UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 1994/95

April 1995

EKC 121 - ALIRAN BENDALIR KEJURUTERAAN KIMIA

Masa: [3 jam]

ARAHAN KEPADA CALON:

Sila pastikan bahawa kertas soalan ini mengandungi **ENAM** (6) muka surat dan **ENAM** (6) lampiran bercetak sebelum anda memulakan peperiksaan.

Kertas ini mengandungi **LIMA** (5) soalan.

Jawab **EMPAT** (4) soalan. Soalan Nombor 1 dan Nombor 2 adalah diwajibkan dan pilih dua soalan dari nombor 3, 4 dan 5.

Soalan No. 1 **MESTI** dijawab dalam Bahasa Malaysia. Anda dibolehkan menjawab soalan-soalan lain dalam Bahasa Inggeris.

Soalan terjemahan Bahasa Inggeris ditaip dalam bentuk tulisan Italic.

...2/-

1. [a] Minyak yang mempunyai spesifik graviti 0.80 membuat dua lapisan dengan air (lapisan minyak dan lapisan air) di dalam sebuah tangki sedalam 3.05m. Tebal lapisan minyak tersebut ialah 0.91m. Berapakah tekanan di dasar tangki tersebut?

Oil with a specific gravity of 0.80 is 0.91 m deep in an open tank which is otherwise filled with water. If the tank is 3.05 m deep, what is the pressure at the bottom of the tank?

(50 markah)

[b] Satu blok seberat 45.36 kgf dan berkeluasan 0.37 m^2 mengelonsor di atas sebuah papan yang senget dengan satu kelajuan tetap. Ruang minyak diantara blok dan papan adalah 0.03 sm tebal, papan tersebut disengetkan pada sudut 30° dan kelajuan blok ialah 2 m/s. Carikan/kirakan kelikatan lapisan pelincir (viscosity) dengan menimbangkan bahawa papan tersebut berpermukaan licin.

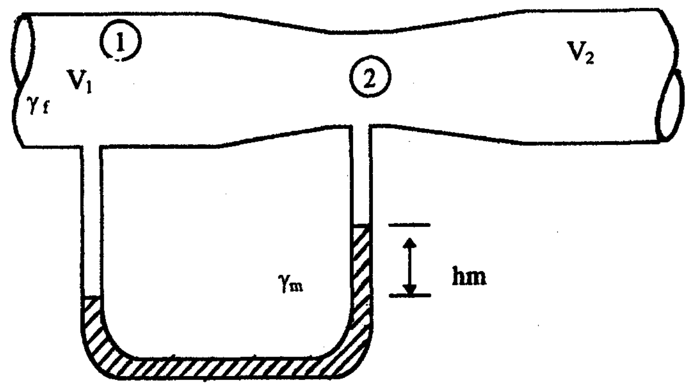
A block weighing 45.36 kgf and having an area of 0.37 m^2 slides down an inclined plane with a constant velocity. An oil gap between the block and the plane is 0.03 cm thick, the inclination of the plane is 30° to the horizontal and the velocity of the block is 2 m/s. Find the viscosity of the lubricating film; consider the plane is a smooth surface.

(50 markah)

2. [a] Satu meter venturi seperti di dalam rajah 2[a], mengandungi leher luas A_2 pada satu paip luas A_1, digunakan untuk mengukur kadar aliran volumetrik satu cecair yang mempunyai berat spesifik (γ_f). Satu manometer yang menggunakan cecair yang lebih berat (γ_m) disambungkan seperti di dalam gambarajah dan menghasilkan bacaan h_m meter. Apakah kadar aliran cecair? Abaikan kesan kelikatan.

A venturi meter in Fig. 2[a] consists of throat of circular area A_2 in a pipe of circular area A_1 and is used to measure the volumetric flow rate of a liquid of specific weight (γ_f). A manometer connected as shown in the figure uses a heavier liquid of specific weight (γ_m) and indicates a deflection of h_m meters. What is the flow rate? Neglect viscous effects.

..3/-



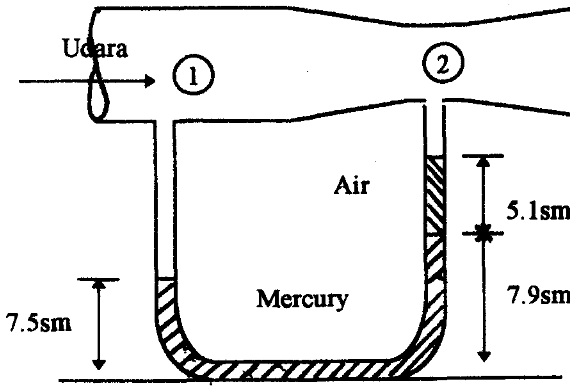
Rajah 2[a]

(50 markah)

[b] Meter venturi seperti Rajah 2[b] mengandungi udara yang mengalir di dalamnya. Manometer mengandungi air dan raksa. Luas keratan rentas di hulu adalah 0.93 m^2 dan dileher 0.093 m^2. Apakah kadar aliran volumetrik bagi udara tersebut? Angkali semburan (C_v) = 1.0.

The venturi meter in Fig. 2[b] has air flowing through it. The manometer, contains both mercury and water. The cross-sectional area at the upstream location and at the throat are 0.93 m^2 and 0.093 m^2, respectively. What is the volumetric flow rate of the air? The discharge coefficient (C_v) is equal to 1.0.

(50 markah)



Rajah 2[b]

..4/-

3. [a] Nyatakan persamaan barometric dalam bentuk bezaan (differential form) serta terangkan had-hadnya. Tunjukkan bagaimana persamaan ini boleh digunakan bagi cecair yang ketumpatan berubah-ubah.

State the barometric equation on its differential form and explain its limitations. Show how this equation can be used for fluids with changing densities.

(30 markah)

[b] Satu telaga gas asli mengandungi metana (M = 16 g/mol), yang dianggap sebagai gas unggul. Tekanan pada permukaan telaga 70.31 kgf/cm^2. Berapakah tekanan pada 3 km dalam telaga tersebut. Berapa banyak kesilapan akan dibuat jika diandaikan ketumpatan metana tidak berubah? Andaikan takungan gas tersebut bersuhu tetap pada 70°F.

A natural gas well contains methane (M = 16 g/mol), which is practically a perfect gas. The pressure at the surface is 70.31 kgf/cm^2. What is the pressure at the depth of 3 km? How much error would be made by assuming that methane is a constant-density fluid? Assume the reservior temperature is constant at 70°F.

(70 markah)

4. [a] Lakarkan hubungkait antara garispusat paip dengan kos-kos yang berbeza dengan menunjukkan posisi garispusat optimum paip tersebut. Apakah yang dapat diterangkan oleh gambarajah tersebut?

Sketch the relationship between pipe diameter and various costs, showing the position of optimum pipe diameter. What does this Figure indicate?

(30 markah)

..5/-

[b] Air dipam menerusi paip 3 inci, seperti yang ditunjukkan di Rajah 4. Panjang paip dan panjang setara pemasangan ialah 700m. Kadar alirannya 150 US gal/min.

Water is being pumped through a 3-in pipe, as shown in Fig. 4. The length of the pipe plus the equivalent length for fittings is 700 m. The design flow rate is 150. US gal/min.

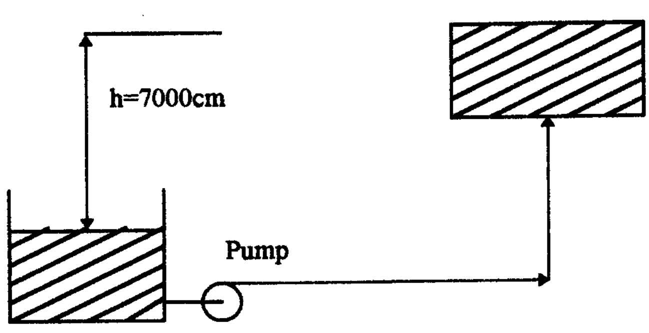
[i] Pada kadar aliran ini, apakah tekanan yang diperlukan pam tersebut? Berikan jawapan anda dalam Kgf/cm^2.

At this flow rate, what pressure rise across the pump is required? Give your answer in kgf/cm^2

[ii] Jika tiada sebarang kerugian pada pam, motor, perangkai dan lain-lain, berapakah kuasa kuda yang perlu oleh pam tersebut?

If there are no losses in pump, motor, coupling etc. how much horse power must the pump's motor deliver?

(70 markah)



Rajah 4

..6/-

5. [a] Huraikan beberapa rejim bagi lapisan terbendalir dan tunjukkan bagaimana halaju terbendalir minima dianggarkan.

Describe the different regimes of fluidized bed and show how the minimum fluidization velocity is estimated.

(30 markah)

[b] Kejatuhan tekanan menerusi lapisan zarah boleh digunakan untuk menentukan luas permukaan dan saiz purata zarah. Data suatu lapisan zarah bijih menunjukkan $\Delta\rho/L$ = 20 (kgf/cm^2)/m bagi aliran udara pada kelajuan permukaan 0.5 cm/s. Bahagian kosong yang dikira ialah 0.47 dan anggaran $\phi_s = 0.7$. Kirakan purata saiz zarah dan luas permukaan per unit jisim jika pepejal tersebut berketumpatan 4.1 g/cm^3. Berapakah sensitiviti jawapan tersebut jika kesilapan adalah 0.01 dalam ε?

The pressure drop through a particle bed can be used to determine the external surface area and the average particle size. Data for a bed of crushed ore particles show $\Delta\rho/L$ = 20 (kgf/cm^2)/m for air flow at a superficial velocity of 0.5 cm/s. The measured void fraction is 0.47 and the estimated sphericity ϕ_s is = 0.7. Calculate the average particle size and the surface area per unit mass if the solid has a density of 4.1 g/cm^3. How sensitive is the answer to an error of 0.01 in ε?

(70 markah)

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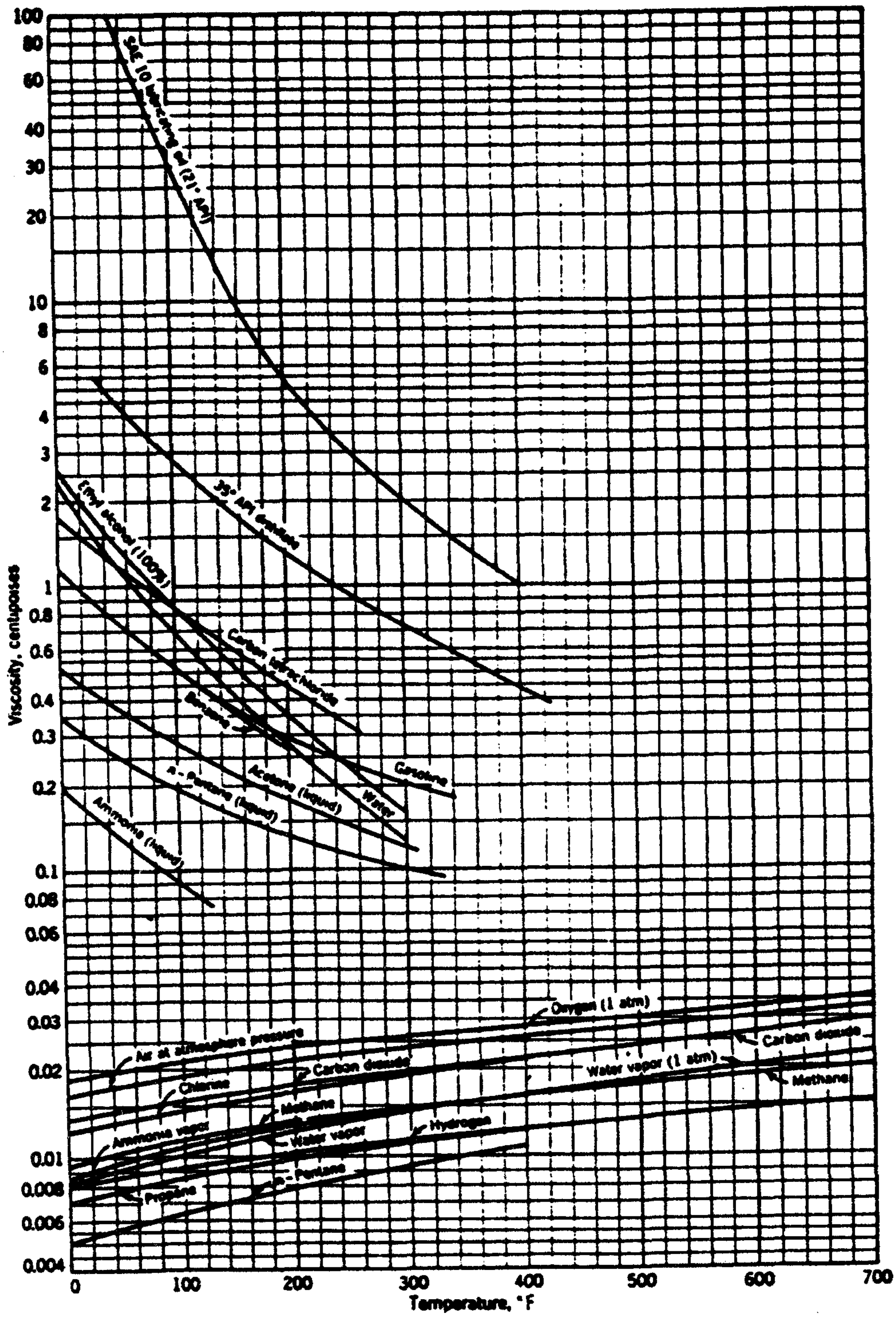
LAMPIRAN

VISCOSITIES OF VARIOUS FLUIDS AT 1-ATM PRESSURE



Nominal pipe size, in	Outside diam., in	Schedule no.	Wall thickness, in	Inside diam., in	Cross-sectional area metal, in^2	Inside sectional area, ft^2	Circumference, ft, or surface, ft^2/ft, of length: Outside	Circumference, ft, or surface, ft^2/ft, of length: Inside	Capacity at 1 ft/s velocity: U.S. gal/min	Capacity at 1 ft/s velocity: lb/h water	Weight of pipe, lb/ft
2	2.375	40	0.154	2.067	1.075	0.02330	0.622	0.542	10.45	5,225.0	3.66
		80	0.218	1.939	1.477	0.02050	0.622	0.508	9.20	4,600.0	5.03
		160	0.343	1.689	2.190	0.01556	0.622	0.442	6.97	3,485.0	7.45
2½	2.875	40	0.203	2.469	1.704	0.3322	0.753	0.647	14.92	7,460.0	5.80
		80	0.276	2.323	2.254	0.02942	0.753	0.609	13.20	6,600.0	7.67
		160	0.375	2.125	2.945	0.02463	0.753	0.557	11.07	5,535.0	10.0
3	3.500	40	0.216	3.068	2.228	0.05130	0.917	0.804	23.00	11,500.0	7.58
		80	0.300	2.900	3.016	0.04587	0.917	0.760	20.55	10,275.0	10.3
		160	0.437	2.626	4.205	0.03761	0.917	0.688	16.90	8,450.0	14.3
3½	4.000	40	0.226	3.548	2.680	0.06870	1.047	0.930	30.80	15,400.0	9.11
		80	0.318	3.364	3.678	0.06170	1.047	0.882	27.70	13,850.0	12.5
4	4.500	40	0.237	4.026	3.173	0.08840	1.178	1.055	39.6	19,800.0	10.8
		80	0.337	3.826	4.407	0.07986	1.178	1.002	35.8	17,900.0	15.0
		120	0.437	3.626	5.578	0.07170	1.178	0.950	32.2	16,100.0	19.0
		160	0.531	3.438	6.621	0.06447	1.178	0.901	28.9	14,450.0	22.6
5	5.563	40	0.258	5.047	4.304	0.1390	1.456	1.322	62.3	31,150.0	14.7
		80	0.375	4.813	6.112	0.1263	1.456	1.263	57.7	28,850.0	20.8
		120	0.500	4.563	7.953	0.1136	1.456	1.197	51.0	25,500.0	27.1
		160	0.625	4.313	9.696	0.1015	1.456	1.132	45.5	22,750.0	33.0
6	6.625	40	0.280	6.065	5.584	0.2006	1.734	1.590	90.0	45,000.0	19.0
		80	0.432	5.761	8.405	0.1810	1.734	1.510	81.1	40,500.0	28.6
		120	0.562	5.501	10.71	0.1650	1.734	1.445	73.9	36,950.0	36.4
		160	0.718	5.189	13.32	0.1469	1.734	1.360	65.8	32,900.0	45.3
8	8.625	20	0.250	8.125	6.570	0.3601	2.258	2.130	161.5	80,750.0	22.4
		30	0.277	8.071	7.260	0.3553	2.258	2.115	159.4	79,700.0	24.7
		40	0.322	7.981	8.396	0.3474	2.258	2.090	155.7	77,850.0	28.6
		60	0.406	7.813	10.48	0.3329	2.258	2.050	149.4	74,700.0	35.7
		80	0.500	7.625	12.76	0.3171	2.258	2.000	142.3	71,150.0	43.4

VALUES OF THE UNIVERSAL GAS CONSTANT

$$R = \frac{10.73(\text{lbf/in}^2)\text{ft}^3}{\text{lbmol}\cdot{}^\circ\text{R}} = \frac{0.7302\ \text{atm}\cdot\text{ft}^3}{\text{lbmol}\cdot{}^\circ\text{R}}$$

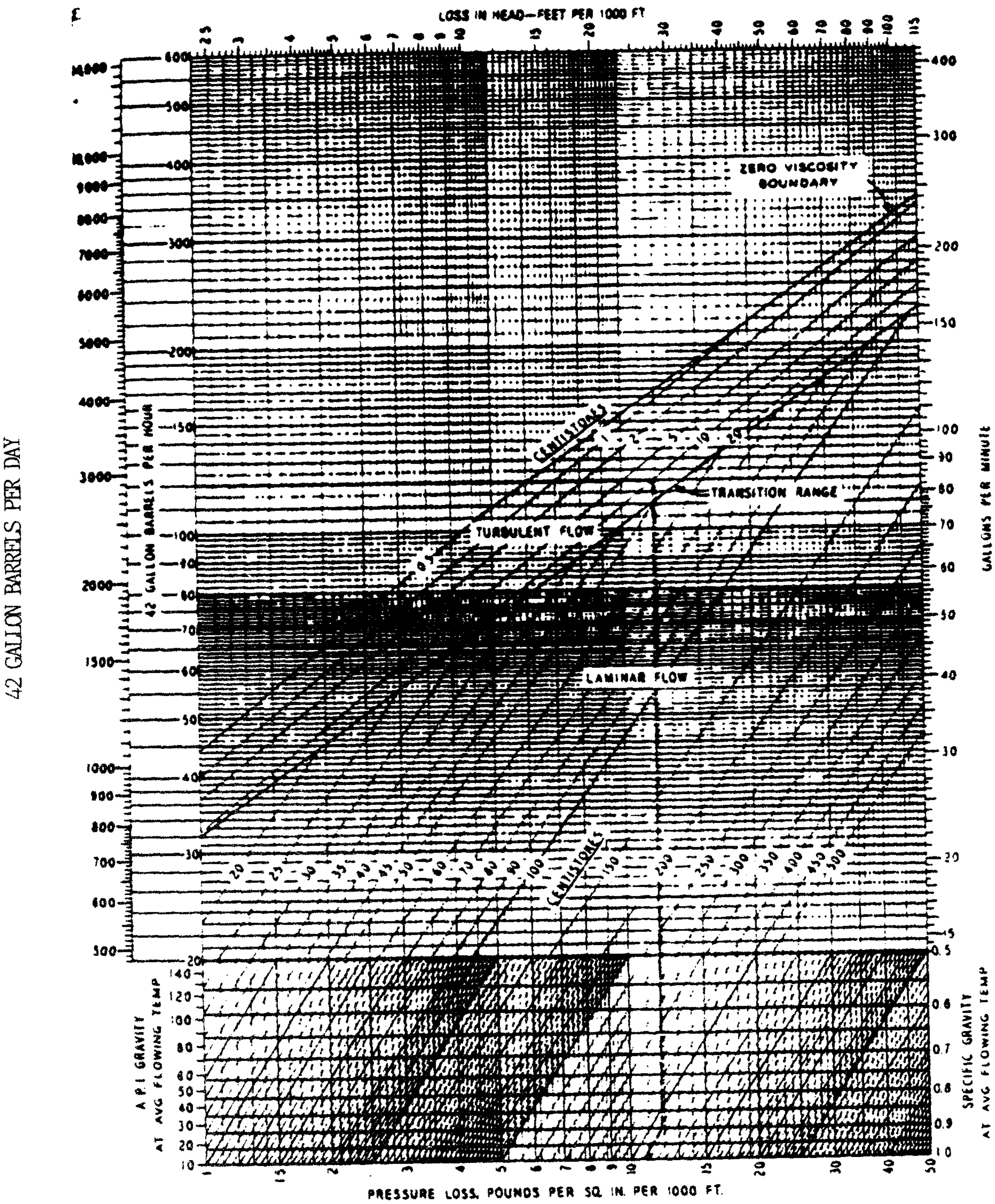
$$= \frac{8.314\ \text{m}^3\cdot\text{Pa}}{\text{mol}\cdot\text{K}} = \frac{0.08206\ \text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} = \frac{0.08314\ \text{L}\cdot\text{bar}}{\text{mol}\cdot\text{K}}$$

$$= \frac{1.987\ \text{Btu}}{\text{lbmol}\cdot{}^\circ\text{R}} = \frac{1.987\ \text{cal}}{\text{mol}\cdot\text{K}} = \frac{1.987\ \text{kcal}}{\text{kgmol}\cdot\text{K}} = \frac{8.314\ \text{J}}{\text{mol}\cdot\text{K}}$$

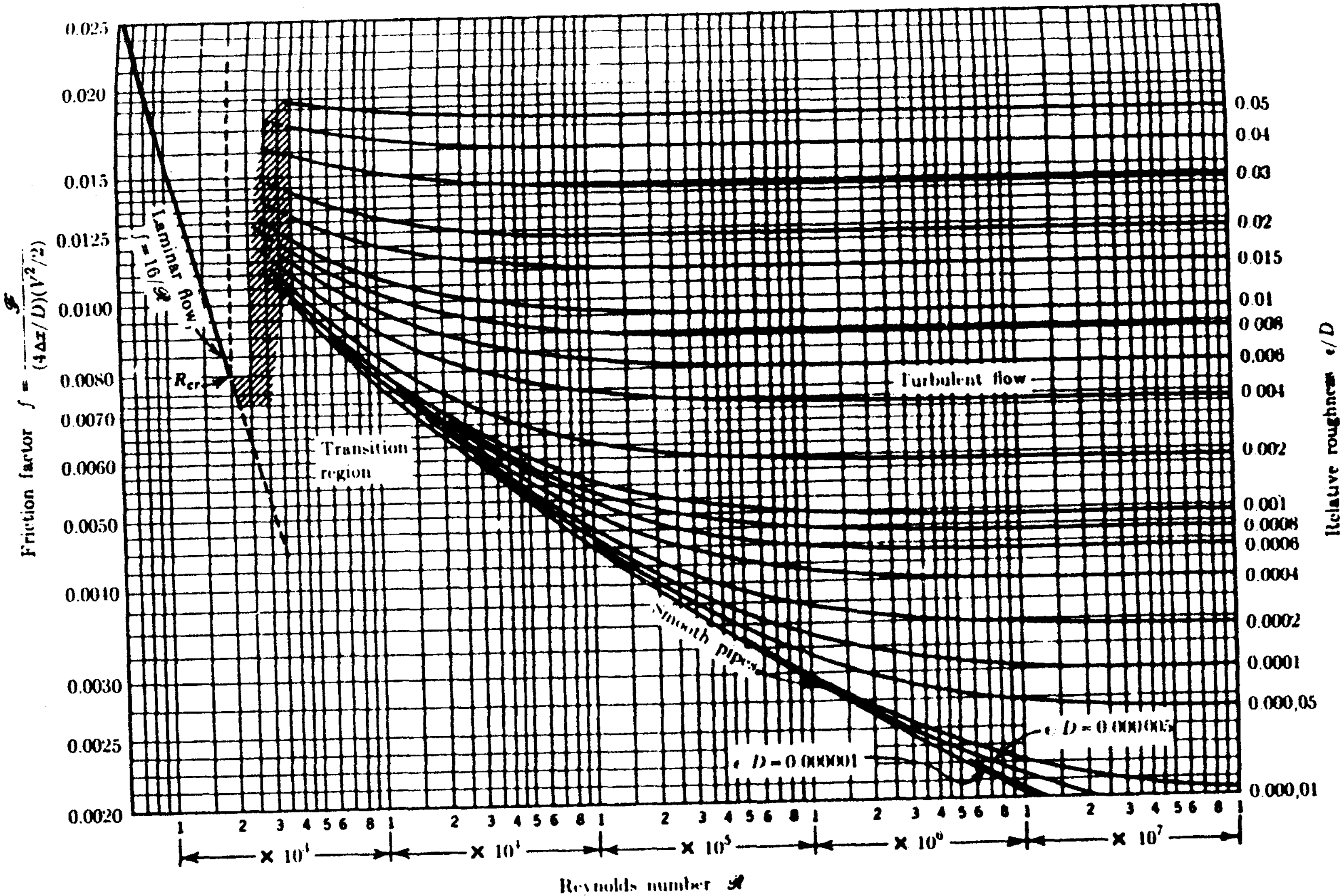
SOME PROPERTIES OF LIQUIDS

Liquid	Density,† lbm/ft³	$10^3\alpha(1/\text{F}^\circ)$	$10^5\beta(1/\text{psi})$
Hydrogen	4.4	34	11
Helium	9.1	15	48
Typical gasoline	43	1	0.7
Benzene	54.6	0.67	0.7
Water	62.3	0.11	0.3
Carbon tetrachlo ide	99.2	0.67	0.7
Mercury	845	0.10	0.3

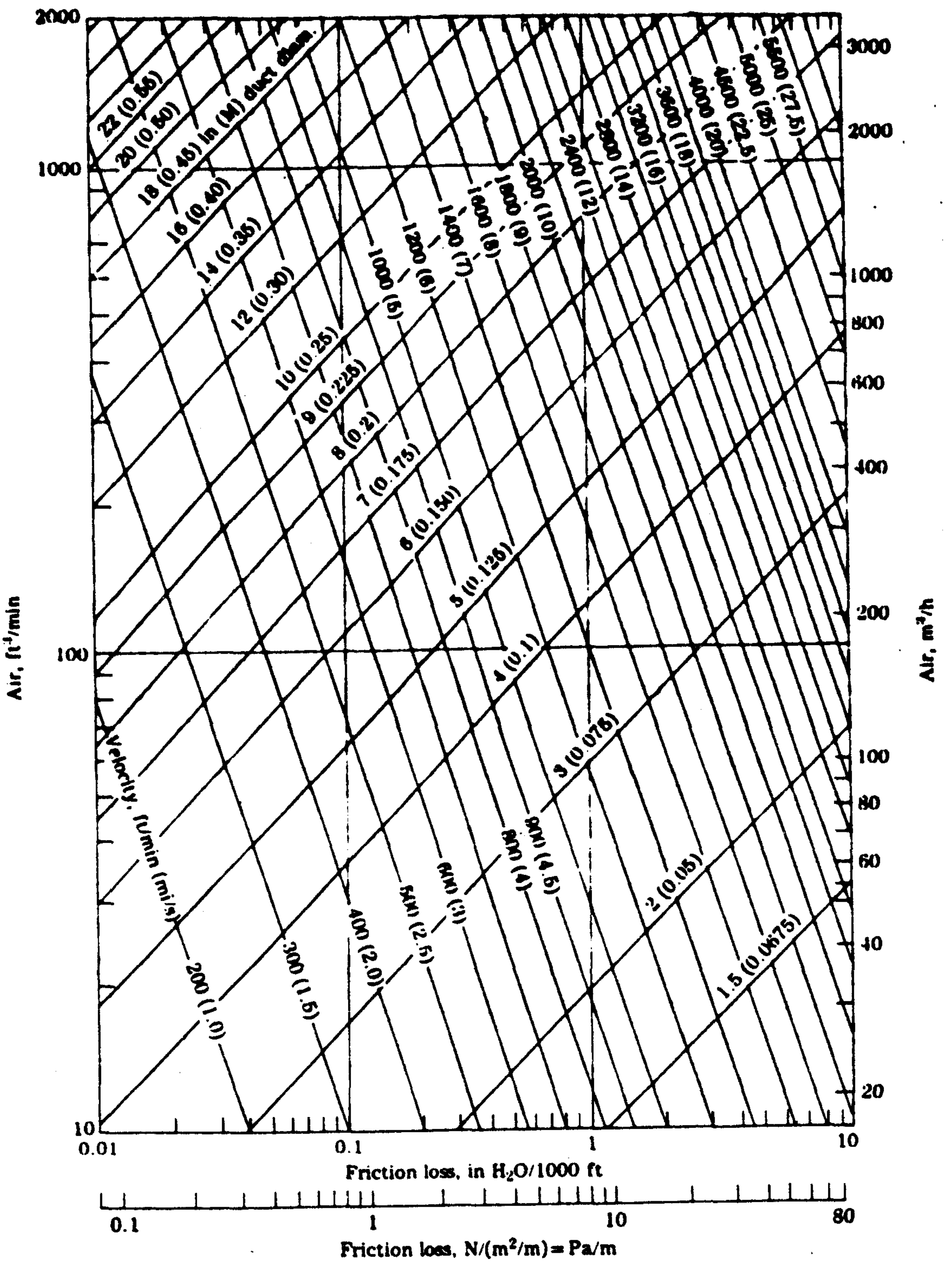
† Measured at 1 at ı and 60°F, except for hydrogen and helium, which are at their 1-atm boiling points, 20 and 2.1 K, respectivel



Pressure drop in a 3-in schedule 40 pipe, with 3.068-in inside diameter. For example shown: flow rate = 120 barrels per hour (BPH); kinematic viscosity = 10 cSt, specific gravity = 0.9, pressure loss (follow dashed line) = 10.7 psi/1000 ft. (Courtesy of the Board of Engineers, Standard Oil Company of California.)



Friction factor plot for pipes. [From L. W. Moody, "Friction factors for pipeflow," *Trans. ASME* 66, 672 (1944). Reproduced by permission of the publisher.]



Friction of air in straight ducts for volumetric flow rates of 10 to 2000 ft³/min (20 to 3000 m³/h), based on standard air of 0.075 lb/ft³ (1.2 kg/m³) density flowing through average, clean, round galvanized metal ducts having approximately 40 joints per 100 ft (30 m). Do not extrapolate below chart. (Reprinted from the *1972 ASHRAE Handbook—Fundamentals*, with permission.)