



REDUCING VULNERABILITY TO AQUATHERM FAILURES

Aquatherm™ piping is a relatively new entry as a plumbing pipe material in the United States. It was first introduced in Europe several decades ago and seems to have performed well there. Aquatherm pipes and couplings are made from PPR, a (polypropylene-random copolymer), similar to plastics labeled with a No. 5 recyclability. While generally considered adequate for many plumbing applications, recent high-profile failures have attracted the attention of building owners who have installed this product. There appear to be severable conditions that, when acting together, form the “witches brew” that may cause the pipes to fail prematurely.

The purpose of this article is to identify what has been learned from Aquatherm failures and to provide building owners with a set of guidelines to inspect, maintain, repair, or replace their Aquatherm systems as needed. This is especially important where difficulty is encountered making a warranty claim with Aquatherm – an owner may seek to repair what can be repaired while maintaining operations. This is only a quick overview that may help the owner engage the right professionals to lead a more detailed analysis.

The Witches Brew

PPR is a simple molecule comprised of Carbon and Hydrogen. Aquatherm includes plastic stabilizers meant to resist oxidation and chemical attack. The ultimate cause of failures is often marked by a breakdown in these stabilizers. The witches brew is a set of conditions that, when combined, may increase the likelihood of premature failures by breaking down the chemical stabilizers. Therefore, removing any one or more of the following conditions may prolong the useful life of an existing system.

1. Water chemistry: chlorine, copper ions, and other ingredients
2. Unit-strut clamps: over-tightening clamps that can deform the material may introduce stresses that can make the material more vulnerable to failure.
3. Max operating temperature of PPR is 180F. The closer you get to the temperature limit, the greater the contribution of temperature may be to a failure.
4. The pressure limits of PPR varies with temperature. The closer you get to these limits, the greater the contribution of pressure may be to a failure.
5. Mixed Systems: If you have a mixed system with copper upstream, or copper heat exchangers in your boilers, the probability of failure may increase.



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6. Retrofitting: PPR may not be a direct replacement for other piping materials without design considerations for specific hydraulic conditions.

**The following is an overview of a complex topic so please consult a licensed engineer before making any major changes to your system.*

Water Chemistry:

Both chlorine and ionized copper are known to attack the stabilizers in PPR. As such, copper, oxygen, chlorine, carbon, plus elevated temperatures together can create a fairly reactive mixture. The stabilizers in PPR are meant to inhibit this reactivity unless they are broken down. Corrosion in PPR may begin in a small area, then increasing in size and frequency throughout the interior of the pipe. In other areas, corrosion begins with a widespread breakdown forming a rough or powdery surface inside the pipe. A thorough panel of water tests under normal operating conditions is the recommended practice when initiating an Aquatherm vulnerability study.

Uni-Strut Clamps

In early advertisements, Aquatherm vendors often made the claim that their product can accommodate all US clamping systems for plumbing if properly sized. However, Aquatherm is supplied in metric sizes only and the wall thickness of Aquatherm is much greater than other materials. This requires that a conversion must be made between metric and imperial sizes, and again between outside diameters for vs. inside diameter specifications. The potential for confusion is problematic.

Uni-strut clamps are among the most common plumbing clamp. They are tightened with a mechanical screw that can easily deform the plastic pipe – most job sites use power tools with little human feel. There are no specifications provided for torque, grip strength or deformation limits on the material. The resulting strain may (like the stretching of a rubber band) create small cracks which may then propagate under an attack on the stabilizers by reactive water chemistry.

Multiple failures have occurred at the clamp and cracking has been observed where clamp deformations were present. A quick external inspection would be able to identify this condition and the owner's plumber should consider backing off the clamp so that strain is relaxed.



Operating temperature:

The ultimate service limits of the PPR pipe are defined in terms of temperature and pressure loads. The higher the temperature, the lower the pressure rating, etc. There is a precipitous drop-off in performance at the upper end of the temperature range. For example: at 160 degrees, the max pressure is 120 psi. At 180 degrees, the max pressure is 100 psi. But at 200 degrees, the max pressure is only 45 psi. However, when mixed with aggressive water and mechanical strain, adverse effects may come at lower temperatures. For example, widespread pressure induced hoop stress at elevated temperature may be responsible for uniform oxidation in some segments, whereas spot corrosion may be seen at clamps and adverse hydraulic conditions. The furnace is another consideration: multiple heater units operating in series or parallel must be balanced for the appropriate temperatures and set points. An experienced mechanical engineer should be consulted.

Operating Pressure:

Similar to temperature, operating pressures may contribute to the witch's brew through hoop stress, static head, dynamic pressure near pumps, valves, transitions, water velocity, etc. Pressure spikes can occur either by water hammers or cavitation. Many of these impacts are difficult to see without expensive measurement and analysis. For this reason, keeping the temperature and pressure well below operating limits is recommended. For more complex systems, designs should be developed specific to the use of PPR rather than retrofit into a design developed for metal or other materials.

Copper in system:

Aquatherm has verified that the presence of copper ions in the fluid may be associated with breakdown of stabilizers. In general, a simple copper pipe conveying water within its operating limits is not likely a problem. However, copper that is actively corroding upstream would be a deeper concern. Copper corrosion is caused by many factors that can complicate analysis. Erosion corrosion, electrolysis, aggressive water chemistry, grounding, bonding, EMI, are all known or suspected failure modes for copper which may result in PPR damage downstream. It is likely best practice to avoid copper in the PPR piping system wherever possible. When copper is unavoidable, make certain that the conditions are suitable for the limitations of *both* the copper and the PPR pipe.



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System Design:

A system that was designed for copper, PEX, or other materials may not be perfectly suited for Aquatherm – a direct substitution of materials should be approached with caution. Many building specifications may specify a copper system, yet approve substitute / alternate materials. Complex buildings such as high-rise, or multi-family residential facilities should be reviewed systemically for Aquatherm applicability. Complex buildings may have integrated systems such as riser clamping requirements spanning several floors, multiple boilers, pressure reduction valves, recirculation pumps, balancing valves, and electronic controls. In these cases, it may be more difficult to predict where system vulnerabilities may be mitigated.

Conclusion:

CoEngineers, PLLC has worked with successful Aquatherm installations and has investigated failing systems. While there is no sure-fire way to eliminate all risk, there seems to be enough known about Aquatherm to likely reduce the potency of the “witches brew” and thus the probability of failures. It is important that owners are proactive in reviewing vulnerability to failure so that they may take advantage of simple ways to mitigate contributing factors where appropriate. Once the corrosion begins, the system is effectively compromised.

Respectfully submitted



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Nothing in this article is meant as professional engineering advice. The factors considered herein are not meant to be a complete catalog of all possible failure modes. Likewise, no guarantee of non-failure is implied by following these guidelines. Information herein is not meant to replace or contradict Aquatherm manufacturers specifications and warranty conditions. As with all high-consequence risks, it is important that owners consult a qualified mechanical engineering (MEP) or architectural firm with no inherent bias and direct experience in both successful and failed installations of this and alternative piping products.