Appendix

NOMENCLATURE AND DIMENSIONS

Symbol	Dimensions	Description
A	L^2	Area
AF	L^3	Acre-feet
a	L/T^2	Acceleration
B	L	Aquifer thickness
B	L^4/T^3	Buoyancy flux for round plume
B	L^3/T^3	Buoyancy flux for plain plume
B_c	L	Conduit diameter
B_d	L	Trench width
b	L	Linear measure
b_0	L	Width of two-dimensional jet
C	...	Runoff coefficient
C	...	Discharge coefficient
C	$L^{1/2}/T$	Chezy coefficient
C	...	Resistance coefficient
C_c	...	Contraction coefficient
C_D	...	Discharge coefficient
C_D	...	Drag coefficient
C_H	...	Head coefficient
C_h	...	Hazen-Williams friction coefficient
CN	...	Curve number in runoff calculation
C_P	...	Power coefficient
C_P	...	Pressure coefficient
C_p	$L^2/T^2\theta$	Specific heat
C_p	...	Constant in synthetic unit hydrograph
C_Q	...	Discharge coefficient
C_t	...	Constant in synthetic unit hydrograph
C_V	...	Velocity coefficient
°C	θ	Temperature, centigrade
c	L/T	Wave celerity
c	L	Chord length
c_f	...	Shear stress coefficient
D	L	Depth in stilling basin
D	L	Diameter
D	T	Duration
d	L	Depth
d	L	Gate opening

NOMEN

Symb
d_c
E
E
E
E
e
e
F
F
F
°F
F_D
F_L
Fr
f
f
f
f
G_0
G_0
g
H
H
H_0
h
h
h_a
h_f
h_L
h_p
h_t
h_v
I
I
I_a
i
i
j
j
K
K

NOMENCLATURE AND DIMENSIONS (continued)

Symbol	Dimensions	Description
d_c	L	Critical depth
E	L	Specific energy
E	L	Total head on weir
E	F/L^2	Elastic modulus
E	L	Evaporation, depth of water
e	...	Efficiency
e	F/L^2	Vapor pressure
F	L	Fetch
F	F	Force
F	...	Functional relation
°F	θ	Temperature, Fahrenheit
F_D	F	Drag force
F_L	F	Lift force
Fr	...	Froude number
f	...	Resistance coefficient (friction factor)
f	T^{-1}	Frequency
f	...	Coefficient of friction
f	L/T	Infiltration rate
G_0	L	Gate opening
G_0	L^3	Volume of subsurface flow
g	L/T^2	Acceleration due to gravity
H	L	Head (on weir, spillway, etc.)
H	L	Height of fill
H_0	L	Design head
h	L	Piezometric head
h	L	Depth
h_a	L	Velocity head
h_f	L	Head loss due to friction
h_L	L	Head loss
h_p	L	Head supplied by pump
h_t	L	Head supplied to turbine
h_v	L	Velocity head
I	L^3/T	Inflow discharge rate
I	L^4	Moment of inertia
I_a	L	Initial abstraction
i	...	Index number
i	...	Unit vector in x direction
j	...	Unit vector in y direction
j	...	Index number
K	F/L	Spring constant
K	...	A constant

(continued)

NOMENCLATURE AND DIMENSIONS (continued)

Symbol	Dimensions	Description
K	L/T	Hydraulic conductivity
K	...	Head-loss coefficient
K	T	Constant in Muskingum flood routing method
K	...	Flow coefficient in discharge equation
K	...	Heat transfer coefficient
K_f	...	Infiltration constant
k	...	Time constant
k	...	Maximizing factor of precipitation
k_s	L	Equivalent sand roughness
L	L	Linear measure
M	FT^2/L	Mass
M	...	Mean volume
M	FL	Moment
M	...	Order in series of events
M	L	Depth of snowmelt
M	L^3	Moisture volume in soil
m	L	Length, meter
N	T^{-1}	Angular speed in rpm
N	...	Number of events
N_s	$L^{3/4}/T^{3/2}$	Specific speed
n	...	Porosity
n	...	Number (years, events, etc.)
n	T^{-1}	Angular speed in rps
n	...	Manning's resistance coefficient
n_s	...	Specific speed
O	L^3/T	Outflow discharge
P	LF/T	Power
P	L	Wetted perimeter
P	L	Height of weir or dam
P	L	Depth of precipitation
P	L	Rainfall excess
p	F/L^2	Pressure
P	...	Probability
p_a	F/L^2	Atmospheric pressure
p_v	F/L^2	Vapor pressure
Q	L^3/T	Discharge
q	L^2/T	Discharge per unit width
q	L/T	Discharge per square mile
R	L^3	Volume of runoff
R	L	Hydraulic radius
R	L	Runup
R	...	Skew

NOMENCLATURE AND DIMENSIONS (continued)

Symbol	Dimensions	Description
R	F	Reaction force
R	L	Rainfall depth
Re	...	Reynolds number
r	L	Radial linear measure
r_0	L	Pipe radius
S	...	Slope
S	L	Potential maximum soil retention
S	...	Dilution
S	F	Strength of pipe
S	...	Storage coefficient
S	...	Standard deviation
S	L^3	Storage volume
S_f	...	Friction slope
S_o	...	Channel slope
S_G	L^3	Ground water storage
S_r	...	Specific retention
S_s	L^3	Surface water storage
S_y	...	Specific yield
s	T	Time, second
sfm	L^3	Second-foot-month
T	T	Recurrence interval
T	T	Wave period
T	L	Top width
T	L^2/T	Transmissivity
T	FL	Torque
T	F	Thrust force
T	T	Time
T_r	...	Time ratio
T_w	θ	Temperature, wet bulb Fahrenheit
t	L	Thickness
t	T	Time
t_c	T	Time of concentration
t_p	T	Time to peak of hydrograph
t_r	T	Rainfall duration
U	L/T	Velocity
u	L/T	Velocity
u	...	Argument of the well function
u'	L/T	Turbulence intensity in x direction
u_*	L/T	Shear velocity
$\forall$	L^3	Volume
V	L/T	Velocity

(continued)

NOMENCLATURE AND DIMENSIONS (continued)

Symbol	Dimensions	Description
V_d	L^3	Drainage volume
V_e	F	Earthquake force
V_t	L^3	Total volume
V_v	L^3	Voids volume
V_w	L^3	Water volume
V	L^3	Volume
v	...	Velocity
v'	L/T	Turbulence intensity in y direction
W	T	Width of synthetic unit hydrograph
W	F	Weight
W	F	Load
W	FL/T	Power, watts
$W(u)$	...	Well function
w	L/T	Velocity in z direction
X	...	Weighting factor in flood routing
x	L	Linear measure
y	L	Linear measure
y_c	L	Critical depth
y_n	L	Normal depth
z	L	Linear measure
z	L	Elevation
Greek Letters		
α	...	Angular measure
α	...	Kinetic energy correction factor
α	θ^{-1}	Coefficient of thermal expansion
α	...	Angle of attack
β	...	Angular measure
γ	F/L^3	Specific weight
Δ	...	Increment
δ	...	Increment
ϵ	...	Strain
η	...	Efficiency
θ	...	Angular measure
λ	...	Earthquake intensity
λ	T^{-1}	Multiplier
μ	FT/L^2	Viscosity, dynamic
ν	L^2/T	Viscosity, kinematic
τ	F/L^2	Shear stress
π	...	3.1416
ρ	FT^2/L^4	Mass density
σ	F/L^2	Normal stress
σ	...	Cavitation index
ϕ	...	Speed ratio
ω	T^{-1}	Angular speed

Figure A-1 Centroids and Moments of Inertia of Plane Area

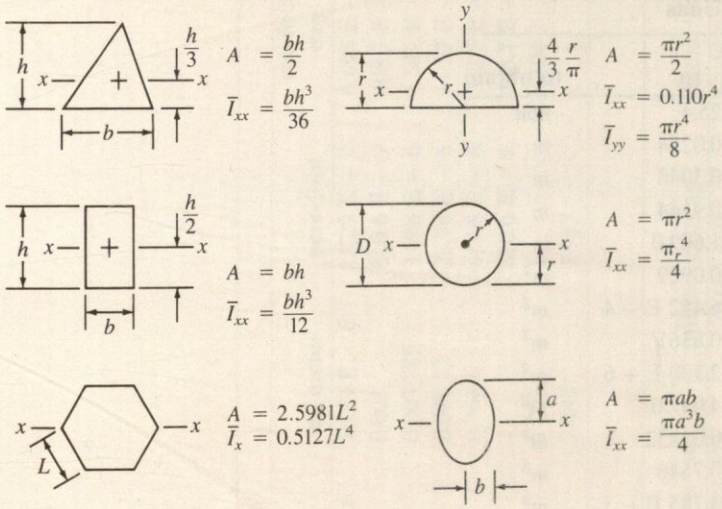


Table A-1 Conversion Factors from Traditional to SI Units

Multiply number of	by	to obtain
in.	25.4	*mm*
in.	0.0254	*m*
ft	0.3048	*m*
yard	0.9144	*m*
mile	1,609.0	*m*
ft^2	0.0929	m^2
$in.^2$	6.452 E − 4	m^2
yd^2	0.8361	m^2
mi^2	2.590 E + 6	m^2
acre	4,047.0	m^2
ft^3	0.02832	m^3
yd^3	0.7646	m^3
U.S. gallon	3.785 E − 3	m^3
acre ft	1,233.0	m^3
ft/s	0.3048	m/s
mi/hr	0.447	m/s
ft^3/s	0.02832	m^3/s
gpm	6.309 E − 5	m^3/s
lbf	4.448	N
ton (2000 lbf)	8896.0	N
ft–lbf	1.356	$N \cdot m$
slug	14.59	kg
$slug/ft^3$	515.4	kg/m^3
lbf/ft^2	47.88	N/m^2
$lbf/in.^2$	6,895.0	N/m^2
lbf/ft^3	157.1	N/m^3
ft^2/s	0.0929	m^2/s
$lbf–s/ft^2$	47.88	$N \cdot s/m^2$
hp	0.747	kW

Table A-2 Commonly Used Equivalent Units in Hydraulic Engineering

Volume

Unit	Equivalent[(a) (b)]							
	cu. inch	liter	U.S. gallon	cu. foot	cu. yard	cu meter	acre-foot	sec-foot-day
cubic inch	1	0.016 39	0.004 329	578.7 E − 6	21.43 E − 6	16.39 E − 6	13.29 E − 9	6.698 E − 9
liter	61.02	1	0.264 2	0.035 31	0.001 308	0.001	810.6 E − 9	408.7 E − 9
U.S. gallon	231.0	3.785	1	0.133 7	0.004 951	0.003 785	3.068 E − 6	1.547 E − 6
cubic foot	1728	28.32	7.481	1	0.037 04	0.028 32	22.96 E − 6	11.57 E − 6
cubic yard	46,660	764.6	202.0	27	1	0.764 6	619.8 E − 6	312.5 E − 6
meter^3	61,020	1000	264.2	35.31	1.308	1	810.6 E − 6	408.7 E − 6
acre-foot	75.27 E − 6	1,233,000	325,900	43 560	1 613	1 233	1	0.504 2
sec-ft-da	149.3 E − 6	2,447,000	646,400	86 400	3 200	2 447	1.983	1

Discharge (Flow Rate, Volume/Time)

Unit	Equivalent[(a) (b)]					
	gallon/min	liter/sec	acre-foot/day	foot^3/sec	million gal/day	meter^3/sec
gallon/minute	1	0.063 09	0.004 419	0.002 228	0.001 440	63.09 E − 6
liter/second	15.85	1	0.070 05	0.035 31	0.022 82	0.001
acre-foot/day	226.3	14.28	1	0.504 2	0.325 9	0.014 28
feet^3/second	448.8	28.32	1.983	1	0.646 3	0.028 32
million gallons/day	694.4	43.81	3.069	1.547	1	0.043 81
meter^3/second	15,850	1000	70.04	35.31	22.82	1

(continued)

Table A-2 (continued)

Velocity

Unit	Equivalent[(a) (b)]				
	foot/day	kilometer/hour	foot/sec	mile/hour	meter/sec
foot/day	1	12.70 E − 6	11.57 E − 6	7.891 E − 6	3.528 E − 6
kilometer/hour	78,740	1	0.911 3	0.621 4	0.277 8
foot/second	86,400	1.097	1	0.681 8	0.304 8
mile/hour	126,700	1.609	1.467	1	0.447 0
meter/second	283,500	3.600	3.281	2.237	1

(a) Equivalent values are shown to 4 significant figures.
(b) Multiply the numerical amount of the given unit by the equivalent value shown (per single amount of given unit) to obtain the numerical amount of the equivalent unit (e.g.: 5 inches × 0.025 40 m/inch = 0.127 0 m).

SOURCE: SI System of Units: Pamphlet prepared for the Universities Council on Water Resources by Peter C. Klingeman, 1976

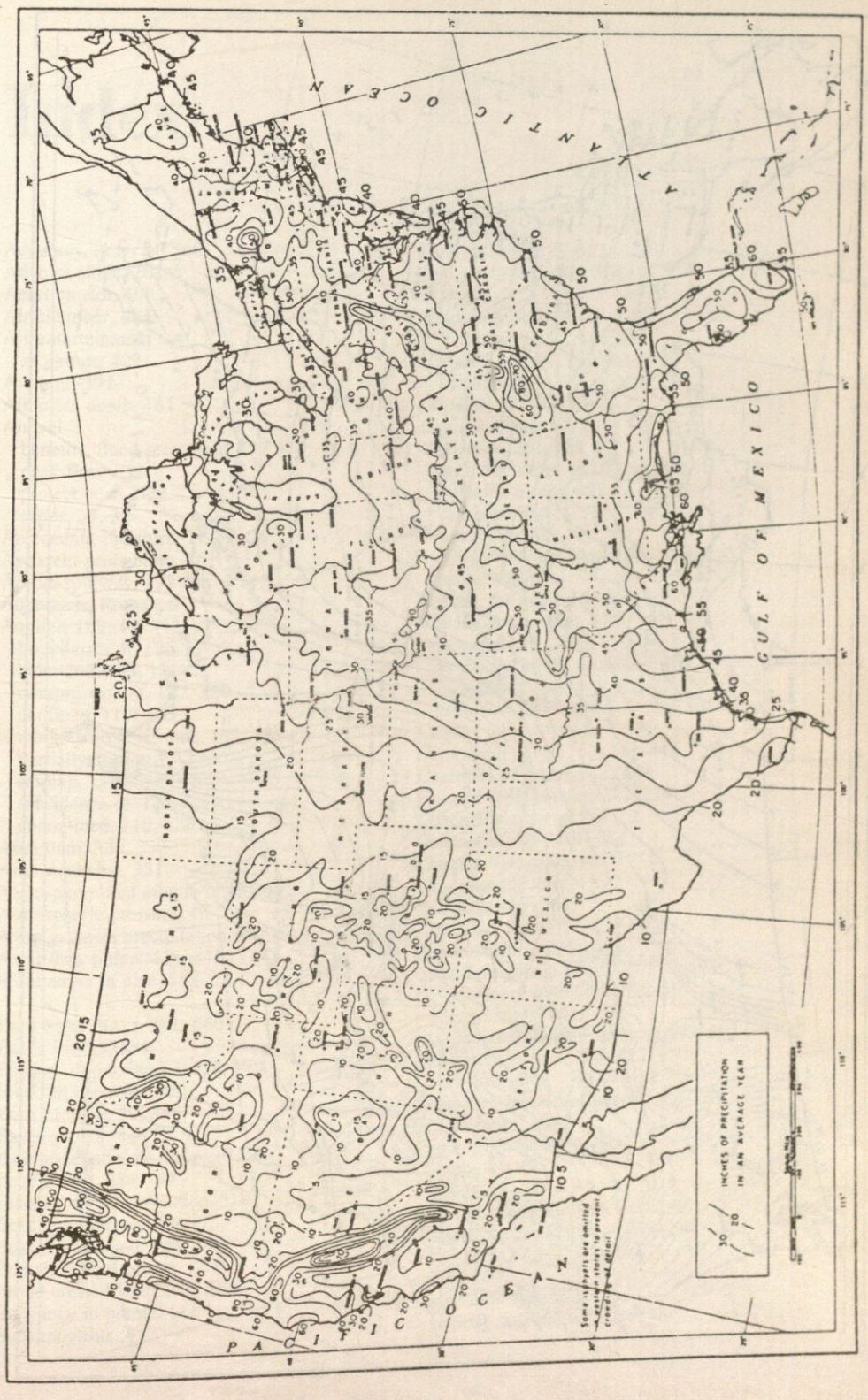
Table A-3 Physical Properties of Water at Atmospheric Pressure–S.I. System of Units

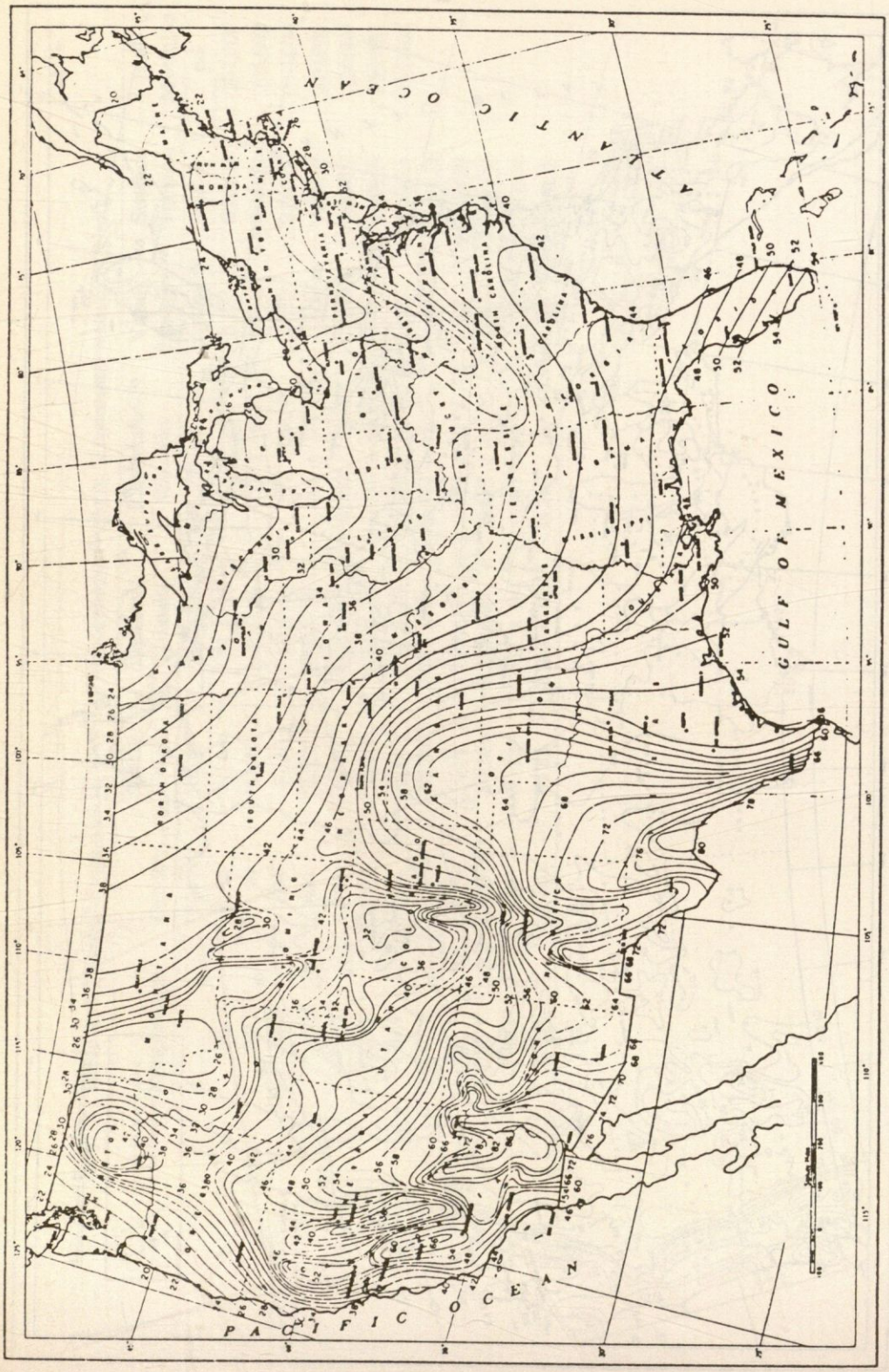
Temperature	Density	Specific Weight	Dynamic Viscosity	Kinematic Viscosity	Vapor Pressure	Surface Tension[1]	Bulk Modulus
	kg/m^3	N/m^3	$N \cdot s/m^2$	m^2/s	N/m^2 abs.	N/m	GN/m^2
0°C	1000	9810	1.79×10^{-3}	1.79×10^{-6}	611	0.0756	1.99
5°C	1000	9810	1.51×10^{-3}	1.51×10^{-6}	872	0.0749	2.05
10°C	1000	9810	1.31×10^{-3}	1.31×10^{-6}	1230	0.0742	2.11
15°C	999	9800	1.14×10^{-3}	1.14×10^{-6}	1700	0.0735	2.16
20°C	998	9790	1.00×10^{-3}	1.00×10^{-6}	2340	0.0728	2.20
25°C	997	9781	8.91×10^{-4}	8.94×10^{-7}	3170	0.0720	2.23
30°C	996	9771	7.97×10^{-4}	8.00×10^{-7}	4250	0.0712	2.25
35°C	994	9751	7.20×10^{-4}	7.24×10^{-7}	5630	0.0704	2.27
40°C	992	9732	6.53×10^{-4}	6.58×10^{-7}	7380	0.0696	2.28
50°C	988	9693	5.47×10^{-4}	5.53×10^{-7}	12,300	0.0679	
60°C	983	9643	4.66×10^{-4}	4.74×10^{-7}	20,000	0.0662	
70°C	978	9594	4.04×10^{-4}	4.13×10^{-7}	31,200	0.0644	
80°C	972	9535	3.54×10^{-4}	3.64×10^{-7}	47,400	0.0626	
90°C	965	9467	3.15×10^{-4}	3.26×10^{-7}	70,100	0.0607	
100°C	958	9398	2.82×10^{-4}	2.94×10^{-7}	101,300	0.0589	

[1] Surface tension of water in contact with air

Table A-4 Physical Properties of Water at Atmospheric Pressure–Traditional System of Units

Temperature	Density	Specific Weight	Dynamic Viscosity	Kinematic Viscosity	Vapor Pressure	Surface Tension	Bulk Modulus
	slugs/ft^3	lbf/ft^3	lbf-s/ft^2	ft^2/s	psia	lbf/ft	psi
40°F	1.94	62.43	3.23×10^{-5}	1.66×10^{-5}	0.122	0.00514	297,000
50°F	1.94	62.40	2.73×10^{-5}	1.41×10^{-5}	0.178	0.00508	306,000
60°F	1.94	62.37	2.36×10^{-5}	1.22×10^{-5}	0.256	0.00504	313,000
70°F	1.94	62.30	2.05×10^{-5}	1.06×10^{-5}	0.363	0.00498	320,000
80°F	1.93	62.22	1.80×10^{-5}	0.930×10^{-5}	0.506	0.00492	324,000
100°F	1.93	62.00	1.42×10^{-5}	0.739×10^{-5}	0.949	0.00479	330,000
120°F	1.92	61.72	1.17×10^{-5}	0.609×10^{-5}	1.69	0.00466	332,000
140°F	1.91	61.38	0.981×10^{-5}	0.514×10^{-5}	2.89	0.00452	
160°F	1.90	61.00	0.838×10^{-5}	0.442×10^{-5}	4.74	0.00439	
180°F	1.88	60.58	0.726×10^{-5}	0.385×10^{-5}	7.51	0.00427	
200°F	1.87	60.12	0.637×10^{-5}	0.341×10^{-5}	11.53	0.00414	
212°F	1.86	59.83	0.593×10^{-5}	0.319×10^{-5}	14.70	0.00408	


ATLANTIC OCEAN
GULF OF MEXICO
PACIFIC OCEAN
INCHES OF PRECIPITATION IN AN AVERAGE YEAR



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