# Thermoplastic Piping Applications for Building Systems– Part 1

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In this first part of a two-part series on thermoplastic piping, we will focus specifically on newer PP-R (Polypropylene Random Copolymer) piping technology that is becoming an ever-popular choice for domestic and hydronic system installations in North America. We will share our opinions, key takeaways, and lessons learned from recent projects.

The Proliferation of Plastic Piping

Plastic piping is not new. It has been used successfully in the building industry for decades. In the commercial market for example, we most commonly see PVC (polyvinyl chloride) and CPVC (chlorinated polyvinyl chloride) for underground plumbing waste and vent piping, specialty waste, and certain domestic water applications. On the residential side, we are seeing more and more plastic piping of various types. Visit any home goods or hardware store and you will find that the plumbing section which was once flush with copper and iron pipe is now dominated by PEX (crosslinked polyethylene piping), PVC, and ABS (Acrylonitrile-Butadiene-Styrene) piping products. Why? Plastic piping is simple to install, cheaper than metal, generally has better corrosion resistance, is safe for potable water, has reliable fitting and joining options, and is light weight for ease of transportation and handling.

*Traditional Commercial Building Pressure System Piping Systems largely include Copper, Steel, and Ductile Iron Piping*

One area where plastic piping has not fully gained ground is in institutional and building hydronic system applications. Traditional hydronic piping systems have mainly included copper, steel, and iron piping largely because most of the available plastic piping materials were limited by both temperature and pressure ratings, could not meet fire and smoke ratings for plenum applications, and could more easily break/shatter due to limited ductility. Those limitations are disappearing - a myriad of newer thermoplastic materials is now readily available in North America that can withstand higher temperatures and pressures while offering many more advantages their metal counterparts.

This article will focus on the PP-R family of thermoplastic piping which is suitable for Chilled Water and Hot Water with wider permissible and continuous operating temperatures ranging from 49°F (-45°C) to 180°F (82°C) with intermittent temperatures up to 203°F (95°C).

Definitions

"Thermoplastic" - a plastic copolymer material that becomes pliable or moldable at a certain elevated temperature and solidifies upon cooling

"Copolymer" – Synthetic molecules (monomers) that are selected for physical properties (e.g. strength, brittleness/plasticity, temperature resistance) and are strung together in a process called copolymerization

"PP-R"– Polypropylene Random Copolymer refers to a unique family of Polypropylene piping (ASTM F2389). For the purposes of this article, PP-R also includes PP-RCT (PP-R with modified crystallinity and temperature resistance) which different manufacturers leverage to offer differing resistance and durability properties. All PP-R family piping features Extruded Pipe and Injection Molded Fittings.

"Pipe or Tube" – Term used interchangeably for this article

General Applications and Common Manufacturers

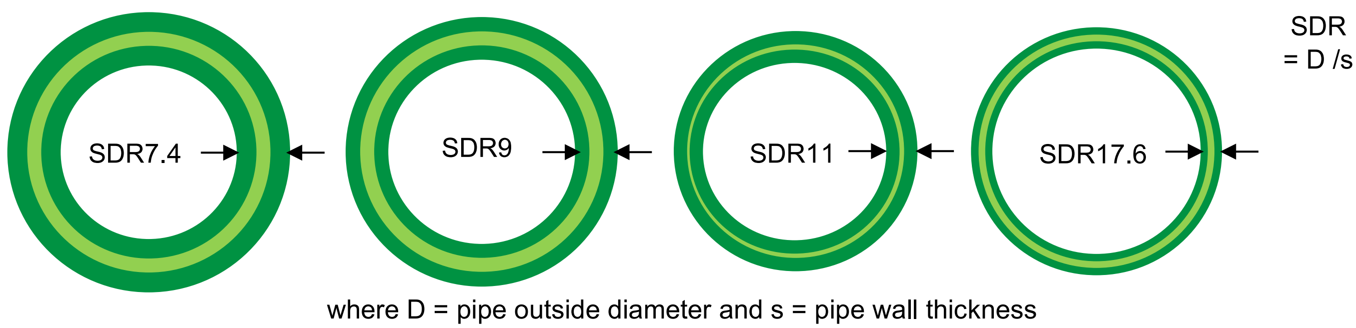
PP-R Products can be used in building systems applications including: Potable Water, Hydronic Systems, Chilled Water Systems, Chemical Feed Lines, Geothermal Systems, Compressed Air and Vacuum Lines, Process Water, Rainwater Collection, Grey and Reclaimed Water

PP-R Products can be installed bare inside of the building in concealed applications, in air plenums (note: insulation required to provide minimum flame and smoke indices), outside of the building (with proper UV protection), and direct buried.

Several PP-R piping system manufacturers that you will find in North America include: Aquatechnik North America, Aquatherm, Asahi/America, NUPI Americas, Pestan, Poloplast, and Teel BQ

Physical Considerations

Unlike traditional copper and steel piping which is inside diameter controlled, PP-R is outside diameter controlled and follows the Standard Dimension Ratio (SDR) criteria.




*Diagrammatic Representation of SDR Criteria*

In general, the heaver the wall thickness, the higher the pressure the pipe can withstand. With a thinner pipe wall, greater flow is realized because the I.D. is larger. Note that PP-R pipe is specified in metric units and is produced to ISO/DIN/DVS pipe standards. Nominal Imperial pipe size equivalents have been assigned for use in the United States:

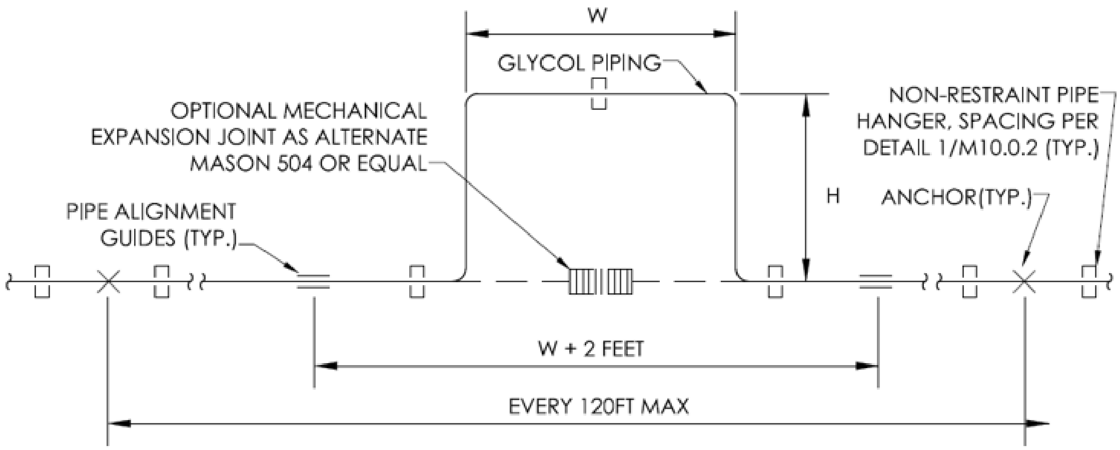
| | | | | |
|---|---|---|---|---|
| 20 mm = ½" | 50 mm = 1 ½" | 125 mm = 4 | 315 mm = 12" | 500 mm = 20" |
| 25 mm = ¾" | 63 mm = 2" | 160 mm = 6" | 355 mm = 14" | 560 mm = 22" |
| 32 mm = 1" | 75 mm = 2 ½" | 200 mm = 8" | 400 mm = 16" | 630 mm = 24" |
| 40 mm = 1 ¼" | 90 mm = 3" | 250 mm = 10" | 450 mm = 18" | |

Principal Challenges in Designing and Installing PP-R Piping Systems

There are two (2) principal challenges to consider during the design and installation of PP-R piping systems:

1. Accommodating Thermal Expansion
2. Working within allowable temperature and pressure ratings

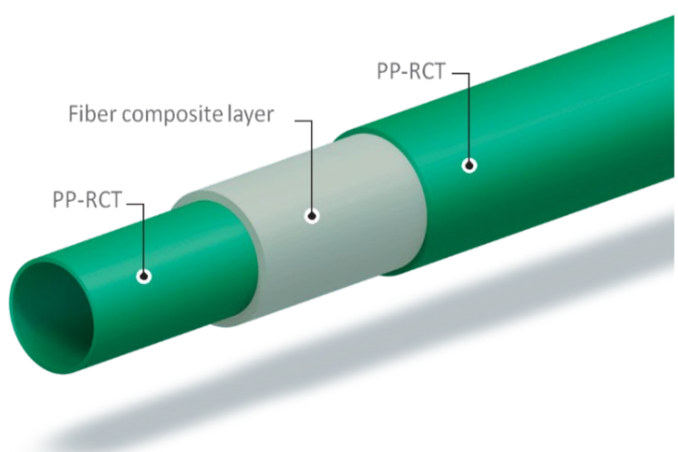
In general, PP-R piping (along with other plastic piping products) have much higher thermal expansion coefficients in comparison to their metal counterparts. Unlike many copper and steel piping systems that can often be installed in a 'floating' or unrestrained fashion, most PP-R piping systems require thermal expansion controls to prevent unwanted damage from thermal expansion: pipe fracture, fitting tear out, cross sectional distortion, kinking, etc. Traditional piping expansion control methods can be used, such as 'U' and 'L' Bends.




*Typical 'U' Bend Thermal Expansion Compensation Assembly Detail*

*Example of Installed 'U' Bend Thermal Expansion Compensation Assembly*

PP-R Pipes can be uniformly extruded or can be of fiber composite construction using co-extrusion technology where the inner and outer layers of the pipe are PP-R and the special fiber composite is coextruded into the Mid-layer. The composite piping construction is very beneficial: Reduces thermal linear expansion and contraction (making it comparable to metals), increases pressure rating and compression strength, affords longer stress times, provides greater stability (increases clamp/hanger distances)




*PPRCT Composite Pipe Construction (courtesy of Pestan)*

In general, uniform wall PP-R pipes are less expensive and are more commonly used for low thermal expansion applications such as domestic cold water and chilled water systems. Applications that require higher fluid temperatures (up to 180F) favor the use of composite layer piping to significantly reduce expansion and benefit from greater allowable pressure ratings.

Pressure and temperature ratings are inversely related in ductile piping systems, both metal and plastic. In general, as piping service temperature requirements increase, the allowable pipe pressure decreases.

PP-R piping is not an option for steam due to high service temperatures; however, most building and district heating low temperature domestic and heating hot water systems are prime candidates for PP-R piping.

| Allowed Pressure (psi) for Service Life of 50+ years | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wall Thickness | SDR7.4 | | SDR9 | | SDR11 | | SDR17.6 |
| Safety Factor | 1.25 | 1.5 | 1.25 | 1.5 | 1.25 | 1.5 | 1.25 (Recommended SF by ISO 15874 & DIN 8077-8078) |
| 50° F | 487 | 406 | 387 | 322 | 308 | 257 | 160 |
| 68° F | 423 | 352 | 335 | 280 | 266 | 222 | 135 |
| 73° F | 400 | 335 | 324 | 270 | 252 | 210 | 133 |
| 86° F | 364 | 303 | 289 | 241 | 230 | 192 | 121 |
| 104° F | 312 | 260 | 248 | 206 | 197 | 164 | 103 |
| 122° F | 265 | 221 | 211 | 176 | 167 | 140 | 88 |
| 140° F | 223 | 186 | 177 | 148 | 141 | 118 | 70 |
| 160° F | 187 | 155 | 147 | 123 | 117 | 97 | 62 |
| 180° F | 100* (149) | 100* (120) | 100* (120) | 100 | 100 | 85 | 50 |

*PP-R Pressure Ratings versus Permissible Service Temperatures - Courtesy of Aquatherm*

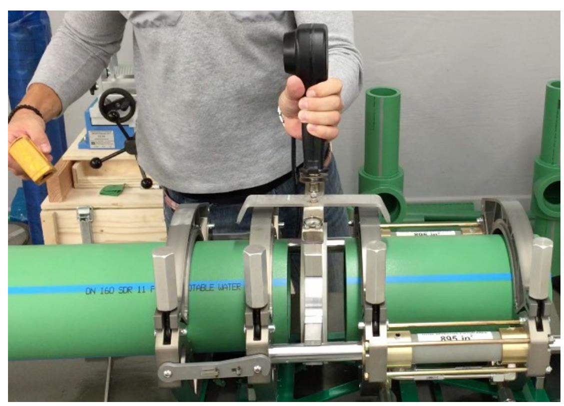
Joint Methodology

Joining PP-R piping and fittings is made by Fusion, Non-Fusion, Electrofusion methods.

Fusion Joints require external pipe face heating equipment to melt the mating surface. Fusion joints include Socket joints (mainly used with 4" or smaller diameters), Butt joints (used for pipes with larger than 4" diameters) and Saddle joints (1:2 ratio, outlets up to 6").

Non-Fusion joints are intended for connections to non-fusion components of the system such as mechanical equipment, valves, different piping materials prefabricated sections, etc. They include a myriad of fittings.

Electrofusion joining is ideally suited for the repair of small/tight space joints where the heating equipment cannot be mounted to make traditional butt and socket joints. Electrofusion fittings have built-in electric heating elements which are used to weld the joint together.



*Making a Thermoplastic Butt Joint - courtesy of McElroy Fusion Equipment*

Advantages and Disadvantages over Traditional Metal Piping Systems

The advantages of a PP-R system (v. traditional metal piping) include the below:

- Lightweight Material in comparison to steel and copper
- Joined with heat fusion which means NO VOC's, Solvents or Glues and no open flames
- Saddle Outlet joints for easy building of manifolds

- Systems can be prefabricated at their shop or jobsite fusion stations which minimizes required overhead work
- Uniform, Clean and Rigid installations
- Easy to Transition to other piping systems, material, or equipment
- Fittings and fusion equipment readily available
- Corrosion resistant / non-scale building surfaces
- Minimal Training Required

*Example of a Non-Fusion fitting that permits transition from PP-R to non-thermoplastic pipe or fitting with threaded connection – courtesy of Pestan*

Naturally, there are also some disadvantages of a PP-R system; they include the below**:**

- Upper limit ~ 180°F(82°C) [which reduces with increased pressure]
- Must account for increased linear expansion and contraction
- Must wrap with insulation for use in air plenums
- Need to rent or purchase tools
- Learning curve for familiarity, sizing, etc.
- Assembly and Repair in tight spaces can be challenging
- More Hangers Required, especially as service temperature increases
- Leadtime for procuring certain PP-R piping products can be longer as most PP-R pipe is produced overseas

*PP-R Electrofusion Coupling - Courtesy of NUPI Americas*

<u>Relative Installed Costs</u>

- < 3" Pipe Size – Similar in cost to steel and copper.
- >3" Pipe Size – More economical to use than steel and copper. Most of the savings is evident in labor costs – Lightweight, do not have to braze or weld

<u>Just Because It Is Offered Does Not Mean You Must Buy It</u>

- PP-R manufacturers have created expansive product lines with proprietary fittings. A prime example would be isolation ball valves that have fusible socket connections. It can be more economical and more practical to purchase standard off-the-shelf ball valves and simply provide the necessary PP-R transitions.
- Specialty pipe hanger systems – there are several pipe hanger manufacturers that tailor their product line to plastic piping systems. From our experience, standard clevis or split ring hangers will work just fine provided you protect the outer pipe wall from gouging that may manifest from pipe expansion during normal startup and seasonal heating/cooling. Gouging can be prevented by simply adding tape or felt linings to hanger pipe-bearing surfaces.

Myth or No Myth?

- Myth - You do not have to insulate PP-R piping because the pipe is self-insulating. It is true that PP-R piping does have relatively thicker walls than metal, and the PP-R material is more insulative in nature. However, most service temperatures (hot or cold) will require supplemental insulation to meet energy standards for allowable heat loss. This goes for buried piping as well. Also keep in mind that for piping that is installed in building areas such as plenums will require insulation to meet flame and smoke requirements.

Lessons Learned

- Do not skimp on system flushing before startup
- Use bypasses to flush around equipment

Plastic shavings will manifest in plastic piping systems due to pipe cutting and drilling for branch circuit socket fittings and joints. We find that traditional flushing is insufficient to remove most plastic pipe debris. Require that all fittings with strainers and cartridges (such as thermostatic mixing valves) be inspected and cleaned post system flush. Such considerations should also be made when modifying existing installations.


*Residual plastic slivers and chips will clog fittings/devices if not properly removed*

- Follow temperature and pressure guidelines closely
- Make sure you have over-temp safeties built-in

PP-R Plastic piping has a narrower operational temperature and pressure band than comparative metal systems. For heating applications, be sure to include digital temperature and pressure limits with hard-wired safeties to prevent overtempt/overpressure excursions that may manifest due operator or system error, leaking heat exchanger valves, etc. Failures can be localized or can be pervasive depending on the severity of an over temperature event. Protect your assets.

*Example of a PP-R Pipe Failure due to prolonged overtemperature*

Summary

There is nothing wrong with specifying and installing traditional steel and copper piping for use in hydronic systems – they are tried and true and remain the design and specification standard/preference for many institutions. However, developments in thermoplastic piping technology make PP-R a legitimate alternative. This is largely since PP-R can meet most domestic and hydronic system temperature and pressure requirements while offering many other advantages (labor cost, chemical resistance, etc.).

Up Next - In Part 2 of this series on thermoplastic piping, we will focus on HDPE (High Density Polyethylene) piping with a specific emphasis on District Heating and Cooling systems and implementing Directional Boring Technology.

Additional PP-R Piping Resources
Plastics Pipe Institute - https://plasticpipe.org/
Aquatechnik America - https://www.aquatechnikna.com/
Aquatherm - https://aquatherm.com/
Asahi/America - https://www.asahi-america.com/
NUPI Americas - https://www.nupiamericas.com/
Pestan - http://www.pestanpipes.com/
Poloplast - https://poloplast.us/
Teel BQ America - https://www.teelbqamericas.com/

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