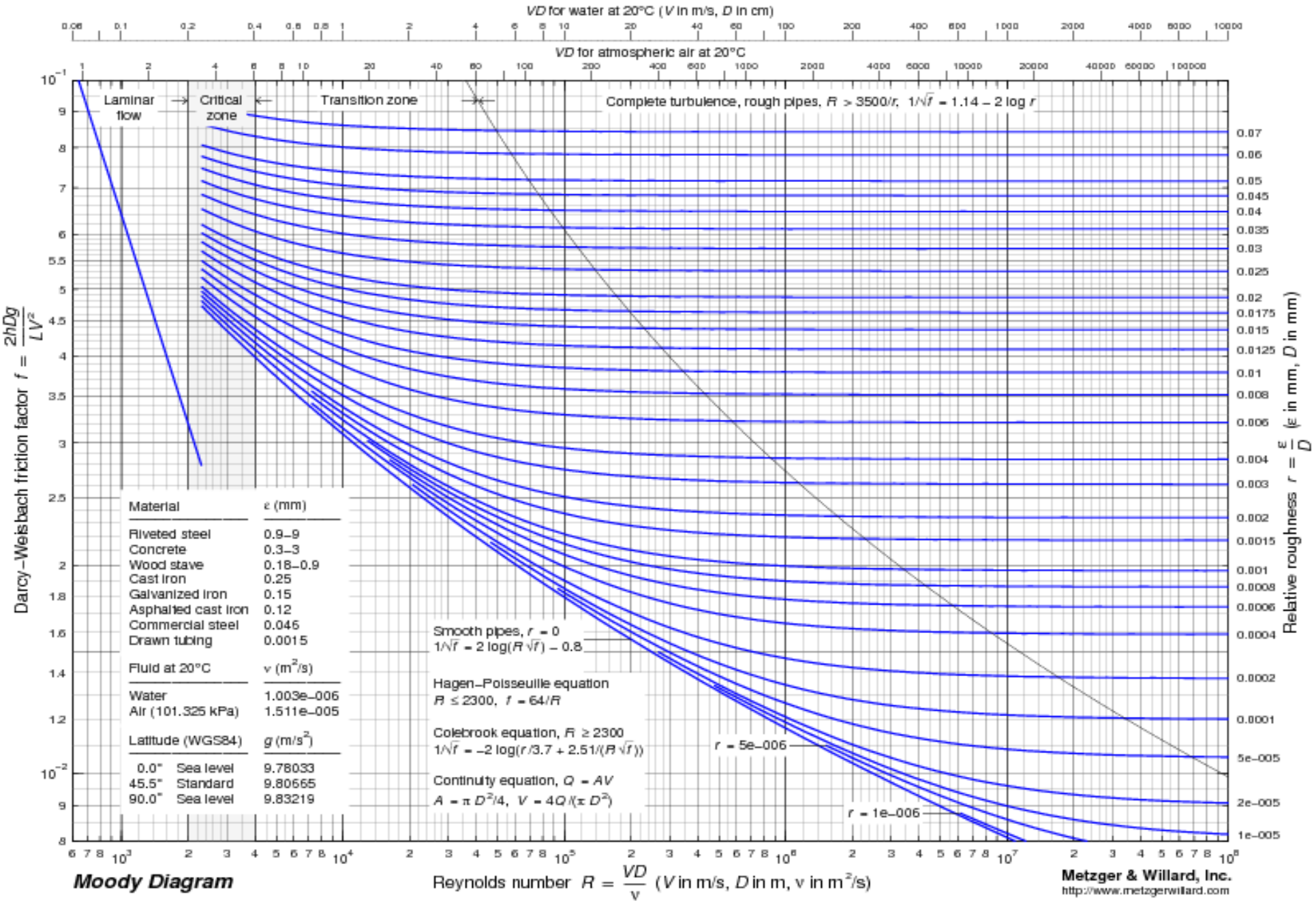
Lampiran 1

Tabel. Karakteristik air

Temperature	Pressure	Saturation vapor pressure	Density	Specific enthalpy of liquid water		Specific heat		Volume heat capacity	Dynamic viscosity
°C	Pa	Pa	kg/m3	kj/kg	kcal/kg	kj/kg.K	kcal/kg.K	kj/m3	kg/m.s
0.00	101325	611	999.82	0.06	0.01	4.217	1.007	4216.10	0.001792
1.00	101325	657	999.89	4.28	1.02	4.213	1.006	4213.03	0.001731
2.00	101325	705	999.94	8.49	2.03	4.210	1.006	4210.12	0.001674
3.00	101325	757	999.98	12.70	3.03	4.207	1.005	4207.36	0.001620
4.00	101325	813	1000.00	16.90	4.04	4.205	1.004	4204.74	0.001569
5.00	101325	872	1000.00	21.11	5.04	4.202	1.004	4202.26	0.001520
6.00	101325	935	999.99	25.31	6.04	4.200	1.003	4199.89	0.001473
7.00	101325	1001	999.96	29.51	7.05	4.198	1.003	4197.63	0.001429
8.00	101325	1072	999.91	33.70	8.05	4.196	1.002	4195.47	0.001386
9.00	101325	1147	999.85	37.90	9.05	4.194	1.002	4193.40	0.001346
10.00	101325	1227	999.77	42.09	10.05	4.192	1.001	4191.42	0.001308
11.00	101325	1312	999.68	46.28	11.05	4.191	1.001	4189.51	0.001271
12.00	101325	1402	999.58	50.47	12.06	4.189	1.001	4187.67	0.001236
13.00	101325	1497	999.46	54.66	13.06	4.188	1.000	4185.89	0.001202
14.00	101325	1597	999.33	58.85	14.06	4.187	1.000	4184.16	0.001170
15.00	101325	1704	999.19	63.04	15.06	4.186	1.000	4182.49	0.001139
16.00	101325	1817	999.03	67.22	16.06	4.185	1.000	4180.86	0.001109
17.00	101325	1936	998.86	71.41	17.06	4.184	0.999	4179.27	0.001081
18.00	101325	2063	998.68	75.59	18.05	4.183	0.999	4177.72	0.001054
19.00	101325	2196	998.49	79.77	19.05	4.182	0.999	4176.20	0.001028
20.00	101325	2337	998.29	83.95	20.05	4.182	0.999	4174.70	0.001003
21.00	101325	2486	998.08	88.14	21.05	4.181	0.999	4173.23	0.000979
22.00	101325	2642	997.86	92.32	22.05	4.181	0.999	4171.78	0.000955
23.00	101325	2808	997.62	96.50	23.05	4.180	0.998	4170.34	0.000933
24.00	101325	2982	997.38	100.68	24.05	4.180	0.998	4168.92	0.000911
25.00	101325	3166	997.13	104.86	25.04	4.180	0.998	4167.51	0.000891
26.00	101325	3360	996.86	109.04	26.04	4.179	0.998	4166.11	0.000871
27.00	101325	3564	996.59	113.22	27.04	4.179	0.998	4164.71	0.000852
28.00	101325	3779	996.31	117.39	28.04	4.179	0.998	4163.31	0.000833
29.00	101325	4004	996.02	121.57	29.04	4.179	0.998	4161.92	0.000815
30.00	101325	4242	995.71	125.75	30.04	4.178	0.998	4160.53	0.000798
31.00	101325	4491	995.41	129.93	31.03	4.178	0.998	4159.13	0.000781
32.00	101325	4754	995.09	134.11	32.03	4.178	0.998	4157.73	0.000765
33.00	101325	5029	994.76	138.29	33.03	4.178	0.998	4156.33	0.000749
34.00	101325	5318	994.43	142.47	34.03	4.178	0.998	4154.92	0.000734
35.00	101325	5622	994.08	146.64	35.03	4.178	0.998	4153.51	0.000720
36.00	101325	5940	993.73	150.82	36.02	4.178	0.998	4152.08	0.000705
37.00	101325	6274	993.37	155.00	37.02	4.178	0.998	4150.65	0.000692
38.00	101325	6624	993.00	159.18	38.02	4.178	0.998	4149.20	0.000678
39.00	101325	6991	992.63	163.36	39.02	4.179	0.998	4147.74	0.000666
40.00	101325	7375	992.25	167.54	40.02	4.179	0.998	4146.28	0.000653

Sumber : http://www.thermexcel.com


VD for water at 20°C (V in m/s, D in cm)
VD for atmospheric air at 20°C
Laminar flow
Critical zone
Transition zone
Complete turbulence, rough pipes, R > 3500/r, 1/√f = 1.14 – 2 log r
Darcy–Weisbach friction factor f = 2hDg / LV²
Relative roughness r = ε/D (ε in mm, D in mm)
Material | ε (mm)
Riveted steel 0.9–9
Concrete 0.3–3
Wood stave 0.18–0.9
Cast iron 0.25
Galvanized iron 0.15
Asphalted cast iron 0.12
Commercial steel 0.046
Drawn tubing 0.0015
Fluid at 20°C | ν (m²/s)
Water 1.003e–006
Air (101.325 kPa) 1.511e–005
Latitude (WGS84) | g (m/s²)
0.0° Sea level 9.78033
45.5° Standard 9.80665
90.0° Sea level 9.83219
Smooth pipes, r = 0
1/√f = 2 log(R √f) – 0.8
Hagen–Poisseuille equation
R ≤ 2300, f = 64/R
Colebrook equation, R ≥ 2300
1/√f = –2 log(r/3.7 + 2.51/(R √f))
Continuity equation, Q = AV
A = π D²/4, V = 4Q/(π D²)
r = 5e–006
r = 1e–006
Moody Diagram
Reynolds number R = VD/ν (V in m/s, D in m, ν in m²/s)
Metzger & Willard, Inc.
http://www.metzgerwillard.com

Lampiran 3

Tabel Koefisien Kerugian Belokan Pipa (Sularso, 2000)

Sudut (θ°)		5	10	15	22,5	30	45	60	90
k	Halus	0,016	0,034	0,042	0,066	0,13	0,236	0,471	1,129
	Kasar	0,024	0,44	0,062	0,154	0,165	0,32	0,684	1,265

Tabel Koefisien Kontraksi (C_c), (Streeter, 1985)

A_2/A_1	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
C_c	0,624	0,632	0,634	0,659	0,681	0,712	0,775	0,813	0,892	1

Tabel Koefisien Kerugian Sambungan (K) (Streeter, 1985)

Lengkapan (Fitting)	K
Katup Bola[58)] (terbuka penuh)	10
Katup Sudut[59)] (terbuka penuh)	5
Katup Searah Ayun [60)] (terbuka penuh)	2,5
Katup Gerbang [61)] (terbuka penuh)	0,19
Belokan Balik Berdekatan [62)]	2,2
T Standar	1,8
Siku Standar	0,9
Siku Lekuk Menengah	0,75
Siku Lekuk Panjang	0,6

58) globe valve

59) angel valve

60) swing check valve

61) gate valve

62) close sweep

Lampiran 4

Tabel Nilai kekasaran

Material	e (mm)	e (inches)
Concrete	0.3 - 3.0	0.012 - 0.12
Cast Iron	0.26	0.010
Galvanized Iron	0.15	0.006
Asphalted Cast Iron	0.12	0.0048
Commercial or Welded Steel	0.045	0.0018
PVC, Glass, Other Drawn Tubing	0.0015	0.00006

Sumber: http://www.pipeflow.com