Digital Technology – the Next Generation of Water Mixing

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When a nurse's aide prepares to bathe an elderly hospital patient or a hotel guest steps into a shower, neither stops to think about water-mixing technology or whether the water they will use might cause injury.

For engineers who design plumbing systems and the facility managers responsible for them, the situation is very different.

Engineers must understand how water temperature is regulated throughout a building and specify the most appropriate water-mixing solution for any given job. That requires familiarity with all the options for protecting building occupants from the risks of water stored and delivered at unsafe temperatures.

Facility managers also need to know how plumbing systems work. They can reap significant benefits from a solution that provides tight control over hot water delivery and access to the system data needed to manage it. In addition, they need to understand how water-mixing solutions vary, in terms of ease of installation, use, and maintenance.

This paper compares the two water-mixing options available to plumbing engineers and facility managers: the more traditional mechanical technology and the more advanced digital water mixing technology. The focus is on requirements for healthcare, hospitality, educational, correctional, office, and other commercial and institutional facilities.

Why controlling water temperature is critical

Much is at stake in controlling water temperature in a commercial or institutional facility.

- Today more people than ever are living or staying in very large facilities. Regardless of the challenges, they expect to have access to safe hot water whenever they need it.

- Serious risks, such as Legionella growth, scalding, and thermal shock, are associated with mismanaged water temperature. Legionella bacteria are destroyed almost instantly at water temperatures above 160°F, but at temperatures between 70°F and 115°F, their growth is abundant.[1] Uncontrolled and unmonitored water distribution systems can create high-temperature

[1] "Preventing Legionnaires' Disease in Building Services," *CIBSE (Chartered Institution of Building Services Engineers) Journal,* http://www.cibsejournal.com/cpd/modules/2012-07/, July 2012.

scalding hazards in bathtubs, sinks and showers. The severity of scalding injuries depends on the temperature of the hot water and duration of the exposure.[2]

- According to the Centers for Disease Control, every year between 8,000 and 18,000 people in the U.S. are hospitalized with Legionnaire's disease[3] (which results from the Legionella virus). Likewise, every year thousands of scald burns occur.[4]

- Plumbing engineers and facility managers are responsible for designing and managing systems that provide water in a safe, consistent way. To meet those requirements, plumbing systems must store and consistently deliver water at temperatures that mitigate risk to building occupants.

- Many Green Building rating systems deal specifically with water conservation. The new USGBC LEED® v4 Integrative Process addresses sustainable design, construction, and on-going operations at the onset of a project. To attain credits for that LEED process, an engineer must create a preliminary water and energy budget. One of the basic requirements of adhering to such a budget would be a way to precisely control water temperature.

The traditional approach to water mixing

Today, the most widely employed approach to managing hot water delivery uses mechanical technologies. Mechanical thermostatic mixing valves (TMVs) mix hot and cold water to provide mixed water at a stabilized temperature, compensating for temperature variations.

Throughout the 20th century, water mixing technology, used to regulate water temperatures in a plumbing system, evolved at a relatively slow pace.

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[2] "Understanding Potential Water Heater Scald Hazards," *American Society of Sanitary Engineering (ASSE) Scald Awareness Task Group,* http://www.asse-plumbing.org/WaterHeaterScaldHazards.pdf, March 2012.
[3] "Legionella (Legionnaires" Disease and Pontiac Fever)," *Centers for Disease Control and Prevention*, October 21, 2015, http://www.cdc.gov/legionella/about/history.html.
[4] "Safety Facts on Scald Burns," *The Burn Foundation,* October 20, 2015, http://www.burnfoundation.org/programs/resource.cfm?c=1&a=3

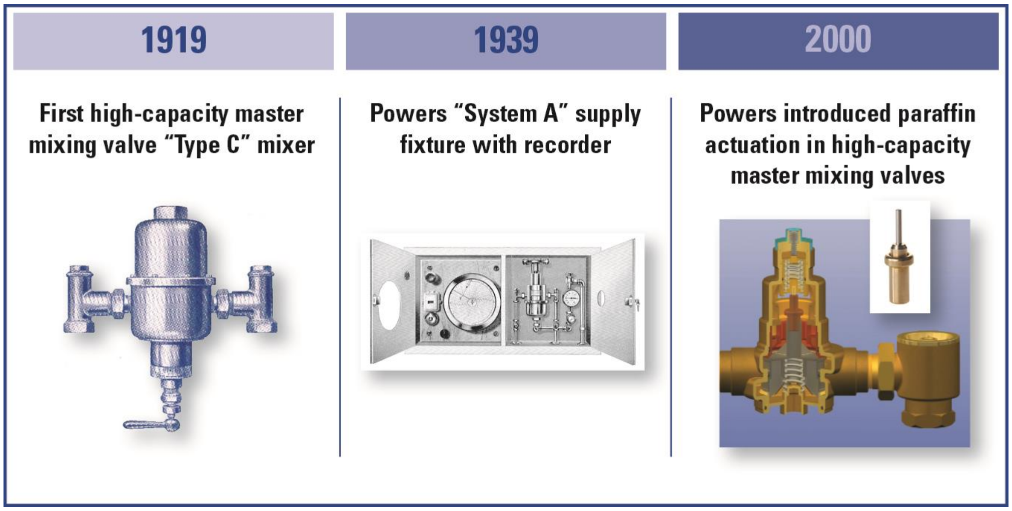
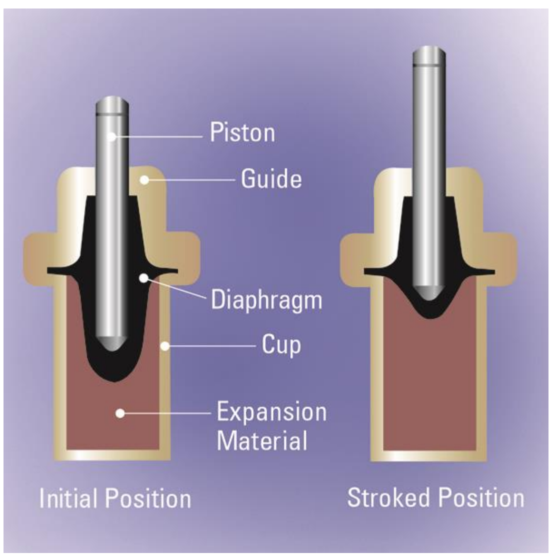


Figure 1 – The Evolution of Mechanical Mixing

The first high-capacity master mixing valve was developed around 1919. Twenty years later, capability for recording temperature over time was added. At the end of the last century, Powers became the first company to use paraffin actuation in high-capacity master mixing valves and systems. Since then, paraffin actuation has been accepted as the most effective way to regulate water temperature.



The temperature within a mixing valve is affected by fluctuations in the inlet water temperature and pressure. Heat is transferred through the walls of the sensor and passed to the media. In the example in Figure 2, that media is paraffin. Ether can also be utilized, and some valve manufacturers use a bimetal coil.[5]

Figure 2 – How TMVs Work

[5] Scott Tibbitts, "High Output Paraffin Actuators: Utilization in Aerospace Mechanisms," *NASA Technical Reports Server*, May 1, 1988.

The different media – paraffin, ether and bimetal – essentially work the same way. The transfer expands the media and changes the ratio of hot to cold water. As the temperature gets warmer, the piston (shown in Figure 3) moves up, closing off the hot water and opening the cold to maintain the setpoint temperature.

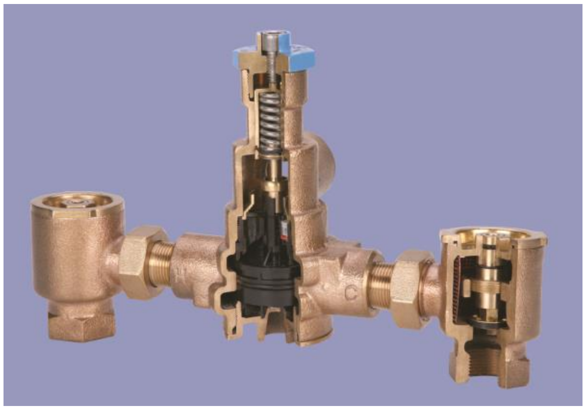


Figure 3 – Cross-section view of a TMV

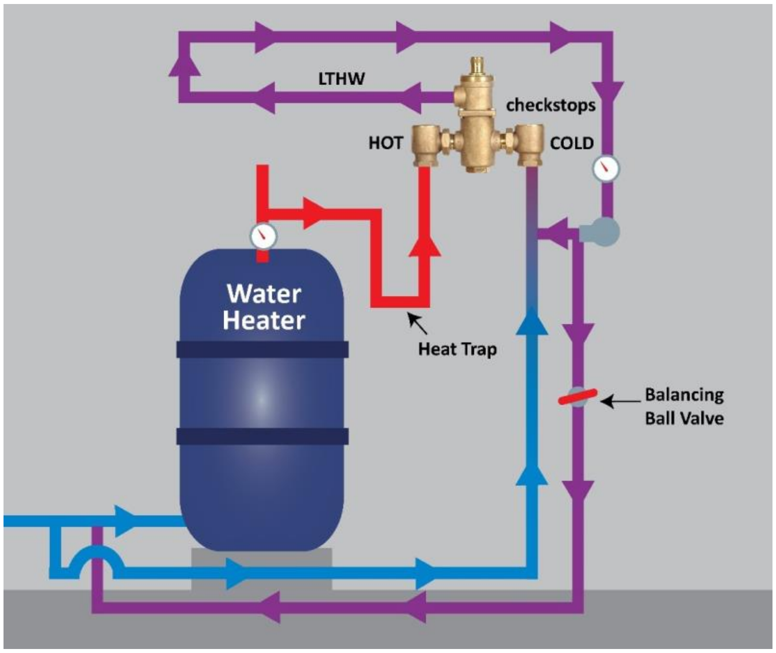


Figure 4 – A thermostatic mixing valve in a plumbing system

TMV requirements

For TMVs to work correctly, the system must be properly designed and balanced. TMVs work most effectively under ideal conditions, for example, with equal inlet supply pressures or when there is no more than a 20% pressure differential across the inlets.

Several characteristics of TMVs determine how well they can meet the demands of different applications: For example, TMVs:

- are subject to temperature creep in low- or no-demand periods, typically overnight
- require checks and regular maintenance to avoid performance problems
- tend to be more susceptible to problems caused by water chemistry because the actuator operates in the water
- may experience performance issues related to flow rates and valve sizing (Because larger valves handling lower flow rates can have difficulty controlling temperature TMVs need to be sized properly.)
- cannot communicate through a building automation system

A newer, smart approach
Digital water mixing represents a significant leap in the technology used to control hot water delivery. This approach incorporates a programmable valve or system to process temperature, flow, and pressure data, which is obtained from the hot and cold water inlets, mixed outlet, and sensors on the mixed-water return. High-speed electronic actuation modulates a simple ball valve that allows the setpoint to be maintained.

Digital technology is very fast and responsive. It enables collection of a large amount of data, which can be communicated through a building automation system (BAS) or locally, at the controller, providing intelligence at the foundation of the entire plumbing system.

Energy conservation with digital technology
A look at how mechanical and digital water-mixing technologies handle the plumbing system sanitization process illustrates how smart technology helps manage energy use.

In mechanical mixing, a critical factor is approach temperature. It can vary by valve design and technology, anywhere from 5°F to more than 25°F. Approach temperature determines the highest mixed-outlet temperature achievable based on hot water inlet temperature. For example, with a hot water inlet temperature of 120°F at a 20°F approach, the maximum temperature of mixed water that could come out of the valve would be 100°F.

120°F - 20°F = 100°F

With a 5°F approach, only 105°F (vs. 120°F) incoming hot water would be required to attain a 100°F outlet temperature.

105°F - 5°F = 100°F

Because of the positive close-off of the cold water port with digital mixing technology, the full inlet hot water temperature can be obtained on the mixed-outlet side. To achieve a mixed-outlet temperature of 140°F, incoming hot water would only have to be 140°F.

Plumbing system sanitization is a process that is particularly important in healthcare facilities such as hospitals and assisted living facilities, where it is used as part of a broader infection control effort. For a high-temperature sanitization setpoint of 160°F (the temperature at which Legionella bacteria are destroyed), a hot water supply of 160°F would be needed.

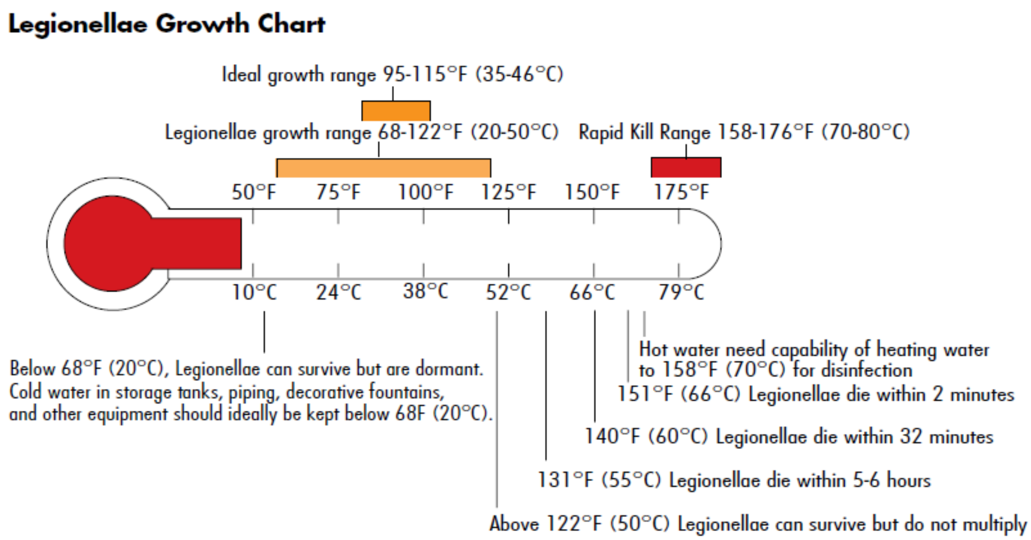


Figure 5 – How Legionella bacteria are affected by temperature

Using a mechanical valve, depending on the design and the technology, the hot water supply would need to be as hot as185°F to ensure that water temperatures would be maintained at 160°F throughout the system. The digital mixing approach, with its much lower temperature requirements, is significantly more energy efficient. In addition, when the process is complete, the TMV outlet temperature has to be re-set and the system re-balanced. With digital technology, the re-setting and re-balancing occur automatically.

Mechanical Mixing	Digital Mixing
The hot water supply must exceed the sanitization temperature setpoint by *5°F to 25°F*	**The hot water supply equals the sanitization temperature setpoint**
With a 160°F sanitization setpoint, a hot water supply of *185°F* may be needed	**With a 160°F sanitization setpoint, a hot water supply of *160°F* is needed**
Risk of having to re-set and re-balance the entire system after the sanitization procedure	**After the sanitization procedure, the system is re-set and re-balanced automatically**

Figure 6 – TMVs' requirements to support the sanitization process at the point of supply

Digital approach exceeds code requirements

The ASSE 1017-2009 standard governs performance for large hot water distribution valves. For larger valves with flow rates of more than 40 gallons per minute, the standard requires that they hold to +/-7°F from the setpoint. Thus if the setpoint is 140°F, the valve must remain within 133°F to 147°F, a 14°F range. Digital mixing technology can deliver much more precise control and hold the setpoint to within +/- 2°F. That is well within the range the ASSE 1017 standard requires. A digital water-mixing system's sensors sample and report temperature ten times per second.

Managers of healthcare and education facilities must protect all occupants of their facilities, particularly people at high risk for water-temperature-related injuries. The elderly and the very young, for example, as well as individuals with limited or undeveloped physical skills and diminished emotional or mental capacity are at a higher risk of scalding. In addition, facility managers need maintain water temperatures that will limit the growth of Legionella and thus mitigate the risk of Legionnaire's disease. Digital water-mixing technology helps them meet those requirements by more precisely and efficiently managing water temperatures in their plumbing systems. As a result, the technology promotes a safer environment, not only for the most vulnerable populations but for all building occupants, including patients, students, employees, and visitors.

Summary
Thermostatic mixing works effectively in many applications. As more demands are placed on water tempering, however, especially by buildings with large populations, a more sophisticated approach is needed. Digital mixing provides a number of advantages.

- +/-2°F temperature control, possible even during low and zero demand periods, provides significantly more control than mechanical valves afford. This level of precision enables the efficient management of plumbing systems and promotes building safety.

- A digital mixing system can be integrated with a building automation system (BAS) to allow facility managers to remotely monitor and control water temperatures in a commercial or institutional building. The result is integrated building management.

- Digital systems provide the potential for conserving energy and reducing energy costs. One system, for example, measures mixed-outlet, return flow, and temperature, and can calculate the energy consumed to heat water. It displays energy consumption data in therms, BTUs, gigajoules, and kilowatts.

- Sophisticated communications capability allows for close system monitoring and control, providing facility managers the ability to track and react to changes as a way to ensure the safety of building occupants.

- With a Sanitization Mode, a digital water mixing system enables high-temperature purges, providing a way to mitigate the risks of associated with Legionella and other water-borne bacteria.[6] ANSI/ASHRAE standard 188-2015, *Legionellosis: Risk Management for Building Water Systems,* provides best practices on limiting and responding to the occurrence of Legionella.

[6] Karlyn D. Beer, PhD et al., "Surveillance for Waterborne Disease Outbreaks Associated with Drinking Water – United States, 2011-2012," Centers for Disease Control and Prevention's *Morbidity and Mortality Report (MMWR)*, August 14, 2015.

Digital Water Mixing Benefits

- Enhanced, more precise control of a hot water delivery system (avoiding temperature creep)
- Greater access to system data
- Advanced communications and integration with a building automation system (BAS)
- Increased ability to mitigate Legionella growth and the risk of scalding and thermal shock
- Safer water for occupants of commercial and institution facilities

In short, digital water mixing provides significant advantages for plumbing engineers who design plumbing systems, as well as for the facility owner and manager who use them to control and monitor hot water. They should consider the five major benefits of a digital mixing system when planning for a new project or scoping out a renovation in a commercial or institutional facility.

The Powers Solution

Since 1891, Powers, a Watts Water Technologies company, has provided distribution, point-of-use, and emergency water-mixing and temperature solutions used in residential, commercial, and institutional applications. Its T/P technology provides superior protection against temperature and pressure changes. In 1924, Powers developed the first modern pressure balance valve, enhancing bather safety and comfort as modern plumbing evolved.

The company's digital mixing solution is the Powers IntelliStation™, a smart mixing and recirculation system for domestic hot water. It provides the precise control and insight into a plumbing system needed by commercial and institutional facilities such as healthcare facilities, hotels, educational institutions, and correctional facilities.

Integrated into a building automation system (BAS), the IntelliStation allows facility managers to remotely monitor and control water temperatures to provide safe, efficient hot water delivery. In addition, the IntelliStation provides features that ease installation, repair, and system maintenance.

Learn more at www.PowersControls.com/intellistation.

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