Chapter 5
Plastic Piping Systems

5-1. General

Thermoplastic piping systems, commonly referred to as plastic piping systems, are composed of various additives to a base resin or composition. Thermoplastics are characterized by their ability to be softened and reshaped repeatedly by the application of heat. Table 5-1 lists the chemical names and abbreviations for a number of thermoplastic piping materials. Because of the slightly different formulations, properties of plastic piping materials (for example, polyvinyl chloride - PVC) may vary from manufacturer to manufacturer[1]. Therefore, designs and specifications need to address specific material requirements on a type or grade basis, which may have to be investigated and confirmed with manufacturers.

a. Corrosion

Unlike metallic piping, thermoplastic materials do not display corrosion rates[2]. That is, the corrosion of thermoplastic materials is dependent totally on the material's chemical resistance rather than an oxide layer, so the material is either completely resistant to a chemical or it deteriorates. This deterioration may be either rapid or slow. Plastic piping system corrosion is indicated by material softening, discoloration, charring, embrittlement, stress cracking (also referred to as crazing), blistering, swelling, dissolving, and other effects. Corrosion of plastics occurs by the following mechanisms:

- absorption;
- solvation;
- chemical reactions such as oxidation (affects chemical bonds), hydrolysis (affects ester linkages), radiation, dehydration, alkylation, reduction, and halogenation (chlorination);

Table 5-1
Abbreviations for Thermoplastic Materials

Abbreviation	Chemical Name
ABS	Acrylonitrile-Butadiene-Styrene
CPVC	Chlorinated Poly(Vinyl Chloride)
ECTFE	Ethylene-Chlorotrifluoroethylene
ETFE	Ethylene-Tetrafluoroethylene
FEP	Perfluoro(Ethylene-Propylene) Copolymer
PE	Polyethylene
PFA	Perfluoro(Alkoxyalkane) Copolymer
PP	Polypropylene
PTFE	Polytetrafluoroethylene
PVC	Poly(Vinyl Chloride)
PVDC	Poly(Vinylidene Chloride)
PVDF	Poly(Vinylidene Fluoride)

Sources: ASTM D 1600.
ASME B31.3 (Used by permission of ASME).

1 Schweitzer, Corrosion-Resistant Piping Systems, p. 17.
2 Ibid., p. 18.

- thermal degradation which may result in either depolymerization or plasticization;
- environmental-stress cracking (ESC) which is essentially the same as stress-corrosion cracking in metals;
- UV degradation; and
- combinations of the above mechanisms.

For plastic material compatibility with various chemicals, see Appendix B. If reinforcing is used as part of the piping system, the reinforcement is also a material that is resistant to the fluid being transported. Material selection and compatibility review should consider the type and concentration of chemicals in the liquid, liquid temperature, duration of contact, total stress of the piping system, and the contact surface quality of the piping system. See Appendix A, paragraph A-4 - Other Sources of Information, for additional sources of corrosion data.

b. Operating Pressures and Temperatures

The determination of maximum steady state design pressure and temperature is similar to that described for metallic piping systems. However, a key issue that must be addressed relative to plastic piping systems is the impact of both minimum and maximum temperature limits of the materials of construction.

c. Sizing

The sizing for plastic piping systems is performed consistent with the procedures of Paragraph 3-3. However, one of the basic principles of designing and specifying thermoplastic piping systems for liquid process piping pressure applications is that the short and long term strength of thermoplastic pipe decreases as the temperature of the pipe material increases.

Thermoplastic pipe is pressure rated by using the International Standards Organization (ISO) rating equation using the Hydrostatic Design Basis (HDB) as contained in ASTM standards and Design Factors (DFs). The use of DFs is based on the specific material being used and specific application requirements such as temperature and pressure surges. The following is the basic equation for internal hydraulic pressure rating of thermoplastic piping:

$$P_R = 2(HDS)(t/D_m)$$

where:
P_R = pipe pressure rating, MPa (psi)
t = minimum wall thickness, mm (in)
D_m = mean diameter, mm (in)
HDS = (HDB)(DF)

The minimum pipe wall thickness can also be determined using the requirements of ASME B31.3 as described in Paragraph 3-3b. This procedure is not directly applicable to thermoplastic pipe fittings, particularly in cyclic pressure operations due to material fatigue. Therefore, it should not be assumed that thermoplastic fittings labeled with a pipe schedule designation will have the same pressure rating as pipe of the same designation. A good example of this is contained in ASTM D 2466 and D 2467 which specify pressure ratings for PVC schedule 40 and 80 fittings. These ratings are significantly lower than the rating for PVC pipe of the same designation. For thermoplastic pipe fittings that do not have published pressure ratings information similar to ASTM standards, the fitting manufacturer shall be consulted for fitting pressure rating recommendations.

d. Joining

Common methods for the joining of thermoplastic pipe for liquid process waste treatment and storage systems are contained in Table 5-2. In selecting a joining method for liquid process piping systems, the advantages and disadvantages of each method are evaluated and the manner by which the joining is accomplished for each liquid service is specified. Recommended procedures and specification for these joining methods are found in codes, standards and manufacturer procedures for joining thermoplastic pipe. Table 5-3 lists applicable references for joining thermoplastic pipe.

e. Thermal Expansion

When designing a piping system where thermal expansion of the piping is restrained at supports, anchors, equipment nozzles and penetrations, large thermal stresses and loads must be analyzed and accounted for within the design. The system PFDs and P&IDs are analyzed to determine the thermal conditions or modes to

Table 5-2
Thermoplastic Joining Methods

Joining Method	ABS	PVC	CPVC	PE	PP	PVDF
Solvent Cementing	X	X	X			
Heat Fusion				X	X	X
Threading*	X	X	X	X	X	X
Flanged Connectors**	X	X	X	X	X	X
Grooved Joints***	X	X	X	X	X	X
Mechanical Compression****	X	X	X	X	X	X
Elastomeric seal	X	X	X	X	X	X
Flaring				X		

Notes:
X = applicable method
* Threading requires a minimum pipe wall thickness (Schedule 80).
** Flanged adapters are fastened to pipe by heat fusion, solvent cementing, or threading.
*** Grooving requires a minimum pipe wall thickness (material dependent).
**** Internal stiffeners are required.
Source: Compiled by SAIC, 1998.

Table 5-3
Thermoplastic Joining Standards

Reference	Key Aspects of Reference
ASTM D 2657	Recommended practice for heat fusion.
ASTM D 2855	Standard practice for solvent cementing PVC pipe and fittings.
ASTM D 3139	Elastomeric gasketed connections for pressure applications.
ASTM F 1290	Recommended practice for electrofusion.

Source: Compiled by SAIC, 1998.

which the piping system will be subjected during operation. Based on this analysis, the design and material specification requirements from an applicable standard or design reference are followed in the design.

A basic approach to assess the need for additional thermal stress analysis for piping systems includes identifying operating conditions that will expose the piping to the most severe thermal loading conditions. Once these conditions have been established, a free or unrestrained thermal analysis of the piping can be performed to establish location, sizing, and arrangement of expansion loops, or expansion joints (generally, bellows or slip types).

If the application requires the use of a bellow or piston joint, the manufacturer of the joint shall be consulted to determine design and installation requirements.

When expansion loops are used, the effects of bending on the fittings used to install the expansion loop are considered. Installation of the loop should be performed in consultation with the fitting manufacturer to ensure that specified fittings are capable of withstanding the anticipated loading conditions, constant and cyclic, at the design temperatures of the system. Terminal loadings on equipment determined from this analysis can then be used to assess the equipment capabilities for withstanding the loading from the piping system. It should also be noted that this termination analysis at equipment and anchor terminations should consider the movement and stress impacts of the "cold" condition.

No rigid or restraining supports or connections should be made within the developed length of an expansion loop, offset, bend or brand. Concentrated loads such as valves should not be installed in the developed length. Piping support guides should restrict lateral movement and should direct axial movement into the compensating configurations. Calculated support guide spacing distances for offsets and bends should not exceed recommended hanging support spacing for the maximum temperature. If that occurs, distance between anchors will have to be decreased until the support guide spacing distance equals or is less than the recommended support spacing. Use of the rule of thumb method or calculated method is not recommended for threaded Schedule 80 connections. Properly cemented socket cement joints should be utilized.

Expansion loops, offsets and bends should be installed as nearly as possible at the mid point between anchors.

Values for expansion joints, offsets, bends and branches can be obtained by calculating the developed length from the following equation.

$$L = n_1 \left(\frac{3\ E\ D_o\ e}{S} \right)^{1/2}$$

where:

L = developed length, m (ft)
n_1 = conversion factor, 10^{-3} m/mm (1/12 ft/in)
E = tensile modulus of elasticity, MPa (psi)
D_o = pipe outer diameter, mm (in)
e = elongation due to temperature rise, mm (in)
S = maximum allowable stress, MPa (psi)

In determining the elongation due to temperature rise information from the manufacturer on the material to be used should be consulted. For example, the coefficient of expansion is 6.3×10^{-5} mm/mm/°C (3.4×10^{-5} in/in/°F) for Type IV Grade I CPVC and 5.4×10^{-5} mm/mm/°C (2.9×10^{-5} in/in/°F) for Type I Grade I PVC. Other sources of information on thermal expansion coefficients are available from plastic pipe manufacturers.

PVC and CPVC pipe does not have the rigidity of metal pipe and can flex during expansion, especially with smaller diameters. If expansion joints are used, axial guides should be installed to ensure straight entrance into the expansion joint, especially when maximum movement of the joint is anticipated. Leakage at the seals can occur if the pipe is cocked. Independent anchoring of the joint is also recommended for positive movement of expansion joints.

f. Piping Support and Burial

Support for thermoplastic pipe follows the same basic principles as metallic piping. Spacing of supports is crucial for plastic pipe. Plastic pipe will deflect under load more than metallic pipe. Excessive deflection will lead to structural failure. Therefore, spacing for plastic pipe is closer than for metallic pipe. Valves, meters, and fittings should be supported independently in plastic pipe systems, as in metallic systems.

In addition, plastic pipe systems are not located near sources of excessive heat. The nature of thermoplastic pipe is that it is capable of being repeatedly softened by increasing temperature, and hardened by decreasing temperature. If the pipe is exposed to higher than design value ambient temperatures, the integrity of the system could be compromised.

Contact with supports should be such that the plastic pipe material is not damaged or excessively stressed. Point contact or sharp surfaces are avoided as they may impose excessive stress on the pipe or otherwise damage it.

Support hangers are designed to minimize stress concentrations in plastic pipe systems. Spacing of supports should be such that clusters of fittings or concentrated loads are adequately supported. Valves, meters, and other miscellaneous fittings should be supported exclusive of pipe sections.

Supports for plastic pipe and various valves, meters, and fittings, should allow for axial movement caused by thermal expansion and contraction. In addition, external stresses should not be transferred to the pipe system through the support members. Supports should allow for axial movement, but not lateral movement. When a pipeline changes direction, such as through a 90° elbow, the plastic pipe should be rigidly anchored near the elbow.

Plastic pipe systems should be isolated from sources of vibration, such as pumps and motors. Vibrations can negatively influence the integrity of the piping system, particularly at joints.

Support spacing for several types of plastic pipe are found in Tables 5-4 through 5-6. Spacing is dependent upon the temperature of the fluid being carried by the pipe.

The determining factor to consider in designing buried thermoplastic piping is the maximum allowable deflection in the pipe. The deflection is a function of the bedding conditions and the load on the pipe. The procedure for determining deflection is as follows[3]:

$$\%\ deflection = \frac{100\ \Delta Y}{D_o}$$

where:
ΔY = calculated deflection
D_o = outer pipe diameter, mm (in)

$$\Delta Y = \frac{(K_x)(d_e)(W)}{[0.149(PS) + 0.061(E')]}$$

where:
ΔY = calculated deflection
K_x = bedding factor, see Table 5-7
d_e = deflection lag factor, see Table 5-8
W = weight per length of overburden, N/m (lb/in)
PS = pipe stiffness, MPa (psi)
E' = soil modulus, MPa (psi), see Table 5-9

$$W = \frac{(H)(D_o)(\gamma)}{144} = (\sigma)(D_o)$$

where:
W = weight per length of overburden, N/m (lb/in)
H = height of cover, m (ft)
D_o = outer pipe diameter, mm (in)
γ = density of soil N/m^3 (lb/ft^3)
σ = soil overburden pressure, MPa (psi)

$$PS = \frac{(E)(I_a)}{0.149\ (R)^3}$$

where:
PS = pipe stiffness, MPa (psi)
E = modulus of elasticity of pipe, MPa (psi)
I_a = area moment of inertia per unit length of pipe, mm^4/mm (in^4/in)
R = mean radii of pipe, MPa (psi)

$$R = \frac{(D_o - t)}{2}$$

where:
R = mean radii of pipe, MPa (psi)
D_o = outer pipe diameter, mm (in)
t = average wall thickness, mm (in)

$$I_a = \frac{t^3}{12}$$

where:
I_a = area moment of inertia per unit length of pipe, mm^4/mm (in^4/in)
t = average wall thickness, mm (in)

Proper excavation, placement, and backfill of buried plastic pipe is crucial to the structural integrity of the system. It is also the riskiest operation, as a leak in the system may not be detected before contamination has occurred. A proper bed, or trench, for the pipe is the initial step in the process. In cold weather areas, underground pipelines should be placed no less than one

[3] ASTM D 2412, Appendices.

Table 5-4
Support Spacing for Schedule 80 PVC Pipe

Nominal Pipe Size, mm (in)	Maximum Support Spacing, m (ft) at Various Temperatures				
	16EC (60EF)	27EC (80EF)	38EC (100EF)	49EC (120EF)	60EC (140EF)*
25 (1)	1.83 (6.0)	1.68 (5.5)	1.52 (5.0)	1.07 (3.5)	0.91 (3.0)
40 (1.5)	1.98 (6.5)	1.83 (6.0)	1.68 (5.5)	1.07 (3.5)	1.07 (3.5)
50 (2)	2.13 (7.0)	1.98 (6.5)	1.83 (6.0)	1.22 (4.0)	1.07 (3.5)
80 (3)	2.44 (8.0)	2.29 (7.5)	2.13 (7.0)	1.37 (4.5)	1.22 (4.0)
100 (4)	2.74 (9.0)	2.59 (8.5)	2.29 (7.5)	1.52 (5.0)	1.37 (4.5)
150 (6)	3.05 (10.0)	2.90 (9.5)	2.74 (9.0)	1.83 (6.0)	1.52 (5.0)
200 (8)	3.35 (11.0)	3.2 (10.5)	2.90 (9.5)	1.98 (6.5)	1.68 (5.5)
250 (10)	3.66 (12.0)	3.35 (11.0)	3.05 (10.0)	2.13 (7.0)	1.83 (6.0)
300 (12)	3.96 (13.0)	3.66 (12.0)	3.2 (10.5)	2.29 (7.5)	1.98 (6.5)
350 (14)	4.11 (13.5)	3.96 (13.0)	3.35 (11.0)	2.44 (8.0)	2.13 (7.0)

Note: The above spacing values are based on test data developed by the manufacturer for the specific product and continuous spans. The piping is insulated and is full of liquid that has a specific gravity of 1.0.
* The use of continuous supports or a change of material (e.g., to CPVC) is recommended at 60EC (140EF).
Source: Harvel Plastics, Product Bulletin 112/401 (rev. 10/1/95), p. 63.

Table 5-5
Support Spacing for Schedule 80 PVDF Pipe

Nominal Pipe Size, mm (in)	Maximum Support Spacing, m (ft) at Various Temperatures			
	20EC (68EF)	40EC (104EF)	60EC (140EF)	80EC (176EF)
25 (1)	1.07 (3.5)	0.91 (3.0)	0.91 (3.0)	0.76 (2.5)
40 (1.5)	1.22 (4.0)	0.91 (3.0)	0.91 (3.0)	0.91 (3.0)
50 (2)	1.37 (4.5)	1.22 (4.0)	0.91 (3.0)	0.91 (3.0)
80 (3)	1.68 (5.5)	1.22 (4.0)	1.22 (4.0)	1.07 (3.5)
100 (4)	1.83 (6.0)	1.52 (5.0)	1.22 (4.0)	1.22 (4.0)
150 (6)	2.13 (7.0)	1.83 (6.0)	1.52 (5.0)	1.37 (4.5)

Note: The above spacing values are based on test data developed by the manufacturer for the specific product and continuous spans. The piping is insulated and is full of liquid that has a specific gravity of 1.0.
Source: Asahi/America, Piping Systems Product Bulletin P-97/A, p. 24.

Table 5-6
Support Spacing for Schedule 80 CPVC Pipe

Nominal Pipe Size, mm (in)	Maximum Support Spacing, m (ft) at Various Temperatures					
	23EC (73EF)	38EC (100EF)	49EC (120EF)	60EC (140EF)	71EC (160EF)	82EC (180EF)
25 (1)	1.83 (6.0)	1.83 (6.0)	1.68 (5.5)	1.52 (5.0)	1.07 (3.5)	0.91 (3.0)
40 (1.5)	2.13 (7.0)	1.98 (6.5)	1.83 (6.0)	1.68 (5.5)	1.07 (3.5)	0.91 (3.0)
50 (2)	2.13 (7.0)	2.13 (7.0)	1.98 (6.5)	1.83 (6.0)	1.22 (4.0)	1.07 (3.5)
80 (3)	2.44 (8.0)	2.44 (8.0)	2.29 (7.5)	2.13 (7.0)	1.37 (4.5)	1.22 (4.0)
100 (4)	2 59 (8.5)	2 59 (8.5)	2 59 (8.5)	2.29 (7.5)	1.52 (5.0)	1.37 (4.5)
150 (6)	3.05 (10.0)	2.90 (9.5)	2.74 (9.0)	2.44 (8.0)	1.68 (5.5)	1.52 (5.0)
200 (8)	3.35 (11.0)	3.20 (10.5)	3.05 (10.0)	2.74 (9.0)	1.83 (6.0)	1.68 (5.5)
250 (10)	3.51 (11.5)	3.35 (11.0)	3.20 (10.5)	2.90 (9.5)	1.98 (6.5)	1.83 (6.0)
300 (12)	3.81 (12.5)	3.66 (12.0)	3.51 (11.5)	3.20 (10.5)	2.29 (7.5)	1.98 (6.5)

Note: The above spacing values are based on test data developed by the manufacturer for the specific product and continuous spans. The piping is insulated and is full of liquid that has a specific gravity of 1.0.
Source: Harvel Plastics, Product Bulletin 112/401 (rev. 10/1/95), p. 63.

Table 5-7
Bedding Factor, K_x

Type of Installation	K_x
Shaped bottom with tamped backfill material placed at the sides of the pipe, 95% Proctor density or greater	0.083
Compacted coarse-grained bedding and backfill material placed at the side of the pipe, 70-100% relative density	0.083
Shaped bottom, moderately compacted backfill material placed at the sides of the pipe, 85-95% Proctor density	0.103
Coarse-grained bedding, lightly compacted backfill material placed at the sides of the pipe, 40-70% relative density	0.103
Flat bottom, loose material placed at the sides of the pipe (not recommended); <35% Proctor density, <40% relative density	0.110

Source: Reprinted from Schweitzer, Corrosion-Resistant Piping Systems, p. 49, by courtesy of Marcel Dekker, Inc.

Table 5-8
Deflection Lag Factor, d_e

Installation Condition	d_e
Burial depth <5 ft. with moderate to high degree of compaction (85% or greater Proctor, ASTM D 698 or 50% or greater relative density ASTM D-2049)	2.0
Burial depth <5 ft. with dumped or slight degree of compaction (Proctor > 85%, relative density > 40%)	1.5
Burial depth >5 ft. with moderate to high degree of compaction	1.5
Burial depth > 5 ft. with dumped or slight degree of compaction	1.25

Source: Reprinted from Schweitzer, Corrosion-Resistant Piping Systems, p. 49, by courtesy of Marcel Dekker, Inc.

Table 5-9
Values of EN Modulus of Soil Reaction for Various Soils

Soil Type and Pipe Bedding Material	EN for Degree of Compaction of Bedding, MPa (lb/ft^2)			
	Dumped	Slight <85% Proctor >40% rel. den.	Moderate 85-95% Proctor 40-70% rel. den.	High >90% Proctor >70% rel. den.
Fine-grained soils (LL >50) with medium to high plasticity CH, MH, CH-MH	No data available - consult a soil engineer or use EN = 0			
Fine-grained soils (LL <50) with medium to no plasticity CL, ML, ML-CL, with <25% coarse-grained particles	0.35 (50)	1.38 (200)	2.76 (400)	6.90 (1000)
Fine-grained soils (LL <50) with no plasticity CL, ML, ML-CL, with >25% coarse-grained particles.	0.69 (100)	2.76 (400)	6.90 (1000)	13.8 (2000)
Coarse-grained soils with fines GM, GC, SM, SC contains >12% fines.	0.69 (100)	2.76 (400)	6.90 (1000)	13.8 (2000)
Coarse-grained soils with little or no fines GW, SW, GP, SP contains <12% fines (or any borderline soil beginning with GM-GC or GC-SC)	1.38 (200)	6.90 (1000)	13.8 (2000)	20.7 (3000)
Crushed rock	6.90 (1000)	20.7 (3000)	20.7 (3000)	20.7 (3000)

Notes: LL = liquid limit
Sources: AWWA C900, Table A.4., p.17.
Schweitzer, Corrosion-Resistant Piping Systems, p. 48, (by courtesy of Marcel Dekker, Inc.).

foot below the frost line. The trench bottom should be relatively flat, and smooth, with no sharp rocks that could damage the pipe material. The pipe should be bedded with a uniformly graded material that will protect the pipe during backfill. Typical installations use an American Association of State Highway Transportation Officials (AASHTO) #8 aggregate, or pea-gravel for six inches below and above the pipe. These materials can be dumped in the trench at approximately 90-95% Proctor without mechanical compaction. The remainder of the trench should be backfilled with earth, or other material appropriate for surface construction, and compacted according to the design specifications.

5-2. Polyvinyl Chloride (PVC)

Polyvinyl chloride (PVC) is the most widely used thermoplastic piping system. PVC is stronger and more rigid than the other thermoplastic materials. When specifying PVC thermoplastic piping systems particular attention must be paid to the high coefficient of expansion-contraction for these materials in addition to effects of temperature extremes on pressure rating, viscoelasticity, tensile creep, ductility, and brittleness.

a. PVC Specifications

PVC pipe is available in sizes ranging from 8 to 400 mm (1/4 to 16 in), in Schedules 40 and 80. Piping shall conform to ASTM D 2464 for Schedule 80 threaded type; ASTM D 2466 for Schedule 40 socket type; or ASTM D 2467 for Schedule 80 socket type.

Maximum allowable pressure ratings decrease with increasing diameter size. To maintain pressures ratings at standard temperatures, PVC is also available in Standard Dimension Ratio (SDR). SDR changes the dimensions of the piping in order to maintain the maximum allowable pressure rating.

b. PVC Installation

For piping larger than 100 mm (4 in) in diameter, threaded fittings should not be used. Instead socket welded or flanged fittings should be specified. If a threaded PVC piping system is used, two choices are available, either use all Schedule 80 piping and fittings, or use Schedule 40 pipe and Schedule 80 threaded fittings. Schedule 40 pipe will not be threaded. Schedule 80 pipe would be specified typically for larger diameter pipes, elevated temperatures, or longer support span spacing. The system is selected based upon the application and design calculations.

The ranking of PVC piping systems from highest to lowest maximum operating pressure is as follows: Schedule 80 pipe socket-welded; Schedule 40 pipe with Schedule 80 fittings, socket-welded; and Schedule 80 pipe threaded. Schedule 40 pipe provides equal pressure rating to threaded Schedule 80, making Schedule 80 threaded uneconomical. In addition, the maximum allowable working pressure of PVC valves is lower than a Schedule 80 threaded piping system.

5-3. Polytetrafluoroethylene (PTFE)

Polytetrafluoroethylene (PTFE) is a very common thermoplastic material used in many other applications in addition to piping systems. PTFE is chemically resistant and has a relatively wide allowable temperature range of -260EC (-436EF) to 260EC (500EF). Furthermore, PTFE has a high impact resistance and a low coefficient of friction and is often considered “self-lubricating.” The most common trade name for PTFE is Teflon, registered trademark of E.I Dupont Company.

5-4. Acrylonitrile-Butadiene-Styrene (ABS)

Acrylonitrile-Butadiene-Styrene (ABS) is a thermoplastic material made with virgin ABS compounds meeting the ASTM requirements of Cell Classification 4-2-2-2-2 (pipe) and 3-2-2-2-2 (fittings). Pipe is available in both solid wall and cellular core wall, which can be used interchangeably. Pipe and fittings are available in size 32 mm (1-1/4 in) through 300 mm (12 in) in diameter. The pipe can be installed above or below grade.

a. ABS Standards

ASTM D 2282 specifies requirements for solid wall ABS pipe. ASTM D 2661 specifies requirements for solid wall pipe for drain, waste, and vents. ASTM F 628 specifies requirements for drain, waste, and vent pipe and fittings with a cellular core. Solid wall ABS fittings conform to ASTM D 2661. The drainage pattern for fittings is specified by ASTM D 3311.

ABS compounds have many different formulations that vary by manufacturer. The properties of the different formulations also vary extensively. ABS shall be specified very carefully and thoroughly because the acceptable use of one compound does not mean that all ABS piping systems are acceptable. Similarly, ABS compositions that are designed for air or gas handling may not be acceptable for liquids handling.

b. ABS Limitations

Pigments are added to the ABS to make pipe and fittings resistant to ultraviolet (UV) radiation degradation. Pipe and fittings specified for buried installations may be exposed to sunlight during construction, however, and prolonged exposure is not advised.

ABS pipe and fittings are combustible materials; however, they may be installed in noncombustible buildings. Most building codes have determined that ABS must be protected at penetrations of walls, floors, ceilings, and fire resistance rated assemblies. The method of protecting the pipe penetration is using a through-penetration protection assembly that has been tested and rated in accordance with ASTM E 814. The important rating is the "F" rating for the through penetration protection assembly. The "F" rating must be a minimum of the hourly rating of the fire resistance rated assembly that the ABS plastic pipe penetrates. Local code interpretations related to through penetrations are verified with the jurisdiction having authority.

5-5. Chlorinated Polyvinyl Chloride (CPVC)

Chlorinated polyvinyl chloride (CPVC) is more highly chlorinated than PVC. CPVC is commonly used for chemical or corrosive services and hot water above 60EC (140EF) and up to 99EC (210EF). CPVC is commercially available in sizes of 8 to 300 mm (1/4 to 12 in) for Schedule 40 and Schedule 80. Exposed CPVC piping should not be pneumatically tested, at any pressure, due to the possibility of personal injury from fragments in the event of pipe failure; see Paragraph 3-8d for further information.

ASTM specifications for CPVC include: ASTM F 437 for Schedule 80 threaded type; ASTM F 439 for Schedule 80 socket type; and ASTM F 438 for Schedule 40 socket type. However, note that Schedule 40 socket may be difficult to procure.

5-6. Polyethylene (PE)

Polyethylene (PE) piping material properties vary as a result of manufacturing processes. Table 5-10 lists the common types of PE, although an ultra high molecular weight type also exists. PE should be protected from ultraviolet radiation by the addition of carbon black as a stabilizer; other types of stabilizers do not protect adequately[4]. PE piping systems are available in sizes ranging from 15 to 750 mm (½ to 30 in). Like PVC, PE piping is available in SDR dimensions to maintain maximum allowable pressure ratings.

5-7. Polypropylene (PP)

Polypropylene (PP) piping materials are similar to PE, containing no chlorine or fluorine. PP piping systems are available in Schedule 40, Schedule 80, and SDR dimensions. With a specific gravity of 0.91, PP piping systems are one of the lightest thermoplastic piping systems.

5-8. Polyvinylidene Fluoride (PVDF)

Polyvinylidene fluoride (PVDF) pipe is available in a diameter range of 15 to 150 mm (½ to 6 in); Schedules 40 and 80; and pressure ratings of 1.03 MPa (150 psig) and 1.59 MPa (230 psig). Use of PVDF with liquids above 49EC (120EF) requires continuous support. Care must be taken in using PVDF piping under suction. PVDF does not degrade in sunlight; therefore, PVDF does not require UV stabilizers or antioxidants. PVDF pipe is chemically resistant to most acids; bases and organics; and can transport liquid or powdered halogens such as chlorine or bromine. PVDF should not be used with strong alkalies, fuming acids, polar solvents, amines, ketones or esters[5]. Trade names for PVDF pipe include Kynar by Elf Atochem, Solef by Solvay, Hylar by Ausimont USA, and Super Pro 230 by Asahi America.

Fusion welding is the preferred method for joining PVDF pipe. Threading can only be accomplished on Schedule 80 pipe.

---

[4] Schweitzer, Corrosion-Resistant Piping System, p. 39.

[5] Ibid., p. 43.

Table 5-10
Polyethylene Designations

Type	Standard	Specific Gravity
Low Density (LDPE)	ASTM D 3350, Type I	0.91 to 0.925
Medium Density (MDPE)	ASTM D 3350, Type II	0.926 to 0.940
High Density (HDPE)	ASTM D 3350, Type III and ASTM D 1248 Type IV	0.941 to 0.959

Source: Compiled by SAIC, 1998