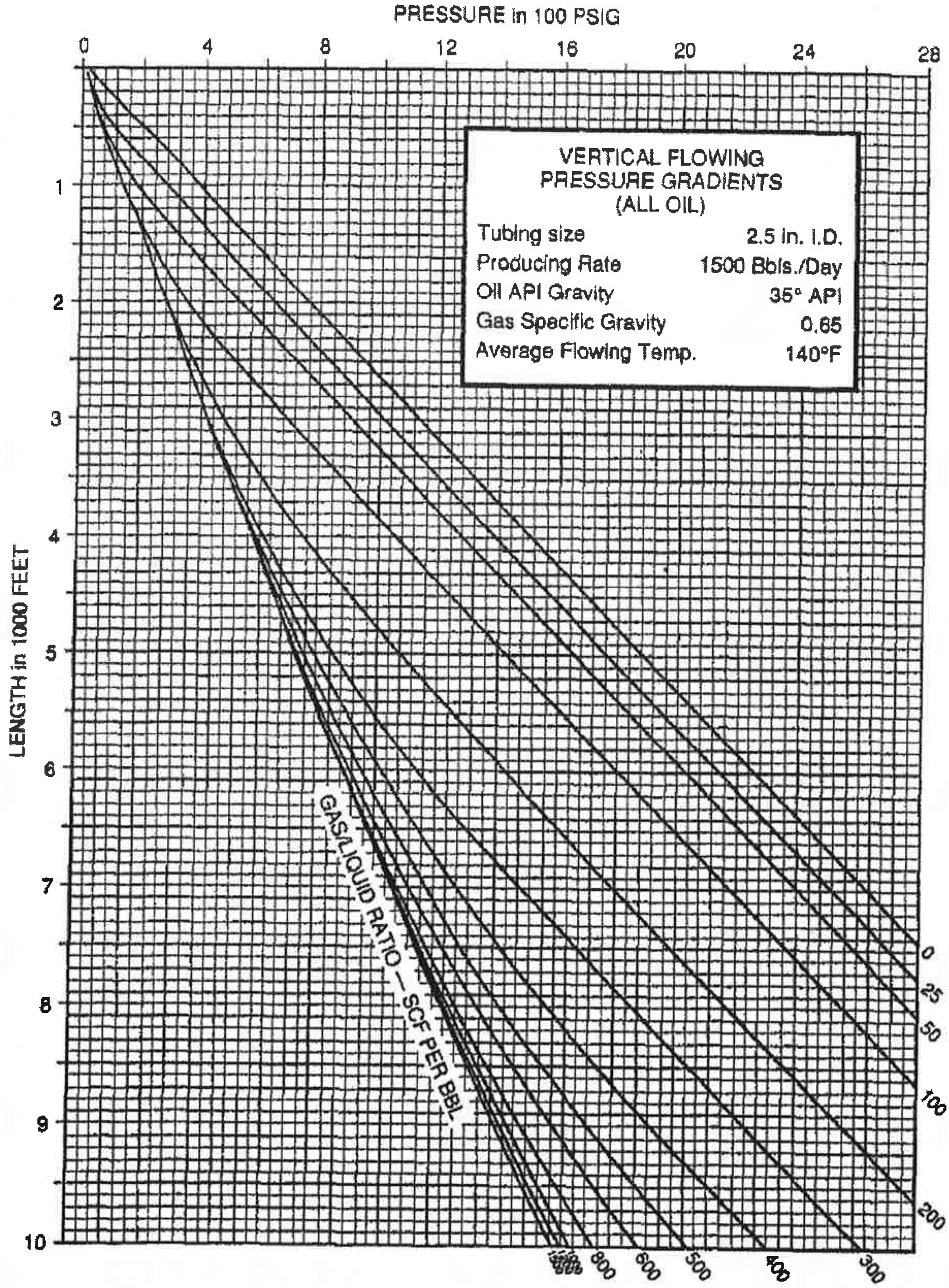
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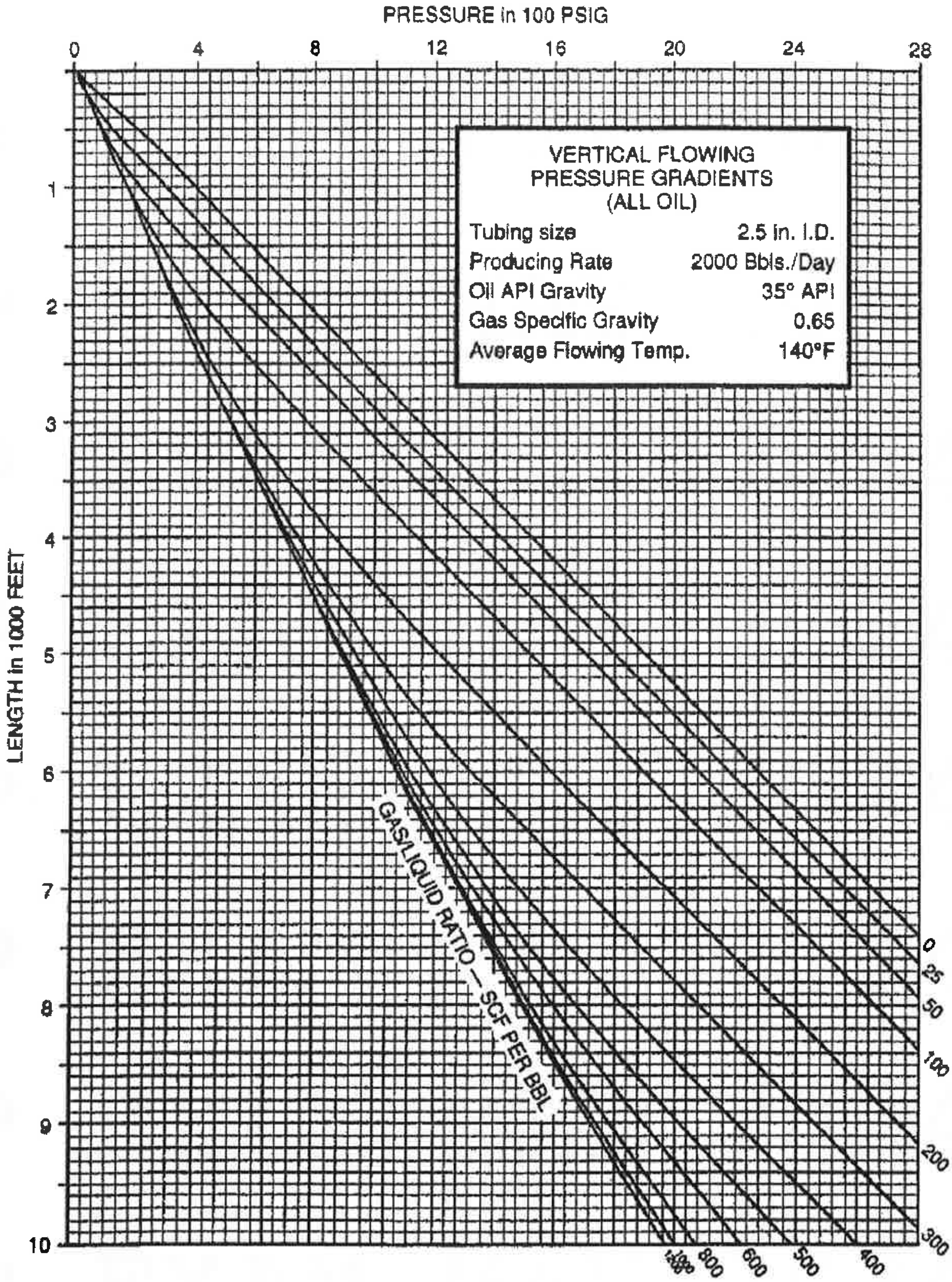
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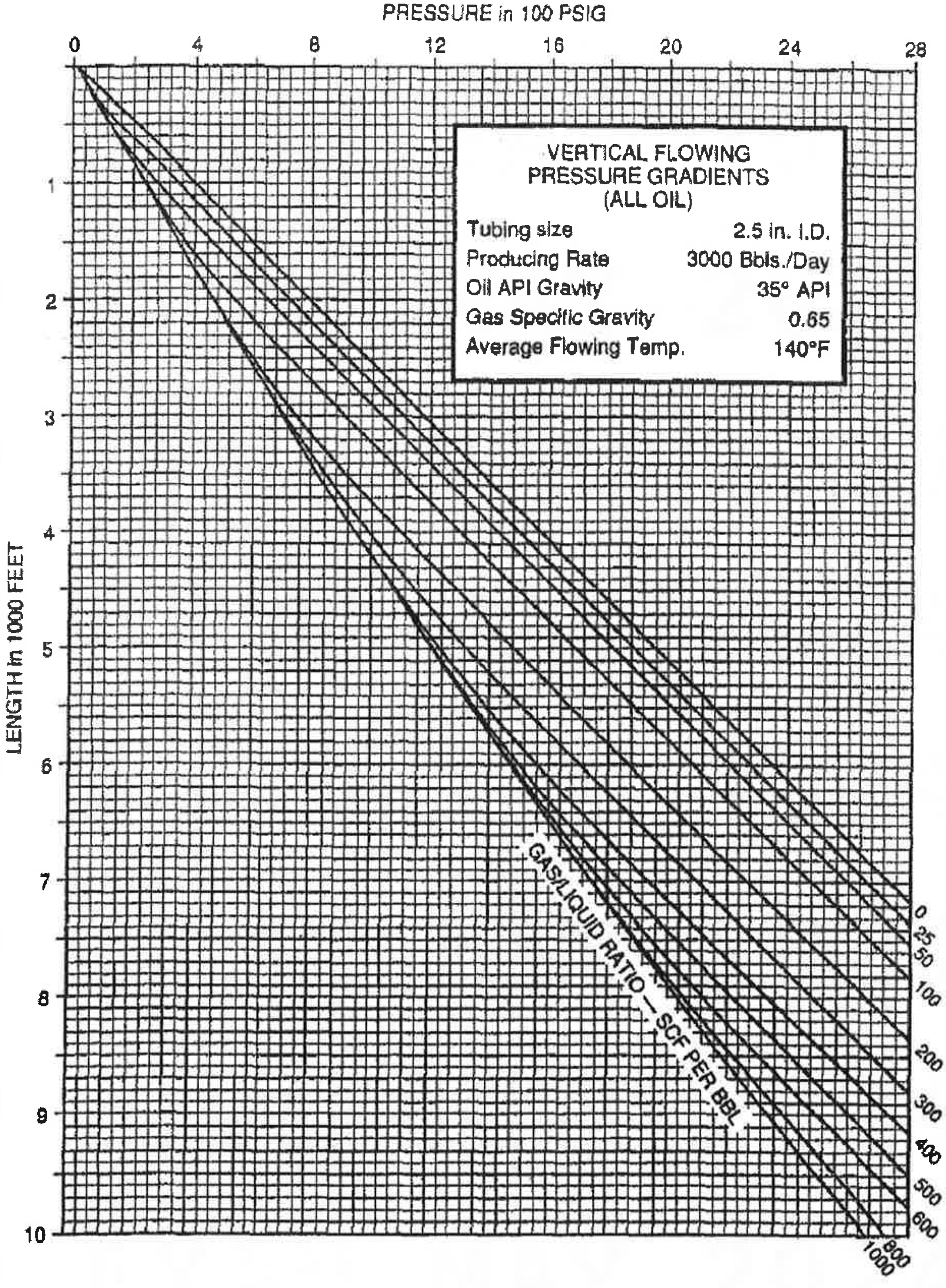
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VERTICAL FLOWING
PRESSURE GRADIENTS
(ALL OIL)
Tubing size 2.5 in. I.D.
Producing Rate 3000 Bbls./Day
Oil API Gravity 35° API
Gas Specific Gravity 0.65
Average Flowing Temp. 140°F
LENGTH in 1000 FEET
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