PRESSURE RATINGS OF THERMOPLASTIC FITTINGS

In the engineering of thermoplastic piping systems, it is necessary to have not only a working knowledge of piping design but also an awareness of a number of the unique properties of thermoplastics.

In addition to chemical resistance, important factors to be considered in designing piping systems employing thermoplastics are:

- Pressure ratings.
- Temperature-Pressure relationships.
- Water Hammer.
- Friction-loss characteristics

This article covers pressure-stress performance ratings and measurement only.

DETERMINING PRESSURE-STRESS-PIPE RELATIONSHIPS:

ISO EQUATION

Circumferential stress is the largest stress present in any pressurized piping system. It is this factor that determines the pressure that a section of pipe can withstand. The relationship of stress, pressure, and pipe dimensions is described by the ISO (for International Standardization Organization) Equation. A simplified form of this equation is:

$$S=\frac{P(D_O-1)}{2t}$$

Where:
- P =Internal Pressure, psi
- S =Circumferential Stress, psi
- t =Wall Thickness, inches
- D_O=Outside Pipe Diameter, inches

LONG-TERM STRENGTH

To determine the long-term strength of thermoplastic pipe, lengths of pipe are capped at both ends (see Fig. 1-C) and subjected to various internal pressures to produce circumferential stresses that will produce failure in 10 to 10,000 hours. The test is run according to ASTM D-1598---Standard Test for Time-to-Failure of Plastic Pipe Under Long-Term Hydrostatic Pressure. The resulting failure points are used in a statistical analysis (outlined in ASTM D-2837; see Appendix B) to determine the characteristic regression curve that represents the stress/time-to-failure relationship for the particular thermoplastic pipe compound under test. This curve is represented by the equation:

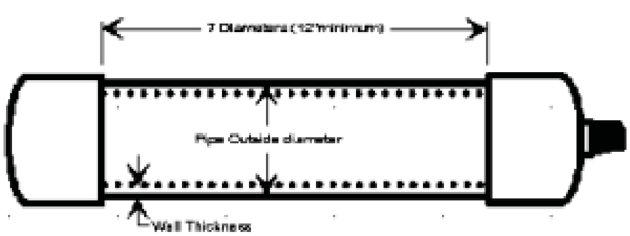
$$\text{Log } T = \alpha + \beta \log S$$

Where: a and b are constants describing the slope and intercept of the curve, and T and S are time-to-failure and circumferential stress, respectively.

The regression curve may be plotted on log paper and extrapolated from 10,000 to 100,000 hours (11.4 years). The stress at 100,000 hours is known as the Hydrostatic Design Basis (HDB) for that particular thermoplastic compound. From the HDB, the Hydrostatic Design Stress (HDS) is easily determined by applying the service factor multiplier, as described below.

Figure 1-C

Long-Term Strength Test per ASTM D-1598



Pipe test specimen per ASTM D-1598 for "Time-to-Failure of Plastic Pipe Under Long-Term Hydrostatic Pressure"

REGRESSION CURVE--STRESS/TIME-TO-FAILURE FOR PVC TYPE I SERVICE FACTOR

The Hydrostatic Stress Committee of the Plastics Pipe Institute (PPI) has determined that a service (design) factor of one-half the Hydrostatic Design Basis would provide an adequate safety margin for use with water to ensure useful plastic-pipe service for a long period of time. While not stated in the standards, it is generally understood within the industry that this "long period of time" is a minimum of 50 years.

Accordingly, the standards for plastic pipe, using the 0.5 service factor, required that the pressure rating of the pipe be based upon this Hydrostatic Design Stress, again calculated with the ISO equation.

While early experience indicated that this service factor (or multiplier of 0.5) provided adequate safety for many if not most uses, some experts felt that a more conservative service factor of 0.4 would better compensate for water hammer pressure surges, as well as for slight manufacturing variations and damage suffered during installation.

The PPI has issued a policy statement officially recommending this 0.4 service factor. This is equivalent to recommending that the pressure rating of the pipe should equal 1.25 times the system design pressure for any particular installation. Based upon this policy, many millions of miles of thermoplastic pipe have been installed in the worldwide without failure.

It is best to consider the actual surge conditions, as outlined later in this section. In addition, substantial reductions in working pressure are advisable when handling aggressive chemical solutions and in high-temperature service.

Numerical relationships for service factors and design stresses of PVC are shown below.
Service Factors and Hydrostatic Design Stress (HDS)*.
Hydrostatic Design Basis equal 4000 psi (27.6 Mpa)

Service Factor HDS

0.5 = 2000 psi (13.8 Mpa)

0.4 = 1600 psi (11 Mpa)

*Material: PVC Type I.

MAXIMUM PRESSURES*

The pressure ratings of thermoplastic pipe represent the maximum allowable operating pressure within a piping system for water at 73 degrees Fahrenheit. (23.4 degrees Celsius) based upon a service factor of 0.5. (See Table 1.)
These are the rated pressures for a number of pipe sizes in PVC/CPVC materials.

TABLE 1

Nominal Size	Schedule 40	Schedule 80	Threaded Schedule 80
½	600	850	425
¾	480	690	345
1	450	630	320
1¼	370	520	260
1½	330	470	240
2	280	400	200
2½	300	420	210
3	260	370	190
4	220	320	160
5	190	290	140
6	180	280	140
8	160	250	120
10	140	230	120
12	130	230	110

*Pressure ratings listed here may have to be reduced when the working fluid is other than water at 73° Fahrenheit.

EXTERNAL PRESSURES

Suction Lines

Polyvinyl chloride (PVC) pipe is frequently specified for situations where external pressures are applied to the pipe, such as in underwater applications. In such applications, the collapse rating of the pipe determines the maximum permissible pressure differential between external and internal pressures.

Table III-C gives these collapse ratings in psi at 73.4°F or 23.4°C for Schedule 80 pipe. Note that for other than room temperatures, the collapse pressures must be adjusted. For temperature correction (derating) factors, (see Table 2) in the discussion of "Temperature-Pressure Relationships." (Schedule 80 pipe only.)

Table 2

Nominal Pipe Size (in.)	Threaded Schedule 80
½	1045
¾	650
1	540
1¼	340
1½	270
2	190
2½	220
3	155
4	115
6	80

Collapse Ratings of TYPE I PVC Pipe at 73.4 degrees Fahrenheit.

Vacuum Service

As is implied by the collapse ratings, PVC pipe is suitable for the vacuum or negative-pressure conditions that are found in many piping applications. Laboratory tests have been conducted on Schedule 80 PVC pipe to determine performance under vacuum and at temperatures beyond recommended operating conditions. Pipe sizes under 6" show no deformation at temperatures to 170 degrees Fahrenheit and 27 inches of mercury vacuum. Above this temperature, failure occurred owing to thread deformation.

Conclusion:

All sizes of Schedule 80 PVC pipe are suitable for vacuum service up to 140 degrees Fahrenheit and 30 inches of mercury vacuum. Solvent-cemented joints are recommended for vacuum applications.