PE Pipe—Design and Installation

AWWA MANUAL M55

First Edition

American Water Works Association

Science and Technology

AWWA unites the drinking water community by developing and distributing authoritative scientific and technological knowledge. Through its members, AWWA develops industry standards for products and processes that advance public health and safety. AWWA also provides quality improvement programs for water and wastewater utilities.

MANUAL OF WATER SUPPLY PRACTICES—M55, First Edition

PE Pipe—Design and Installation

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Tables

Terms and Equation Symbols

Term or Symbol	Meaning
a	wave velocity (celerity), ft/sec
A	wheel contact area, $in.^2$
ATL	allowable tensile load, lb
B	float buoyancy, lb/ft
B'	soil elastic support factor
B_d	trench width at the pipe springline, in.
B_N	negative buoyancy, lb/ft
B_P	buoyancy of pipe, lb/ft
C	Hazen-Williams flow coefficient, dimensionless
D	average inside pipe diameter, ft
d	float outside diameter, in.
DF	design factor, dimensionless — the factor that is used to reduce the hydrostatic design basis to arrive at the hydrostatic design stress from which the pressure class is determined. Unless otherwise noted, the design factor for water applications is 0.5
D_i	average inside pipe diameter, in.
DIPS	ductile iron pipe size — the nominal outside diameter is the same as ductile iron pipe
D_M	mean diameter, in. ($D_o - t$)
D_o	average outside diameter of the pipe, in.
DR	dimension ratio (dimensionless) — the ratio of the average specified outside diameter to the specified minimum wall thickness (D_o/t) for outside diameter controlled polyethylene pipe
E	apparent modulus of elasticity for pipe material, psi
e	natural log base number, 2.71828
E′	design modulus of soil reaction, psi
E_d	dynamic instantaneous effective modulus of elasticity of the pipe material, psi (150,000 psi for polyethylene)
E'_E	modulus of soil reaction of embedment soil, psi
E'_N	modulus of soil reaction of native soil, psi
f	Darcy-Weisbach fraction factor, dimensionless
F	pullout force, lb
f_O	ovality compensation factor
f_{SA}	actual float submergence factor
F_T	temperature compensation multiplier, dimensionless
f_T	tensile yield design (safety) factor
f_Y	time under tension design (safety) factor
g	acceleration due to gravity, 32.2 ft/sec^2
H	soil height above pipe crown, ft
h	float submergence below water level, in.

Term or Symbol	Meaning
HDB	hydrostatic design basis, psi — the categorized long-term strength in the circumferential or hoop direction for the polyethylene material as established from long-term pressure tests in accordance with PPI TR-3 and the methodology contained in ASTM D2837
HDS	hydrostatic design stress, psi — the hydrostatic design basis multiplied by the design factor (HDB × DF)
h_f	frictional head loss, ft of liquid
H_{OT}	depth of open trench, ft
H_W	groundwater height above pipe, ft
I	moment of inertia, in.^{4}
I_C	influence coefficient, dimensionless
IDR	inside dimension ratio, dimensionless — the ratio of the average specified inside diameter to the specified minimum wall thickness (D/t) for inside diameter controlled polyethylene pipe
I_f	impact factor, dimensionless
IPS	iron pipe size — the nominal outside diameter is the same as iron (steel) pipe
K	bulk modulus of liquid at working temperature (300,000 psi for water at 73°F [23°C])
K_e	underwater environment factor
L	length of pipe, ft
L_{BS}	ballast weight spacing, ft
L_{eq}	equivalent length of straight pipe, ft — for fittings, the equivalent length of straight pipe that has the same frictional head loss as the fitting
L_F	length of float, ft
L_{OT}	length of open trench, ft
L_S	distance between supports, ft
L_{SP}	length of supported pipeline, ft
L_t	time-lag factor, dimensionless
M_M	density of foam fill, lb/ft^3
N	safety factor
P	pipe internal pressure, psi
$P_{(MAX)(OS)}$	maximum allowable system pressure during occasional surge, psi
$P_{(MAX)(RS)}$	maximum allowable system pressure during recurrent surge, psi
PC	pressure class, psi — the pressure class is the design capacity to resist working pressure up to 80°F (27°C) with specified maximum allowances for recurring positive pressure surges above working pressure. Pressure class also denotes the pipe's maximum working pressure rating for water at 80°F (27°C)
P_{CA}	allowable external pressure for constrained pipe, psi
PE	polyethylene
P_E	earth pressure on pipe, psi
PE 2406	a standard code designation for polyethylene pipe and fittings materials that has a minimum cell classification of 213333C, D, or E per ASTM D3350 and a hydrostatic design basis at 73.4°F (23°C) of 1250 psi
PE 3408	a standard code designation for polyethylene pipe and fittings materials that has a minimum cell classification of 334434C, D, or E per ASTM D3350 and a hydrostatic design basis at 73.4°F (23°C) of 1600 psi
P_{ES}	surcharge earth load pressure at point on pipe crown, psf

Term or Symbol	Meaning
P_L	vertical stress acting on pipe crown, psi
P_{OS}	pressure allowance for occasional surge pressure, psi — occasional surge pressures are caused by emergency operations that are usually the result of a malfunction such as power failure or system component failure, which includes pump seize-up, valve stem failure, and pressure-relief-valve failure
P_{RS}	pressure allowance for recurring surge pressure, psi — recurring surge pressures occur frequently and inherent in the design and operation of the system (such as normal pump startup and shutdown and normal valve opening or closure)
P_S	transient surge pressure, psi — the maximum hydraulic transient pressure increase (water hammer) in excess of the operating pressure that is anticipated in the system as a result of sudden changes in the velocity of the water column
P_{UA}	allowable external pressure for unconstrained pipe, psi
P_V	negative internal pressure (vacuum) in pipe, psi
Q	volumetric liquid flow rate, U.S. gal/min
R	equivalent radius, ft
R_b	buoyancy reduction factor
Re	Reynolds Number, dimensionless
s	hydraulic slope, ft/ft — frictional head loss per foot of pipe (h_f/L)
S	hoop compressive wall stress, psi
S_C	soil support factor
SDR	standard dimension ratio (dimensionless) — the ratio of the average specified outside diameter to the specified minimum wall thickness for outside diameter controlled polyethylene pipe, the value of which is derived by adding one to the pertinent number selected from the ANSI Preferred Number Series R10. Some of the values are as follows:

R10	SDR
5	6
6.3	7.3
8	9
10	11
12.5	13.5
16	17
20	21
25	26
31.5	32.5
40	41

Term or Symbol	Meaning
S_L	specific gravity of liquid
S_P	internal pressure hoop stress, psi
t	minimum specified wall thickness, in.
t_a	average wall thickness, in. — 106% of minimum wall thickness (t*1.06)
T_Y	pipe tensile yield strength, psi
v	average velocity of flowing fluid, ft/sec
V_B	pipe bore volume, ft^3/ft
V_F	float internal volume, ft^3/ft
V_P	displaced volume of pipe, ft^3/ft
w	unit weight of soil, lb/ft^3
W	supported load, lb
W_{BD}	weight of dry ballast, lb/ft
W_{BS}	weight of submerged ballast, lb/ft

Term or Symbol	Meaning
w_F	float weight, lb/ft
WF	float load supporting capacity, lb
W_L	vehicular wheel load, lb
w_{LI}	weight of liquid inside pipe, lb/ft
w_M	weight of floam fill, lb/ft
w_P	pipe weight, lb/ft
WP	working pressure, psi — the maximum anticipated sustained operating pressure applied to the pipe exclusive of surge pressures
WPR	working pressure rating, psi — the working pressure rating is the pipe's design capacity to resist working pressure at the anticipated operating temperature with sufficient capacity against the actual anticipated positive pressure surges above working pressure. A pipe's WPR may be equal to or less than its nominal pressure class depending on the positive transient pressure characteristics of the system and pipe operating temperature if above 80°F (27°C)
W_s	distributed surcharge pressure acting over ground surface, psf
w_S	weight of float attachment structure, lb
y_S	deflection between supports, in.
γ	kinematic viscosity of the flowing fluid, ft^2/sec
Δv	velocity change occurring within the critical time 2L/a, sec
ΔY	change in diameter due to deflection, in.
ε	absolute roughness of the pipe, ft
μ	Poisson's ratio
ω_B	specific weight of ballast material, lb/ft^3
ω_L	specific weight of liquid, lb/ft^3
ω_{LI}	specific weight of the liquid inside the pipe, lb/ft^3
ω_{LO}	specific weight of the liquid outside the pipe, lb/ft^3

Conversions

METRIC CONVERSIONS

Linear Measurement

inch (in.)	× 25.4	= millimeters (mm)
inch (in.)	× 2.54	= centimeters (cm)
foot (ft)	× 304.8	= millimeters (mm)
foot (ft)	× 30.48	= centimeters (cm)
foot (ft)	× 0.3048	= meters (m)
yard (yd)	× 0.9144	= meters (m)
mile (mi)	× 1,609.3	= meters (m)
mile (mi)	× 1.6093	= kilometers (km)
millimeter (mm)	× 0.03937	= inches (in.)
centimeter (cm)	× 0.3937	= inches (in.)
meter (m)	× 39.3701	= inches (in.)
meter (m)	× 3.2808	= feet (ft)
meter (m)	× 1.0936	= yards (yd)
kilometer (km)	× 0.6214	= miles (mi)

Area Measurement

square meter (m^2)	× 10,000	= square centimeters (cm^2)
hectare (ha)	× 10,000	= square meters (m^2)
square inch ($in.^2$)	× 6.4516	= square centimeters (cm^2)
square foot (ft^2)	× 0.092903	= square meters (m^2)
square yard (yd^2)	× 0.8361	= square meters (m^2)
acre	× 0.004047	= square kilometers (km^2)
acre	× 0.4047	= hectares (ha)
square mile (mi^2)	× 2.59	= square kilometers (km^2)
square centimeter (cm^2)	× 0.16	= square inches ($in.^2$)
square meters (m^2)	× 10.7639	= square feet (ft^2)
square meters (m^2)	× 1.1960	= square yards (yd^2)
hectare (ha)	× 2.471	= acres
square kilometer (km^2)	× 247.1054	= acres
square kilometer (km^2)	× 0.3861	= square miles (mi^2)

Volume Measurement

cubic inch ($in.^3$)	× 16.3871	= cubic centimeters (cm^3)
cubic foot (ft^3)	× 28,317	= cubic centimeters (cm^3)
cubic foot (ft^3)	× 0.028317	= cubic meters (m^3)
cubic foot (ft^3)	× 28.317	= liters (L)
cubic yard (yd^3)	× 0.7646	= cubic meters (m^3)
acre foot (acre-ft)	× 123.34	= cubic meters (m^3)
ounce (US fluid) (oz)	× 0.029573	= liters (L)
quart (liquid) (qt)	× 946.9	= milliliters (mL)
quart (liquid) (qt)	× 0.9463	= liters (L)
gallon (gal)	× 3.7854	= liters (L)

gallon (gal)	× 0.0037854	= cubic meters (m^3)
peck (pk)	× 0.881	= decaliters (dL)
bushel (bu)	× 0.3524	= hectoliters (hL)
cubic centimeters (cm^3)	× 0.061	= cubic inches ($in.^3$)
cubic meter (m^3)	× 35.3183	= cubic feet (ft^3)
cubic meter (m^3)	× 1.3079	= cubic yards (yd^3)
cubic meter (m^3)	× 264.2	= gallons (gal)
cubic meter (m^3)	× 0.000811	= acre-feet (acre-ft)
liter (L)	× 1.0567	= quart (liquid) (qt)
liter (L)	× 0.264	= gallons (gal)
liter (L)	× 0.0353	= cubic feet (ft^3)
decaliter (dL)	× 2.6417	= gallons (gal)
decaliter (dL)	× 1.135	= pecks (pk)
hectoliter (hL)	× 3.531	= cubic feet (ft^3)
hectoliter (hL)	× 2.84	= bushels (bu)
hectoliter (hL)	× 0.131	= cubic yards (yd^3)
hectoliter (hL)	× 26.42	= gallons (gal)

Pressure Measurement

pound/square inch (psi)	× 6.8948	= kilopascals (kPa)
pound/square inch (psi)	× 0.00689	= pascals (Pa)
pound/square inch (psi)	× 0.070307	= kilograms/square centimeter (kg/cm^2)
pound/square foot (lb/ft^2)	× 47.8803	= pascals (Pa)
pound/square foot (lb/ft^2)	× 0.000488	= kilograms/square centimeter (kg/cm^2)
pound/square foot (lb/ft^2)	× 4.8824	= kilograms/square meter (kg/m^2)
inches of mercury	× 3,376.8	= pascals (Pa)
inches of water	× 248.84	= pascals (Pa)
bar	× 100,000	= newtons per square meter
pascals (Pa)	× 1	= newtons per square meter
pascals (Pa)	× 0.000145	= pounds/square inch (psi)
kilopascals (kPa)	× 0.145	= pounds/square inch (psi)
pascals (Pa)	× 0.000296	= inches of mercury (at 60°F)
kilogram/square centimeter (kg/cm^2)	× 14.22	= pounds/square inch (psi)
kilogram/square centimeter (kg/cm^2)	× 28.959	= inches of mercury (at 60°F)
kilogram/square meter (kg/m^2)	× 0.2048	= pounds per square foot (lb/ft^2)
centimeters of mercury	× 0.4461	= feet of water

Weight Measurement

ounce (oz)	× 28.3495	= grams (g)
pound (lb)	× 0.045359	= grams (g)
pound (lb)	× 0.4536	= kilograms (kg)
ton (short)	× 0.9072	= megagrams (metric ton)
pounds/cubic foot (lb/ft^3)	× 16.02	= grams per liter (g/L)
pounds/million gallons (lb/mil gal)	× 0.1198	= grams per cubic meter (g/m^3)
gram (g)	× 15.4324	= grains (gr)
gram (g)	× 0.0353	= ounces (oz)
gram (g)	× 0.0022	= pounds (lb)
kilograms (kg)	× 2.2046	= pounds (lb)
kilograms (kg)	× 0.0011	= tons (short)
megagram (metric ton)	× 1.1023	= tons (short)

grams/liter (g/L)	× 0.0624	= pounds per cubic foot (lb/ft^3)
grams/cubic meter (g/m^3)	× 8.3454	= pounds/million gallons (lb/mil gal)

Flow Rates

gallons/second (gps)	× 3.785	= liters per second (L/sec)
gallons/minute (gpm)	× 0.00006308	= cubic meters per second (m^3/sec)
gallons/minute (gpm)	× 0.06308	= liters per second (L/sec)
gallons/hour (gph)	× 0.003785	= cubic meters per hour (m^3/hr)
gallons/day (gpd)	× 0.000003785	= million liters per day (ML/day)
gallons/day (gpd)	× 0.003785	= cubic meters per day (m^3/day)
cubic feet/second (ft^3/sec)	× 0.028317	= cubic meters per second (m^3/sec)
cubic feet/second (ft^3/sec)	× 1,699	= liters per minute (L/min)
cubic feet/minute (ft^3/min)	× 472	= cubic centimeters/second (cm^3/sec)
cubic feet/minute (ft^3/min)	× 0.472	= liters per second (L/sec)
cubic feet/minute (ft^3/min)	× 1.6990	= cubic meters per hour (m^3/hr)
million gallons/day (mgd)	× 43.8126	= liters per second (L/sec)
million gallons/day (mgd)	× 0.003785	= cubic meters per day (m^3/day)
million gallons/day (mgd)	× 0.043813	= cubic meters per second (m^3/sec)
gallons/square foot (gal/ft^2)	× 40.74	= liters per square meter (L/m^2)
gallons/acre/day (gal/acre/day)	× 0.0094	= cubic meters/hectare/day (m^3/ha/day)
gallons/square foot/day (gal/ft^2/day)	× 0.0407	= cubic meters/square meter/day (m^3/m^2/day)
gallons/square foot/day (gal/ft^2/day)	× 0.0283	= liters/square meter/day (L/m^2/day)
gallons/square foot/minute (gal/ft^2/min)	× 2.444	= cubic meters/square meter/hour (m^3/m^2/hr) = m/hr
gallons/square foot/minute (gal/ft^2/min)	× 0.679	= liters/square meter/second (L/m^2/sec)
gallons/square foot/minute (gal/ft^2/min)	× 40.7458	= liters/square meter/minute (L/m^2/min)
gallons/capita/day (gpcd)	× 3.785	= liters/day/capita (L/d per capita)
liters/second (L/sec)	× 22,824.5	= gallons per day (gpd)
liters/second (L/sec)	× 0.0228	= million gallons per day (mgd)
liters/second (L/sec)	× 15.8508	= gallons per minute (gpm)
liters/second (L/sec)	× 2.119	= cubic feet per minute (ft^3/min)
liters/minute (L/min)	× 0.0005886	= cubic feet per second (ft^3/sec)
cubic centimeters/second (cm^3/sec)	× 0.0021	= cubic feet per minute (ft^3/min)
cubic meters/second (m^3/sec)	× 35.3147	= cubic feet per second (ft^3/sec)
cubic meters/second (m^3/sec)	× 22.8245	= million gallons per day (mgd)
cubic meters/second (m^3/sec)	× 15,850.3	= gallons per minute (gpm)
cubic meters/hour (m^3/hr)	× 0.5886	= cubic feet per minute (ft^3/min)
cubic meters/hour (m^3/hr)	× 4.403	= gallons per minute (gpm)
cubic meters/day (m^3/day)	× 264.1720	= gallons per day (gpd)
cubic meters/day (m^3/day)	× 0.00026417	= million gallons per day (mgd)
cubic meters/hectare/day (m^3/ha/day)	× 106.9064	= gallons per acre per day (gal/acre/day)
cubic meters/square meter/day (m^3/m^2/day)	× 24.5424	= gallons/square foot/day (gal/ft^2/day)
liters/square meter/minute (L/m^2/min)	× 0.0245	= gallons/square foot/minute (gal/ft^2/min)
liters/square meter/minute (L/m^2/min)	× 35.3420	= gallons/square foot/day (gal/ft^2/day)

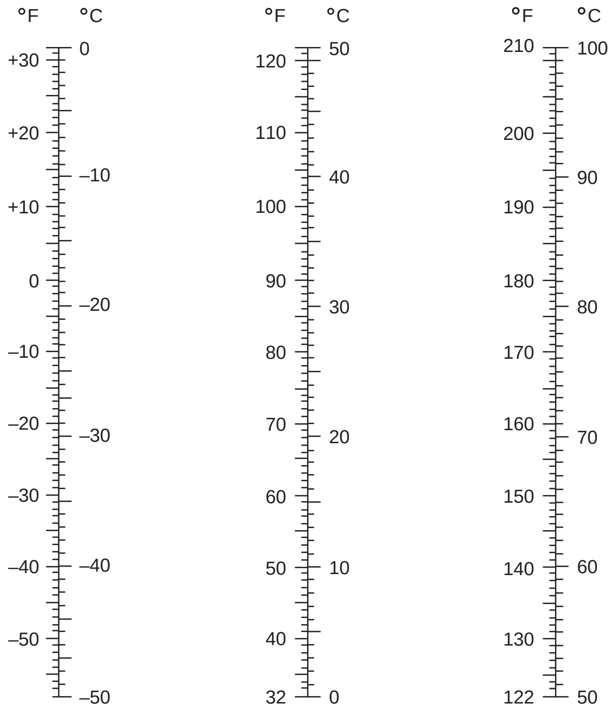
Work, Heat, and Energy

British thermal units (Btu)	× 1.0551	= kilojoules (kJ)
British thermal units (Btu)	× 0.2520	= kilogram-calories (kg-cal)
foot-pound (force) (ft-lb)	× 1.3558	= joules (J)
horsepower-hour (hp·hr)	× 2.6845	= megajoules (MJ)
watt-second (W-sec)	× 1.000	= joules (J)
watt-hour (W·hr)	× 3.600	= kilojoules (kJ)
kilowatt-hour (kW·hr)	× 3,600	= kilojoules (kJ)
kilowatt-hour (kW·hr)	× 3,600,000	= joules (J)
British thermal units per pound (Btu/lb)	× 0.5555	= kilogram-calories per kilogram (kg-cal/kg)
British thermal units per cubic foot (Btu/ft^3)	× 8.8987	= kilogram-calories/cubic meter (kg-cal/m^3)
kilojoule (kJ)	× 0.9478	= British thermal units (Btu)
kilojoule (kJ)	× 0.00027778	= kilowatt-hours (kW·hr)
kilojoule (kJ)	× 0.2778	= watt-hours (W·hr)
joule (J)	× 0.7376	= foot-pounds (ft-lb)
joule (J)	× 1.0000	= watt-seconds (W-sec)
joule (J)	× 0.2399	= calories (cal)
megajoule (MJ)	× 0.3725	= horsepower-hour (hp·hr)
kilogram-calories (kg-cal)	× 3.9685	= British thermal units (Btu)
kilogram-calories per kilogram (kg-cal/kg)	× 1.8000	= British thermal units per pound (Btu/lb)
kilogram-calories per liter (kg-cal/L)	× 112.37	= British thermal units per cubic foot (Btu/ft^3)
kilogram-calories/cubic meter (kg-cal/m^3)	× 0.1124	= British thermal units per cubic foot (Btu/ft^3)

Velocity, Acceleration, and Force

feet per minute (ft/min)	× 18.2880	= meters per hour (m/hr)
feet per hour (ft/hr)	× 0.3048	= meters per hour (m/hr)
miles per hour (mph)	× 44.7	= centimeters per second (cm/sec)
miles per hour (mph)	× 26.82	= meters per minute (m/min)
miles per hour (mph)	× 1.609	= kilometers per hour (km/hr)
feet/second/second (ft/sec^2)	× 0.3048	= meters/second/second (m/sec^2)
inches/second/second (in./sec^2)	× 0.0254	= meters/second/second (m/sec^2)
pounds force (lbf)	× 4.44482	= newtons (N)
centimeters/second (cm/sec)	× 0.0224	= miles per hour (mph)
meters/second (m/sec)	× 3.2808	= feet per second (ft/sec)
meters/minute (m/min)	× 0.0373	= miles per hour (mph)
meters per hour (m/hr)	× 0.0547	= feet per minute (ft/min)
meters per hour (m/hr)	× 3.2808	= feet per hour (ft/hr)
kilometers/second (km/sec)	× 2.2369	= miles per hour (mph)
kilometers/hour (km/hr)	× 0.0103	= miles per hour (mph)
meters/second/second (m/sec^2)	× 3.2808	= feet/second/second (ft/sec^2)
meters/second/second (m/sec^2)	× 39.3701	= inches/second/second (in./sec^2)
newtons (N)	× 0.2248	= pounds force (lbf)

CELSIUS/FAHRENHEIT COMPARISON GRAPH



0.555 (°F – 32)	=	degrees Celsius (°C)
(1.8 × °C) + 32	=	degrees Fahrenheit (°F)
°C + 273.15	=	kelvin (K)
boiling point*	=	212 °F
	=	100 °C
	=	373 K
freezing point*	=	32 °F
	=	0 °C
	=	273 K

*At 14.696 psia, 101.325 kPa.

DECIMAL EQUIVALENTS OF FRACTIONS

Fraction	Decimal	Fraction	Decimal
1/64	0.01563	33/64	0.51563
1/32	0.03125	17/32	0.53125
3/64	0.04688	35/64	0.54688
1/16	0.06250	9/16	0.56250
5/64	0.07813	37/64	0.57813
3/32	0.09375	19/32	0.59375
7/64	0.10938	39/64	0.60938
1/8	0.12500	5/8	0.62500
9/64	0.14063	41/64	0.64063
5/32	0.15625	21/32	0.65625
11/64	0.17188	43/64	0.67188
3/16	0.18750	11/16	0.68750
13/64	0.20313	45/64	0.70313
7/32	0.21875	23/32	0.71875
15/64	0.23438	47/64	0.73438
1/4	0.25000	3/4	0.75000
17/64	0.26563	49/64	0.76563
9/32	0.28125	25/32	0.78125
19/64	0.29688	51/64	0.79688
10/32	0.31250	13/16	0.81250
21/64	0.32813	53/64	0.82813
11/32	0.34375	27/32	0.84375
23/64	0.35938	55/64	0.85938
3/8	0.37500	7/8	0.87500
25/64	0.39063	57/64	0.89063
13/32	0.40625	29/32	0.90625
27/64	0.42188	59/64	0.92188
7/16	0.43750	15/16	0.93750
29/64	0.45313	61/64	0.95313
15/32	0.46875	31/32	0.96875
31/64	0.48438	63/64	0.98438
1/2	0.50000		

Preface

This is the first edition of AWWA M55 *PE Pipe—Design and Installation*. The manual provides the user with both technical and general information to aid in the design, specification, procurement, installation, and understanding of the high-density polyethylene (HDPE) pipe and fittings. It is a discussion of recommended practice, not an American Water Works Association (AWWA) standard calling for compliance with certain specifications. It is intended for use by utilities and municipalities of all sizes, whether as a reference book or textbook for those not fully familiar with HDPE pipe and fittings products. Municipal and consulting engineers may use this manual in preparing plans and specifications for new HDPE pipe projects.

The manual describes HDPE pipe and fittings products and certain appurtenances, and their applications to practical installations, whether of a standard or special nature. For adequate knowledge of these products, the entire manual needs to be studied. Readers will also find the manual a useful source of information for assistance with specific or unusual conditions. The manual contains a list of applicable national standards, which may be purchased from the respective standards organizations (e.g., AWWA, ASTM, etc.). Readers should use the latest editions of the Standards that are referenced.

Credit is extended to The Plastics Pipe Institute, Inc. (www.plasticpipe.org) for its contribution to the manual.

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Acknowledgments

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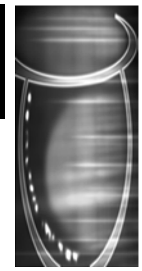

Chapter 1

Engineering Properties of Polyethylene

INTRODUCTION

A fundamental understanding of material characteristics is an inherent part of the design process for any piping system. With such an understanding, the piping designer can use the properties of the material to design for optimum performance. This chapter provides basic information that should assist the reader in understanding how polyethylene's (PE's) material characteristics influence its engineering behavior.

PE is a thermoplastic, which means that it is a polymeric material that can be softened and formed into useful shapes by the application of heat and pressure and which hardens when cooled. PE is a member of the polyolefins family, which also includes polypropylene. As a group of materials, the polyolefins generally possess low water absorption, moderate to low gas permeability, good toughness and flexibility at low temperatures, and a relatively low heat resistance. PE plastics form flexible but tough products and possess excellent resistance to many chemicals.

POLYMER CHARACTERISTICS

In general terms, the performance capability of PE in piping applications is determined by three main parameters: density, molecular weight, and molecular weight distribution. Each of these polymer properties has an effect on the physical performance associated with a specific PE resin. The general effect of variation in these three physical properties as related to polymer performance is shown in Table 1-1.

Density

PE is a semicrystalline polymer composed of long, chain-like molecules of varying lengths and numbers of side branches. As the number of side branches increases, polymer crystallinity and hence, density decreases because the molecules cannot pack as