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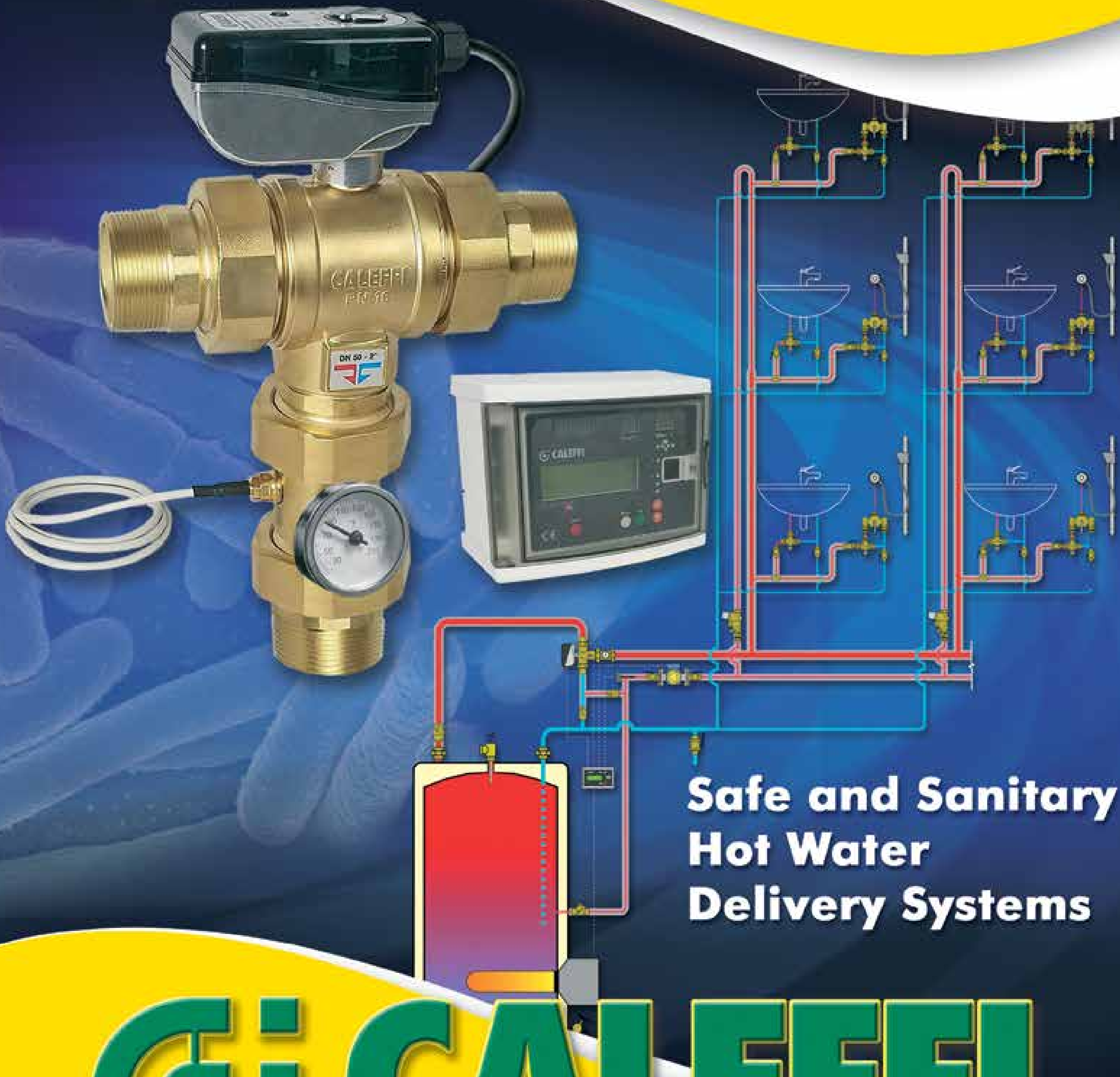
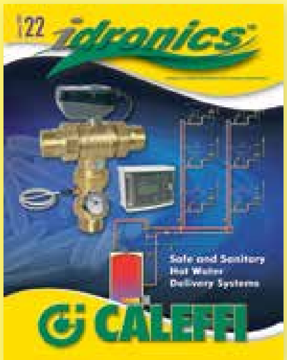


Safe and Sanitary Hot Water Delivery Systems

CALEFFI



A Technical Journal
from
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Dear Plumbing and Hydronic Professional,

We could have titled this *idronics* issue "Safe Domestic Hot Water Delivery Systems". But with growing incidences of water contamination and related problems such as Legionnaires' disease, we thought to include Sanitary to add emphasis on factors other than the one most commonly associated with safe domestic hot water — burn protection.

This issue of *idronics* focuses on methods and hardware for controlling temperature in domestic hot water delivery systems. It describes temperature-based disinfection for minimizing the potential for biological contamination. It also discusses ways to ensure that the water supplied from fixtures will not cause burns.

We hope you enjoy this issue of *idronics* and encourage you to send us any feedback by e-mailing us at idronics@caleffi.com.

For prior issues, please visit us at www.caleffi.us and click on the idronics icon to download the PDF files. You can also register to receive hard copies of future issues.

Mark Olson

Mark Olson

General Manager & CEO

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Safe and Sanitary Hot Water Delivery Systems

1. INTRODUCTION

Most North American buildings require domestic hot water (DHW) service. That water must be delivered to fixtures and appliances at a consistent, safe and suitable temperature. It also needs to be protected against potential biological or chemical contamination. Providing ample domestic hot water that is safe and sanitary is one of the most important responsibilities of plumbing system designers.

In many regions of North America, the chemical and biologic quality of domestic water is maintained by municipal water utilities. In buildings with private wells, water quality is maintained by on-site equipment that filters out sediments and extracts unwanted chemicals, such as sulfur, iron or calcium compounds.

Figure 1-1a-b

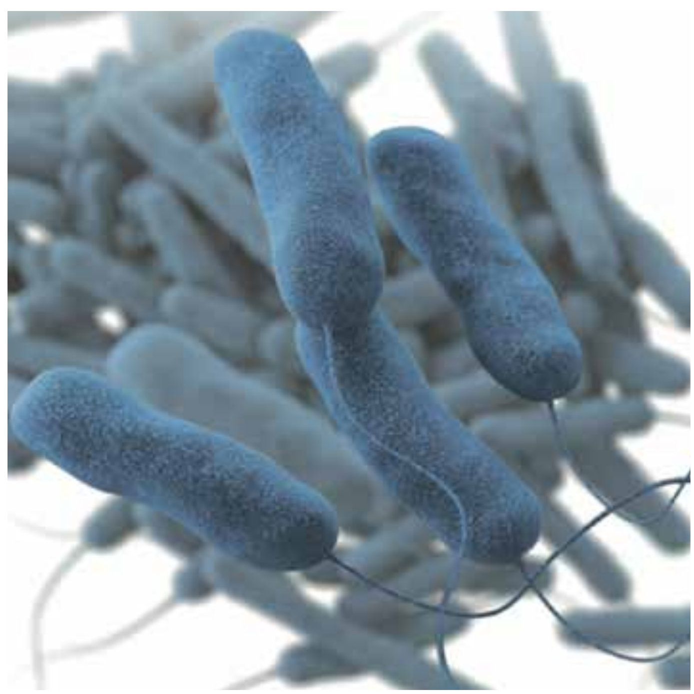
Although municipal water treatment, as well as on-site treatment for sediment and water hardness, improve the quality of all domestic water supplied to a building, *these processes cannot ensure that undesirable biological growth will not occur in the heated portion of building domestic plumbing systems.* Maintaining a minimal level of biological activity in that portion of the system requires additional measures, such as chemical injection, ultraviolet light treatment or thermal disinfection.

Municipal or private water treatment systems also do not play a role in ensuring that domestic hot water is delivered to fixtures at safe and consistent temperatures.

This issue of *idronics* focuses on temperature control in domestic hot water plumbing systems. It describes temperature-based disinfection for minimizing the potential for biological contamination.

It also discusses ways to ensure that the water supplied from fixtures will not cause burns. The methods and hardware required for both objectives can be coordinated to ensure safe delivery of domestic hot water under all conditions.

Figure 1-2



Legionella bacteria, Source CDC

2. TEMPERATURE-RELATED ISSUE IN DHW SYSTEMS

The temperature at which domestic hot water is distributed through building plumbing systems can have profound implications on human health and safety. The DHW must be at a temperature that is appropriate for the intended use. For example, when hot water is used for washing and sanitizing food processing equipment, its minimum temperature is often mandated by law. In the U.S., the Food and Drug Administration typically requires a minimum water temperature of 180ºF for such purposes. Commercial or institutional laundry facilities typically require domestic hot water at temperatures ranging from 140 to 160ºF. The water supplied to patient rooms in hospitals or long-term health care facilities is also governed by law, and typically limited to 110ºF.

The temperature of domestic water also impacts the ability of undesirable and potentially dangerous microorganisms to survive and multiply. Water delivery temperatures that are typically acceptable and comfortable for skin contact range from 100 to 120ºF. However, this temperature range is also conducive to growth of certain microbes, most notably Legionella bacteria.

This section discusses the basics of burn protection and Legionella control. Later sections describe specific hardware that can be used to achieve the water temperatures necessary for safe and sanitary delivery of domestic hot water.

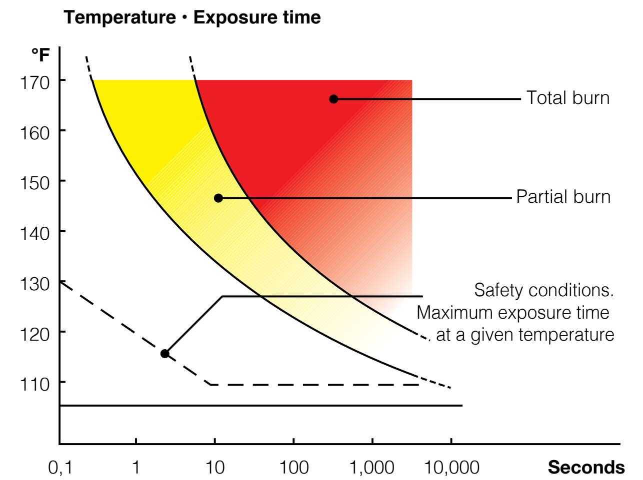
BURN PROTECTION:

One of the greatest potential hazards associated with domestic hot water systems is the risk of moderate to severe burns when skin is exposed to water at high temperatures in sinks, showers, bathtubs or other fixtures.

Figure 2-1

The ability of hot water to burn human skin depends on its temperature and exposure time. It also depends on age. Children's skin is more vulnerable to rapid burns from overly heated water. The higher the water temperature, the shorter the time required to produce a burn of a given severity. Figure 2-2 shows how burn severity of adult skin is affected by water temperature and exposure time.

Figure 2-2



While it may seem intuitive to never set the temperature controls that regulate domestic water heating above a maximum safe temperature, such as 110ºF, there are circumstances where this is not possible.

For example, the DHW systems in restaurants or other facilities involved in food handling or preparation may require water temperatures of 180ºF to ensure disinfection occurs in dishwashing or cleaning of other food-processing equipment. However, if domestic hot water is supplied to a washroom lavatory in that same building, and the hot water supply piping to that lavatory is simply teed into the higher-temperature hot water supply piping, scalding hot water will be delivered to the lavatory faucet. *The potential for serious burns, as well as subsequent legal action by those affected, represents a major liability to the building owner.* Prudence requires that such situations are not inadvertently created, and that existing situations with such piping be corrected as soon as possible.

The low-cost, mass-produced mechanical thermostatic devices that control energy input to most tank-type water heaters do not provide precise adjustment of the water temperature leaving that device. Some do not have

Figure 2-3

specific temperature settings printed on their adjustment dials. Subjective labels such as "hot," "warm," or "vacation," do not allow those adjusting the water heater to make accurate settings to predetermined temperatures. Tank thermostats that do have temperatures printed on their thermostat dials often produce leaving water temperatures that are significantly different from the dial setting. A 10ºF difference in outlet water temperature could make the difference between safe delivery of domestic hot water and the potential for a serious burn.

Figure 2-4

Most water heaters also provide *easy access* to temperature regulating controls. These controls are readily accessible on most gas-fired water heaters, as seen in Figure 2-4. A screwdriver is usually the only tool required for making thermostat adjustments on electric water heaters. This creates the potential for "unauthorized" tampering, and a subsequent major change in delivered water temperature to other occupants of the building, especially if multiple dwelling units are served from a common water heater.

Adjusting the water heater thermostat to a higher-temperature setting is often the perceived solution for inadequate DHW delivery, especially when occupants are unsatisfied with the water heater's performance following a period of high demand. While increasing the temperature setting of the water heater does store more heat in the tank, and thus, makes longer DHW draws possible, it is often done without installation of suitable temperature-limiting devices between the water heater and fixtures.

Figure 2-5

It may also seem intuitive that those using a fixture receiving overly heated water would *quickly adjust* the flow of hot versus cold water to achieve a safe mixed temperature. This approach was used for decades in thousands of buildings, and is still the only method of water-temperature control at many fixtures. However, the reaction time and lack of caution of young children and elderly adults may not be adequate to prevent scalding hot water from causing burns, especially when that water is drawn from unfamiliar fixtures at hotels, restaurants or other commercial/recreational facilities.

Another possibility is hot water provided from heat sources such as solar thermal collectors or biomass boiler systems that can operate over a wide range of temperatures. Domestic hot water supplied directly from a solar thermal system could be at 110ºF one day, and perhaps 170ºF by the end of the following sunny day. Similarly, the water temperature supplied by a heat exchanger in a thermal storage tank connected to a wood-fired boiler could vary considerably depending on how that boiler is operated.

Figure 2-6

For these reasons it is essential to provide accurate and reliable temperature protection between any source of domestic hot water and fixtures where that water will come in contact with skin. The consequences of serious and possibly irreversible burns caused by overheated domestic water should never be taken lightly. In addition to the potentially life-changing medical issues faced by the victim,there is the legal liability associated with designing, installing or adjusting the domestic water-heating system that caused the burn. *It is therefore a highly recommended and often mandated practice to equip all domestic hot water systems with devices that can reliably protect against such conditions.*

BIOLOGICAL CONTAMINANTS:

There are several types of microorganisms that can be present in domestic plumbing systems. Examples are biological or microbial contaminants such as bacteria, viruses, protozoa and parasites. The source of the water often determines the probability and concentration of such contaminants.

Private wells that are dug or driven (versus drilled) can be relatively shallow, and as such more subject to biological (and chemical) contaminants present on ground surfaces or just beneath the surface. Possible sources for biological contaminants include animal feces, microbes associated with decaying plant matter, decaying remains of small vermin, and seepage from septic systems.

Equipment is available to reduce biological contamination in private water systems. This includes chemical injection devices as well as carbon filters and devices that expose water to ultraviolet light. The extent to which these devices are used often depends on building owner attitudes, budgets and tested levels of contaminants. Such devices and treatment processes are not mandated by code or regulation in many regions of North America.

Water supplied from public water systems undergoes continuous monitoring for both biological and chemical contaminants, and is subsequently treated to reduce the level of such contaminants to legally required standards. This monitoring and treatment is essential, especially considering that such systems directly impact the health of thousands of people.

LEGIONELLA BACTERIA:

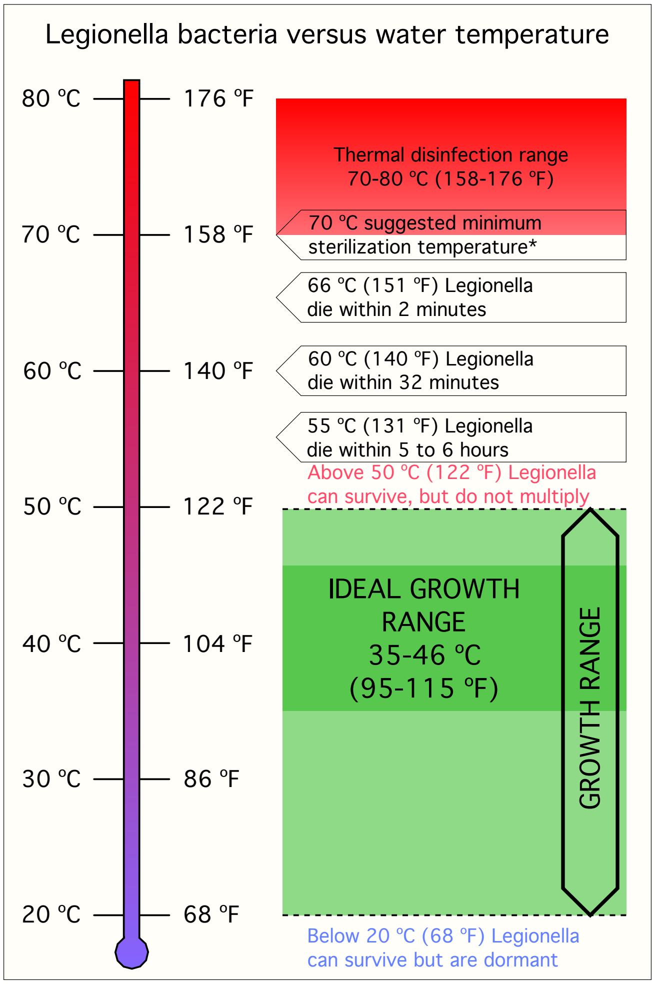
Still, *even when private or public water treatment systems are used, some microbes can survive and subsequently multiply in domestic hot water systems.* One such microbe is *Legionella* bacteria. These bacteria are naturally present in rivers, lakes, wells or stagnant pools of water, and as such, are inevitably present to some degree in many private water supply systems. Legionella bacterial is also found in municipal water mains and can, to some extent, survive municipal water treatment processes.

Legionella bacteria can multiply in water at temperatures between 68 and 122ºF. Below 68ºF, the bacteria are present, but remain dormant. Warm water between 95and 115ºF provides an optimum growth environment for Legionella bacteria. Growth is aided by the presence of biofilms in pipes or tanks, mineral scale, sediment or other microorganisms within plumbing systems. Dead-leg plumbing systems that harbor stagnant water also provide an enhanced growth environment and should be avoided.

Figure 2-7 shows the temperatures under which Legionella bacteria can survive, or be killed.

Given the right conditions, Legionella bacteria can cause two diseases in humans:

Figure 2-7



*Assumes maximum concentration of 1000 colony-forming units /ml^3

• *Pontiac fever*, which develops after an incubation period of 1 to 2 days. Its symptoms include fever, muscle aches, headache and, in some cases, intestinal complaints. This form of Legionella infection is often mistaken as the common flu and usually runs its course in 2 to 5 days without need of antibiotic treatment.

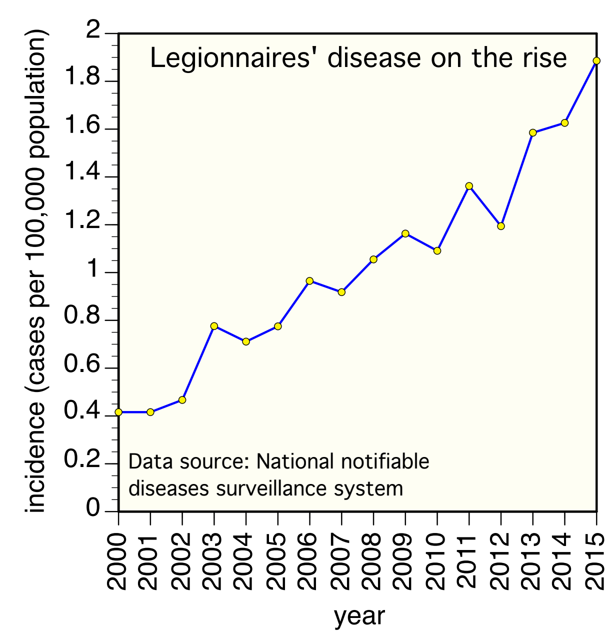
• *Legionnaires' disease,* which was first identified after a 1976 outbreak of pneumonia at a Philadelphia hotel where an American Legion convention was being held. The outbreak affected 221 people and led to 34 deaths.

Legionnaires' disease develops after an incubation period of 2 to 10 days (5 or 6 days on average). Symptoms may include high fever, muscle aches, diarrhea, headache, chest pain, cough, impaired kidney function, mental confusion, disorientation and lethargy. Legionnaires' disease is difficult to distinguish from pneumonia. Treatment involves a course of antibiotics. *Legionnaires' disease can be fatal*, especially if diagnosed late or involving patients that are older, weak or have depressed immune systems.

Legionnaires' disease is contracted by inhaling a sufficient amount of ultra-fine water droplets (1 to 5 microns in diameter) that contain Legionella bacteria. Such droplets can be produced by shower heads, faucets, spas, humidifiers, decorative fountains and cooling towers. Legionnaires' disease is *not* passed from person to person, *nor acquired by drinking* water containing Legionella bacteria.

The rate of reported cases of legionellosis, which comprises both Legionnaires' disease and Pontiac fever, has increased 286% in the United States during 2000–2014. Approximately 5,000 cases were reported to the Centers for Disease Control and Prevention (CDC) in 2014. Approximately 9% of reported legionellosis cases are fatal.[1]

Figure 2-8



Source: United States Center for Disease Control and Prevention

LEGIONELLA CONTROL:

Since Legionella was first identified as a serious health hazard following an outbreak at the 1976 American Legion convention in Philadelphia, various means of minimizing the health risks associated with Legionella bacteria have been developed.

Current Legionella mitigation requirements in the United States include a mandate issued in June 2017 from the Centers for Medicare and Medicaid Services (CMS).[2]

This mandate requires Medicare and Medicaid facilities to implement water testing and management plans that conform to ASHRAE Standard 188 Legionellosis: Risk Management for Building Water Systems, June 26, 2015.

Recent studies by the Center for Disease Control have determined that 19 percent of Legionnaires' disease outbreaks were associated with long-term care facilities and 15 percent with hospitals.

Legionella bacteria can be maintained at acceptable levels using several techniques, including:

- injection of chemical biocides (chlorine and chlorine dioxide)
- periodic flushing of all plumbing systems
- exposure to intense ultraviolet light
- exposure to ozone
- thermal disinfection

The latter method is discussed in this issue of *idronics*.

THERMAL DISINFECTION:

Although there are several methods for maintaining acceptably low levels of Legionella bacteria in domestic hot water systems, thermal disinfection is one of the simplest to execute. Thermal disinfection has been extensively used in European systems for over 15 years, and is currently the dominant method of Legionella control in Europe.

The basic concept of thermal disinfection is to periodically raise the hot water temperature throughout the hot distribution piping to a suitable level and maintain that temperature for a specified time, so that Legionella bacteria within the water, as well as within biofilms or scaling inside the piping system, will be killed.

Thermal disinfection provides the following advantages and benefits:

• There is no need to purchase, transport or store aggressive chemicals such as chlorine for on-site water treatment.

• There is no concern about over-dosing or under-dosing of disinfection chemicals.

• There is no need to flush plumbing after chemical dosing.
• There is no water wasted during thermal disinfection

• There is no concern about human or animal sensitivity to disinfection chemicals.

• There is no need for cleaning the disinfection apparatus, as is required for UV light disinfection systems.

• There is no need to install or maintain "ultra-filtration" or membrane filtration equipment.

• There is no concern about the ability of ozone, which can be used as a disinfection chemical, to react with metals, polymers or elastomers in the system.

• In properly designed systems, there is no change in the water temperature or water chemistry at the fixtures during the disinfection process.

• There is no concern about potential corrosion of system components such as elastomers or metals due to exposure to higher levels of disinfection chemicals. Chlorine-based water-disinfection methods using chlorine, chloramine or chlorine dioxide have caused failure in plumbing systems using copper, polybutylene and PEX. Some of those failures have led to class action lawsuits.[3]

Figure 2-6 shows that maintaining water at a temperature of 140ºF kills Legionella bacteria in that water within 32 minutes. A water temperature of 151ºF reduces the kill time to 2 minutes. A water temperature of 158ºF or higher provides essentially immediate kill.

Although these temperatures can be attained by many domestic water-heating devices, they are all well above the temperatures that are considered safe for delivery of hot water at fixtures where contact with human skin is possible. Thus, *the control of Legionella bacteria combined with the need to provide safe DHW delivery temperatures to fixtures requires multiple water temperatures at different locations and different times within the hot water system.*

Legionella bacteria can live within tiny voids in biofilms or scale inside DHW distribution piping. These films and scale present thermal resistance to hot water passing through the system during a thermal disinfection cycle. It is therefore necessary to *maintain* the flow of elevated-temperature water for sufficient time to allow disinfection conditions to permeate through all films or scaling in the pipe.

It's also important that the elevated water temperature required for thermal disinfection is *distributed throughout the system*.

Consider the situation where water is heated to a minimum thermal disinfection temperature, such as 140ºF, and circulated through the DHW system. Heat loss from piping causes the water temperature to drop, typically several degrees, as it passes through the recirculating system. Piping components near the end of the recirculation system may not achieve the necessary temperature/time conditions to ensure thorough disinfection. Thus, a constraining factor in achieving acceptable thermal disinfection is typically the temperature at the end of a DHW recirculation system.

The higher the temperature attained during a thermal disinfection cycle, the shorter its duration can be. *In the absence of specific codes or standards that require otherwise,* the following water temperatures and associated cycle durations have been commonly used for once-per-day disinfection of domestic hot water-delivery systems:

• At least 158ºF (70 ºC) maintained throughout the system for 10 minutes
• At least 149ºF (65 ºC) maintained throughout the system for 15 minutes
• At least 140ºF (60 ºC) maintained throughout the system for 30 minutes

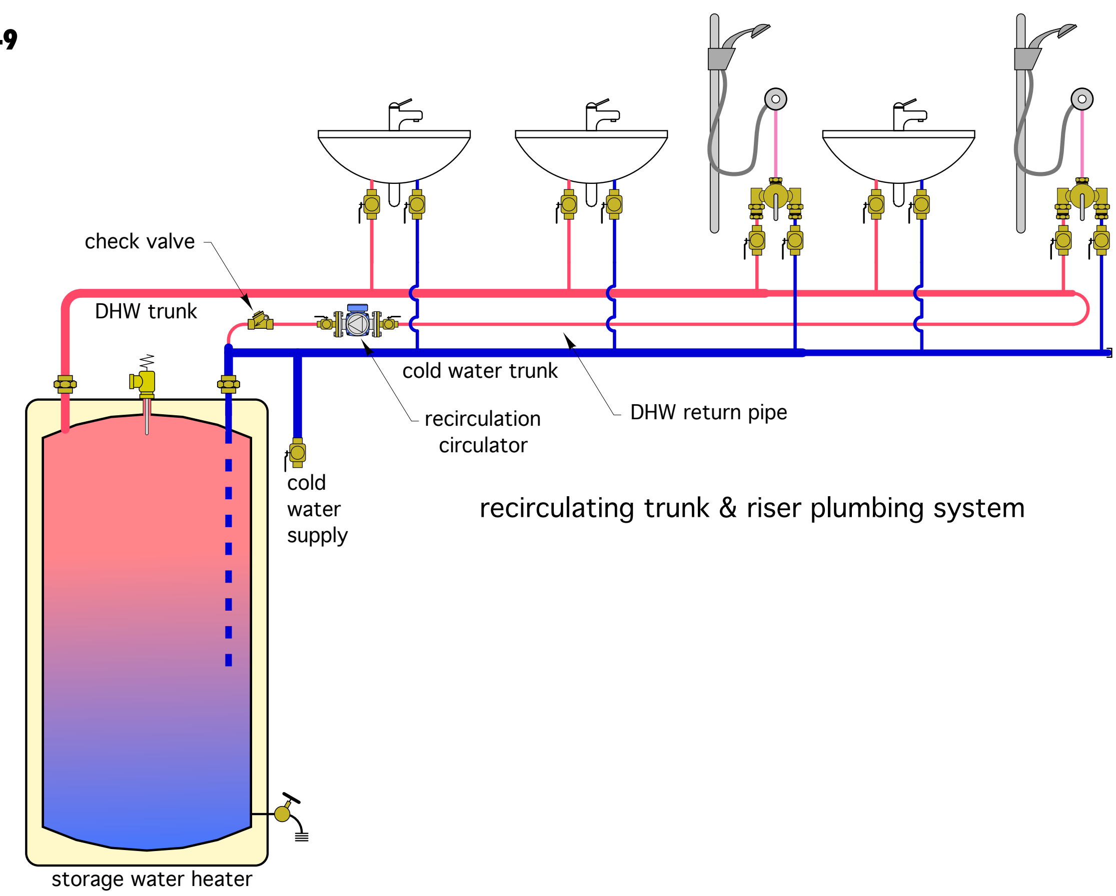
All of these time and temperature criteria stipulate "throughout the system." A thermal disinfection cycle would be considered incomplete if the water temperatures and cycle durations noted above were not achieved and maintained at the *return* of the recirculation loop, as well as elsewhere within the loop. The best designed systems take this into account by *verifying* that the thermal disinfection criteria have been maintained at the return end of the recirculation loop. Later sections describe specific hardware that facilitates this concept.

RECIRCULATING DHW SYSTEMS:

Legionella bacteria are known to multiply at increasing rates in stagnant water. Ensuring movement of domestic hot water through the plumbing system minimizes the possibility of stagnant water. Although there is obviously movement when domestic hot water is drawn from a fixture, the total duration of these hot water draws is minimal relative to total elapsed time.

Adding a small stainless steel or bronze circulator and return piping to the system, as shown in Figure 2-9, creates consistent movement in the hot water recirculation portion

Figure 2-9



of the system, which, depending on the operating times of the circulator, reduces the potential for stagnant water.

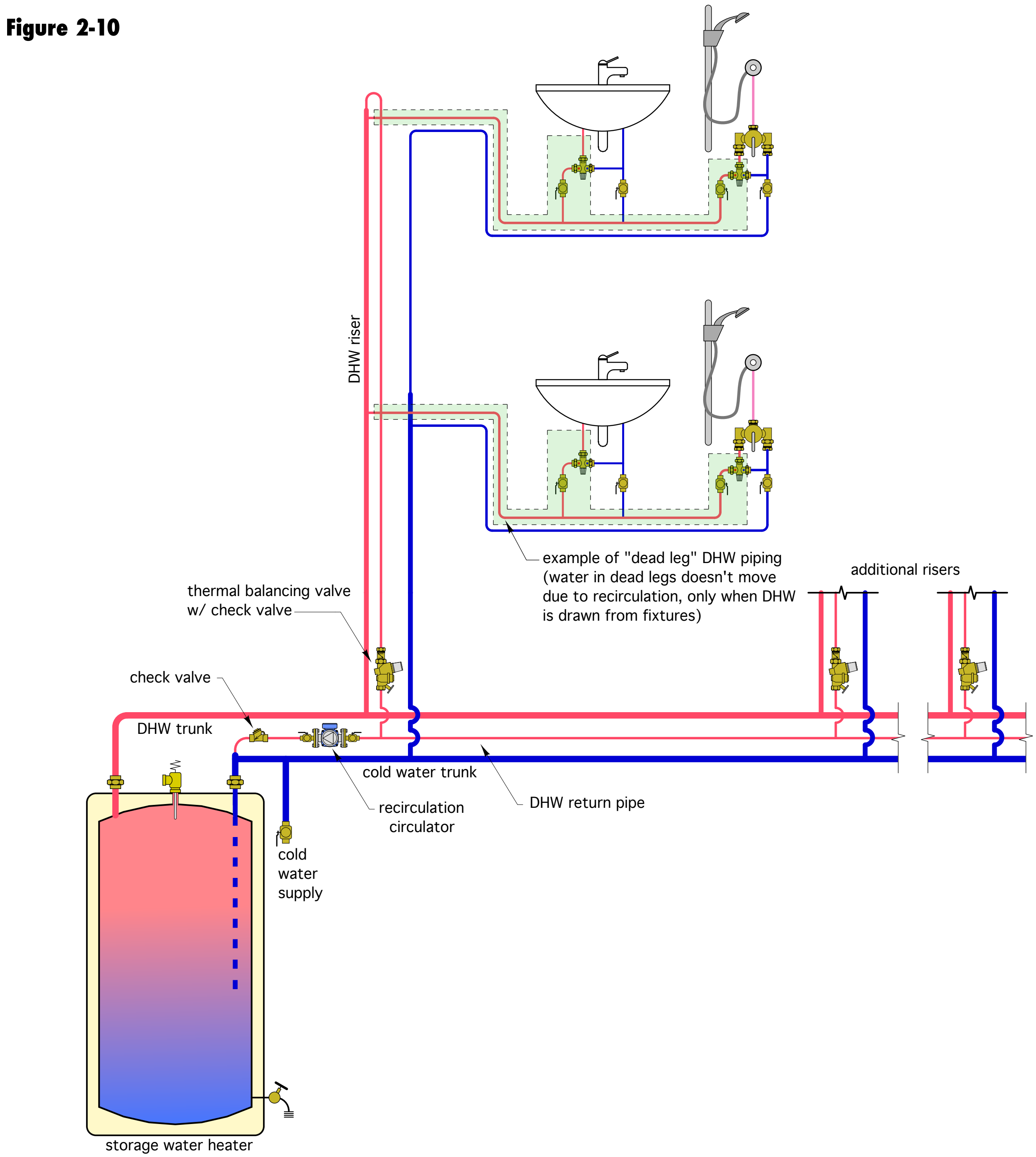
Recirculation also ensures that hot water is *immediately available* from fixtures served by the recirculating loop, and thus, improves owner satisfaction with the system. Use of a recirculating DHW delivery system is one of several “tactics” that can be used to limit potential growth of Legionella bacteria.

Recirculating hot water systems were covered in detail in *idronics* 21.

MINIMIZING “DEAD LEG” PLUMBING:

Reducing stagnant water reduces potential growth environments for Legionella bacteria. Even in systems with recirculating loop piping, there is a potential for water

Figure 2-10



to stagnate in pipes connected between that loop and the fixtures. These pipes are often referred to as “dead legs” in the system. Figure 2-10 shows the concept.

In larger buildings, domestic hot water-delivery systems may serve areas that have infrequent occupancy, or are used in ways that create long periods of no domestic hot water demand. These portions of plumbing systems are especially vulnerable to stagnant water, and thus, create potential breading areas for Legionella bacteria.

Plumbing system designers should make every effort to minimize the amount of piping in the system that could contain stagnant water.

3. TEMPERATURE CONTROL IN DHW SYSTEMS

The previous section discussed the need for multiple water temperatures to provide *both* burn protection and Legionella control in domestic hot water systems. This section describes specific hardware to establish and maintain those temperatures.

WATER HEATER TEMPERATURE CONTROLS:

The most common device used to create domestic hot water in North American homes is a tank-type heater supplied by electricity, natural gas, propane or fuel oil. Some recently released tank-type water heaters also have integral heat pumps that gather heat from air surrounding the tank, increase the temperature of that heat, and release it into domestic water inside the tank.

There is also an assortment of “tankless” water heaters that operate on electricity, natural gas or propane. They are designed to add heat to domestic water as soon as the heater detects a sufficient minimum flow rate caused by a draw at a fixture or appliance within the building.

All these devices contain internal thermostatic controls. Some are very simple bimetal thermostatic elements that snap the electrical contacts necessary to operate the heater closed at some temperature and open at a higher temperature. Others use solid-state temperature sensors wired to electronic controllers.

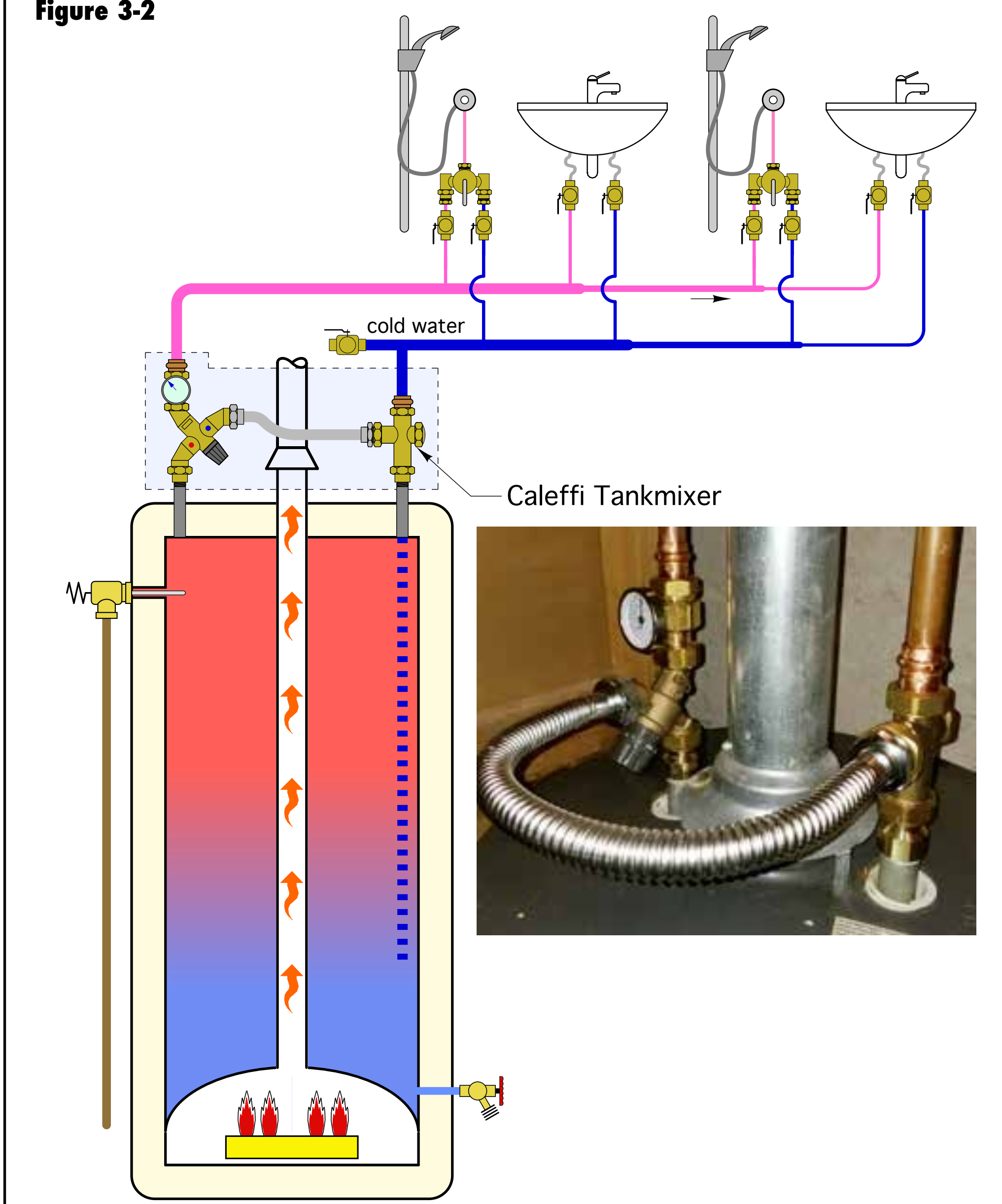
Figure 3-1

Although these devices meet the standards necessary to legally sell the water heater in North America (UL, CSA, etc.), many do not provide precise control of the water temperature leaving the heater. Some thermostats used on electric water heaters have printed temperatures on their adjustment dial, others simply indicate high, medium or low settings. The thermostats used on tank-type water heaters also cannot compensate for incoming water temperatures that are higher than their setting, such as might be the case for water supplied from a solar thermal "preheating" system, or the coil in a thermal storage tank heated by a biomass boiler. *The limited accuracy and inability to prevent potentially high-temperature water within the tank suggest that tank controls should not be the sole means of regulating the water temperature delivered to domestic hot water distribution systems.*

THERMOSTATIC POINT-OF-DISTRIBUTION MIXING VALVES

To ensure accurate control of domestic water temperature leaving a water heater, a thermostatic mixing device conforming to ASSE standard 1017 can be installed between the water heater and DHW distribution piping. One simple method for providing such a valve on a tank-type water heater is shown in Figure 3-2.

Figure 3-2



In this system, which does not have downstream devices to further reduce water temperature, the outlet temperature from the thermostatic mixing valve would typically not be set above 120ºF. Even lower outlet temperature settings such as 110ºF may be required in some circumstances.

Thermostatic mixing valves conforming to ASSE 1017 are also available in larger sizes and with several types of piping connections, including NPT treads, soldered, press and PEX crimp.

For high flow applications, two different sizes of ASSE 1017 thermostatic mixing valves can be combined, along with a differential pressure-sensing valve, to create a 2-stage mixing assembly. Figure 3-4 shows an example of a high/low mixing station available from Caleffi.

This assembly relies on the smaller ASSE 1017 mixing valve to handle DHW temperature control

Figure 3-3

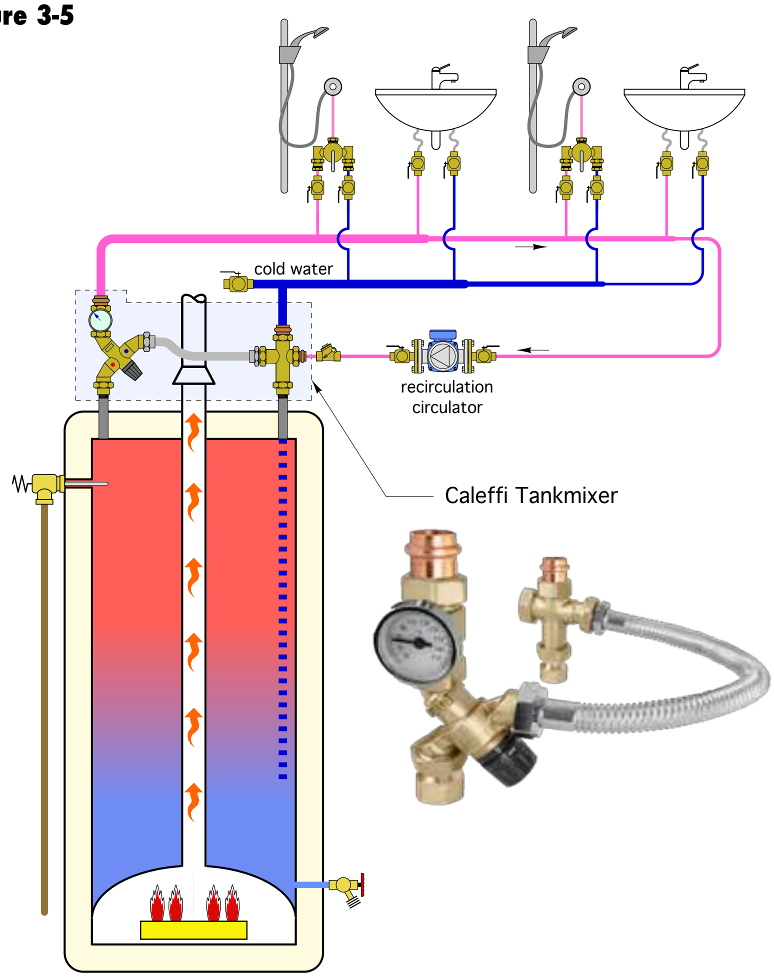
when there is minimal flow. As flow rate increases, the differential pressure sensing valve opens to allow flow through the larger ASSE 1017 valve, which is piped in parallel with the smaller valve. Under high-demand conditions, flow through both valves combines at the upper tee. This assembly helps ensure accurate mixed temperature control over a wide range of DHW flow rates.

The use of ASSE 1017 point-of-distribution mixing valves or 2-stage mixing assemblies by themselves does nothing to prevent water stagnation in portions of the system that experience minimal draws of DHW. However, a system using an ASSE 1017 point-of-distribution mixing valve can be further detailed to reduce the potential for stagnant water.

Figure 3-5 shows how the system from Figure 3-2 can be modified to include a recirculation loop.

Figure 3-4

Figure 3-5



A small stainless steel or bronze circulator has been added to the system, along with piping that carries domestic hot water that has reached the farthest fixture back to the water heater. The same Caleffi TankMixer assembly shown in Figure 3-2 can be used in this application. The cap that covered the side port of the cold water fitting as shown in Figure 3-2 is removed, and the recirculation pipe is connected to this port.

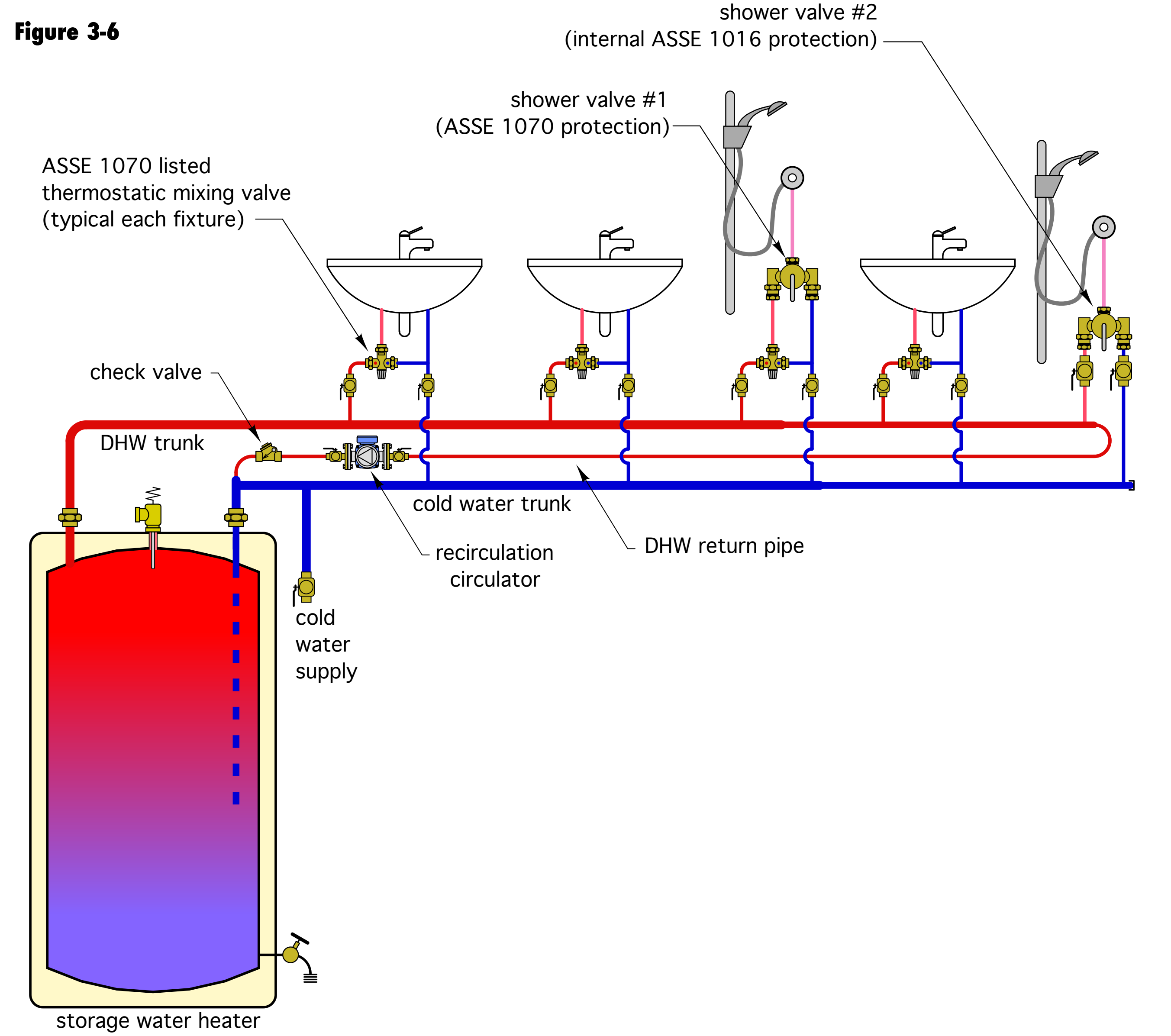
Recirculation ensures that water at the desired temperature is immediately available at all fixtures or appliances served by the plumbing system. It also reduces the potential locations where Legionella bacteria could multiply relative to non-recirculating systems.

THERMOSTATIC POINT-OF-USE MIXING VALVES:

When point-of-distribution mixing valves or 2-stage mixing assemblies are set to temperatures that prevent scalding (typically 110 to 120ºF), they allow domestic hot water to pass throughout the distribution system at temperatures that do not effectively kill Legionella bacteria.

If Legionella disinfection is desired (or required), the tank-type water heater could be operated at a minimum temperature of 140ºF, along with installation of "point-of-use" thermostatic mixing valves conforming to ASSE standard 1070 at each fixture that doesn't have internal anti-scald protection. The concept is shown in Figure 3-6.

Figure 3-6



Four of the five fixtures in Figure 3-6 have ASSE 1070 anti-scald mixing valves installed in close proximity to the fixture. The shower valve at the far right of the system has an internal temperature compensating mechanism conforming to ASSE 1016, and as such does not require an ASSE 1070 mixing valve.

This system allows the water heater to be maintained at a temperature of 140ºF or higher to effectively kill Legionella bacteria carried into the heater with cold water. It also allows each fixture to receive a reduced water temperature, typically in the range of 110to 120ºF, depending on facility type and applicable regulations. The recirculation detail ensures immediate hot water availability and reduces the potential for stagnant water in the system.

All hot water supply and recirculation piping should be insulated to minimize heat loss.

***idronics* 21 presents methods and data for determining heat loss from bare and insulated copper tubing used in recirculating DHW systems.**

Point -of-use thermostatic mixing valves listed to the ASSE 1070 standard should be installed close to the fixture from which hot water will be drawn. A typical installation beneath a lavatory is shown in Figure 3-7.

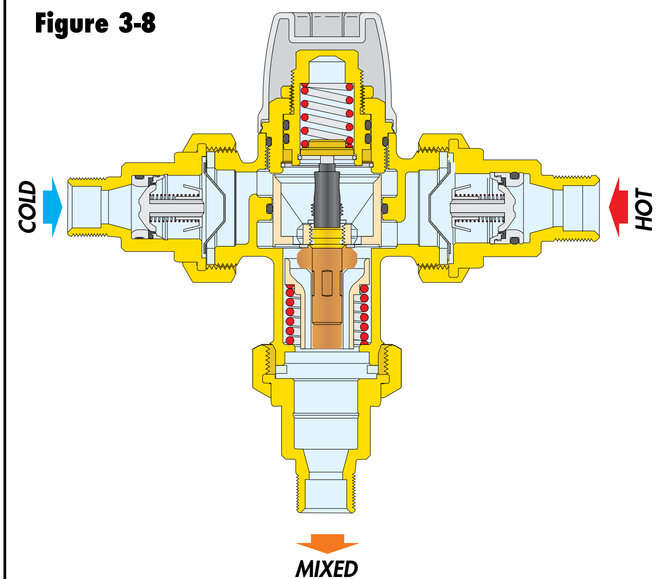
Keeping the point-of-use mixing valve close to the fixture reduces the amount of piping that operates at lower

Figure 3-7

(safe delivery) temperatures that could support growth of Legionella bacteria.

Thermostatic mixing valves continuously adjust the proportions of entering hot and cold water so that the mixed water stream leaving the valve remains at a set temperature. This regulation is created by the movement of a non-electric thermostatic element within the valve, as shown in Figure 3-8.

Figure 3-8



The thermostatic element contains a special wax that expands and contracts with temperature changes. This element is fully immersed in the mixed-flow stream leaving the valve, and thus, it continually reacts to changing inlet temperatures and flow rates. The thermostatic element adjusts the open area of the ports that allow hot water and cold water to enter the valve. As the open area of the hot water inlet port decreases, the open area of the cold water inlet passage increases, and vice versa. If the temperature or pressure at either inlet port changes, the valve quickly and automatically compensates to maintain the set outlet temperature.

Thermostatic mixing valves listed under the ASSE 1070 standard are also *pressure* compensated. If cold water flow to the valve is interrupted, the valve must immediately reduce the flow of hot water leaving the valve to a small percentage of normal flow. The action requires a minimum temperature difference of 18ºF (10ºC) between the hot water inlet and mixed water outlet. Valves listed to the ASSE 1070 standard must also have internal check valves in both inlet ports.

MOTORIZED MIXING VALVES:
Although thermostatic mixing valves have long been the standard for point-of-distribution temperature control in domestic water systems, motorized mixing valves operated by dedicated-purpose electronic controllers are now available. These controllers provide functionality that's not possible with thermostatic valves. Examples of this added functionality include:

• Ability to operate the valve over a very wide range of temperatures, as well as a wide range of temperature *differences* between entering hot and cold water.

Figure 3-9a

Figure 3-9b

• Precise temperature control based on electronic temperature sensing at one or two locations in the system.

• Ability to execute several variations of thermal disinfection cycles involving different water temperatures and durations, and also log the temperatures that have been established during those cycles.

• Ability to connect the controller to a building automation system, allowing the building operator to monitor and change settings without having to be at the valve's physical location.

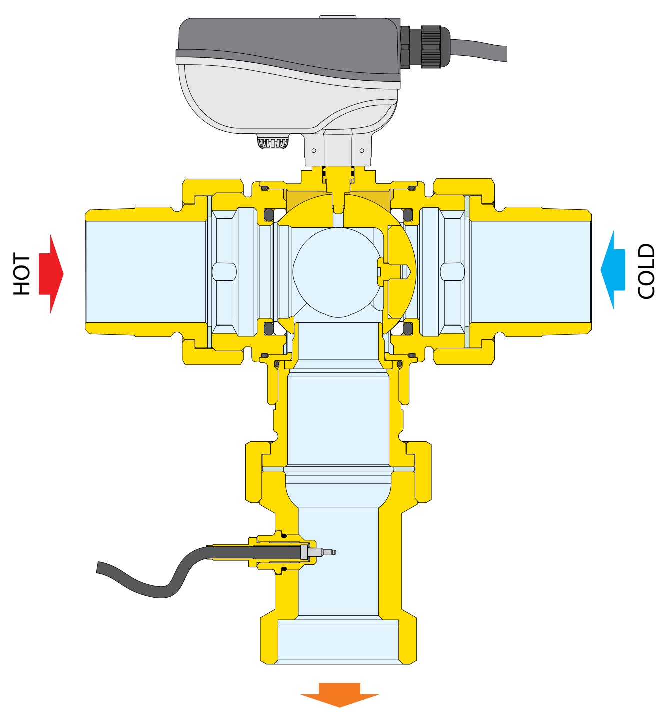
• Ability to automatically adjust flow proportions to maintain the necessary outlet temperature, while experiencing pressure variations on the hot and cold water inlet ports due to other demands in the system.

• Lower pressure drop than thermostatic mixing valves.

Figure 3-9 shows an example of a motorized mixing valve and its associated controller specifically designed to provide central water temperature control in DHW systems.

Figure 3-10 shows the internal construction of this valve.

Figure 3-10



This valve uses a rotating ball to control the proportions of entering hot and cold (or warm) water. The ball is rotated by the motorized actuator at the top of the valve. The mixed flow then passes a temperature sensor, which provides the controller with continuous feedback of leaving water temperature.

The Caleffi LEGIOMIX® motorized mixing valve and its associated controller can be configured for several operating modes. It can operate to maintain a set outlet temperature, while also recording the water temperature on the return side of the recirculation loop. It can initiate a thermal disinfection cycle controlling both the recirculation circulator and water temperature from the heat source during that cycle. It also records the times and temperatures achieved within the system (supply and return) for each day. Alarms can be issued if the programmed thermal disinfection cycle is not successfully completed, (i.e., if the supply or return temperatures drop below their programmed setpoints). The controller can also interface with building automation systems using ModBus or BACnet protocols. More detailed information on the valve's capabilities is given in the product pages at the end of this issue.

Figure 3-11

Designers should note that some regulations require specific safety controls on DHW systems. These controls must provide a fail safe shut off of the hot water supply to the central mixing valve if the temperature leaving that valve exceeds the valve's setpoint by a specific value, such as 10 ºF. The system must also provide a visual and audible alarm, and only allow a manual reset of a detected fault condition. Figure 3-11 shows an example of such a controller.

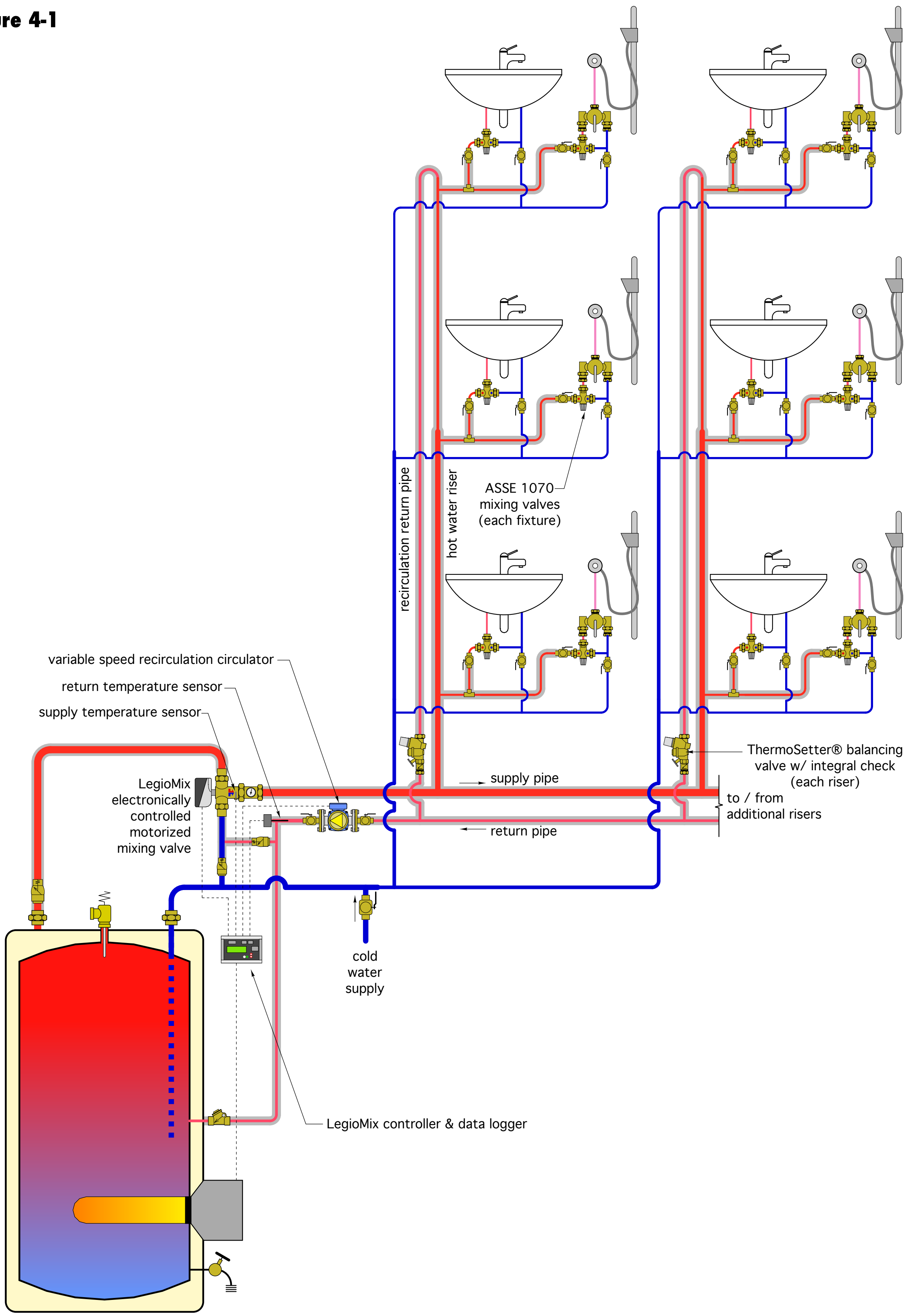
Caleffi LEGIOMIX® valves can also be used in parallel piping configurations to accommodate higher flow requirements, as shown in Figure 3-12.

Section 4 will show how motorized mixing valves can be applied, along with thermal balancing valves and recirculation, to create state-of-the-art DHW delivery systems.

Figure 3-12

Installation at Rio de Janeiro hotel

Figure 4-1



recirculation return pipe
hot water riser
ASSE 1070
mixing valves
(each fixture)
variable speed recirculation circulator
return temperature sensor
supply temperature sensor
LegioMix
electronically
controlled
motorized
mixing valve
supply pipe
return pipe
ThermoSetter® balancing
valve w/ integral check
(each riser)
to / from
additional risers
cold
water
supply
LegioMix controller & data logger

4. STATE-OF-THE ART DHW DELIVERY SYSTEMS

Previous sections have discussed specific issues associated with creating DHW systems that provide safe delivery of water from the standpoints of burn protection and minimal exposure to Legionella bacteria.

***idronics* #21 also described the advantages of recirculating domestic hot water systems and how to properly balance them using thermal balancing valves.**

This section combines all these previously discussed concepts into a state-of-the-art DHW delivery system. Figure 4-1 shows one example of such a system.

This system uses a point-of-distribution motorized mixing valve and its associated controller. The valve and controller have two operating modes:

• *Normal mixing mode*, during which the valve maintains a preset outlet temperature, such as 125ºF to the DHW recirculation loop.

• *Thermal disinfection mode*, during which the valve allows the water temperature leaving the valve to rise to 165ºF for a minimum of 30 minutes. During this time the valve also monitors the water temperature at the return end of the recirculation loop. A successful thermal disinfection cycle is determined by verifying that the return water temperature has been maintained at no less than 140ºF for a minimum of 30 minutes.

The normal mixing mode provides an acceptable delivered water temperature to the fixtures served by the system. Each of these fixtures is equipped with an ASSE 1070 point-of-use thermostatic mixing valve that reduces the water temperature delivered to the fixture to 110ºF, and thus, protects against burns *under all system operating modes* (e.g., both normal and thermal disinfection mode).

The water temperature maintained during the normal mixing mode reduces piping heat loss relative to the losses that would result from higher loop temperatures. This reduces the energy required for system operation. It also reduces heat gain within the building that contributes to cooling load.

The hot water leaving the motorized mixing valve supplies a recirculation loop. Flow in this loop is driven by a small *variable-speed* high-efficiency stainless steel circulator. The flow rate in the main portion of the loop, as well as through the two hot water risers and recirculation return piping, has been determined so that the temperature at the farthest fixture served by each riser is no more than 5ºF lower than the water temperature leaving the mixing valve.

The calculations necessary to determine these flow rates are presented in *idronics* #21.

THERMAL BALANCING:

The recirculation return riser in each of the two riser groups is equipped with a Caleffi ThermoSetter™ thermal balancing valve. An example of such a valve is shown in Figure 4-2.

Figure 4-2

Thermal balancing valves are discussed in detail in *idronics* #21

This valve contains two independent thermostatic elements. The primary element has an adjustable temperature setting. As the water temperature passing into this valve rises toward its setting, the primary thermostatic element throttles the valve to a minimum flow coefficient (e.g., Cv) of 0.23. At that condition, the valve only permits minimal flow of water through the return piping. The flow that does pass through is sufficient to allow the valve to continuously sense water temperature.

If the temperature sensed by the thermal balancing valve decreases, the Cv of the valve increases. At a temperature of 60°F below the setpoint, the Cv of the valve is 2.1. Higher Cv values allow increased flow rate through the valve, which in turn allows higher recirculation flow through the riser group. Those higher flow rates compensate for decreasing water temperature in the riser group that could be caused by piping heat loss under low DHW demand conditions.

The varying Cv of the thermal balancing valve reduces recirculation flow in the DHW riser group when the water temperature through that riser group is sufficient to ensure adequate DHW delivery temperature to the farthest fixtures served by that group. Conversely, when the water temperature entering the thermal balancing valve decreases, which is likely the result of piping heat loss under low-demand conditions, the increasing Cv allows greater flow through the riser group.

By reducing its Cv as the entering water temperature approaches the valve's setpoint, the valve reduces the recirculation flow rate in the portion of the system served by the associated riser group. The variable-speed recirculation circulator "interprets" this flow reduction as an attempt to increase differential pressure between the circulator's inlet and outlet ports. It responds by reducing motor speed to maintain the necessary differential pressure. Reduced motor speed reduces the electrical power input to the circulator. Electrical energy savings associated with variable-flow recirculation DHW systems can be substantial, especially in larger commercial or institutional applications.

Thus, the combination of thermal balancing valves on the recirculation return of each riser group, along with a variable-speed recirculation circulator, ensures adequate (but not excessive) recirculation flow in all portions of the system, while minimizing the power required to operate the recirculation circulator.

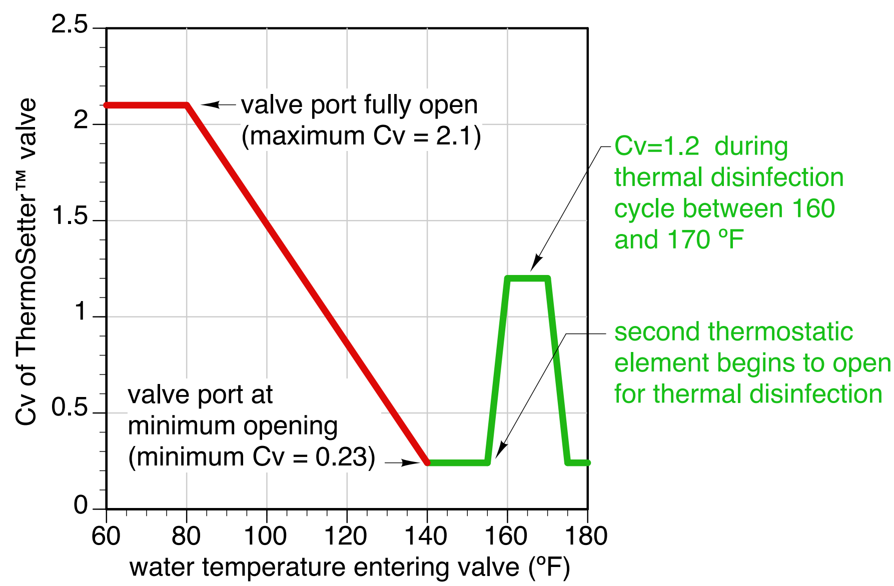
When the motorized point-of-distribution mixing valve enters the thermal disinfection mode, the water temperature passing through the recirculating portions of the system increases to 165°F at the outlet of the valve, and approximately 160°F at the farthest fixture served by each riser group.

When the water temperature entering the thermal balancing valve increases above 155°F, the ThermoSetter™ valve's second thermostatic element reacts by bypassing flow around the primary thermostatic element and increasing the valve's Cv from 0.23 to 1.2, which corresponds to an inlet temperature of 160°F. The increased Cv allows for higher flow rates through the recirculation system during the thermal disinfection cycle. Higher flow rates reduce the temperature drop through the piping circuits, and help ensure that adequate disinfection temperatures are achieved in all portions of the recirculation system. When the thermal disinfection cycle ends and water temperature decreases, the thermal balancing valve returns control to the primary thermostatic element. Figure 4-3 shows how the Cv of a Caleffi ThermoSetter™ valve, when adjusted to a setpoint of 140°F, varies between normal recirculation mode and thermal disinfection mode.

There are many potential variations of the schematic shown in Figure 4-1. For example, each fixture group could be different, having more or less fixtures requiring DHW. What would remain unchanged is the concept of minimizing the dead leg piping within each fixture group.

There could also be more riser groups within the system. What would remain unchanged is the presence of a

Figure 4-3



thermal balancing valve with integral check valve within each of the recirculation return piping paths.

There could also be multiple motorized mixing valves, configured in parallel for high flow applications that are beyond the flow capacity of the largest available valve body.

Yet another variation would be the use of low-voltage valve actuators on each of the thermal balancing valves that are wired to a building automation system. These actuators replace the function of the previously described thermal disinfection thermostatic element. The building automation system could be programmed to power these actuators to create specific thermal disinfection start times and durations for each riser group. These thermal disinfection cycles would be coordinated, through the building automation system with the controller operating the motorized mixing valve.

Figure 4-4 shows an example of a ThermoSetter™ valve equipped with a low-voltage valve actuator.

Figure 4-4

The ThermoSetter™ balancing valves could also be equipped with temperature sensors, rather than dial thermometers, to provide a building automation system with temperatures at the return of each recirculation riser group. Those temperatures could be recorded to verify successful completion of each thermal disinfection cycle, based on maintaining the return end of each riser group at a specific temperature for a specific minimum time.

SUMMARY

The ability to deliver domestic hot water that is both safe and sanitary is critically important in nearly all building plumbing systems. Heated water that's *immediately available* at all fixtures, and at temperatures that are appropriate for each fixture's function, is one goal. Maintaining minimal levels of Legionella bacteria in this water is another goal. The methods and hardware described in this issue of *idronics* can be used to achieve both goals, while also minimizing the electrical power demand of recirculating DHW systems.

REFERENCES:

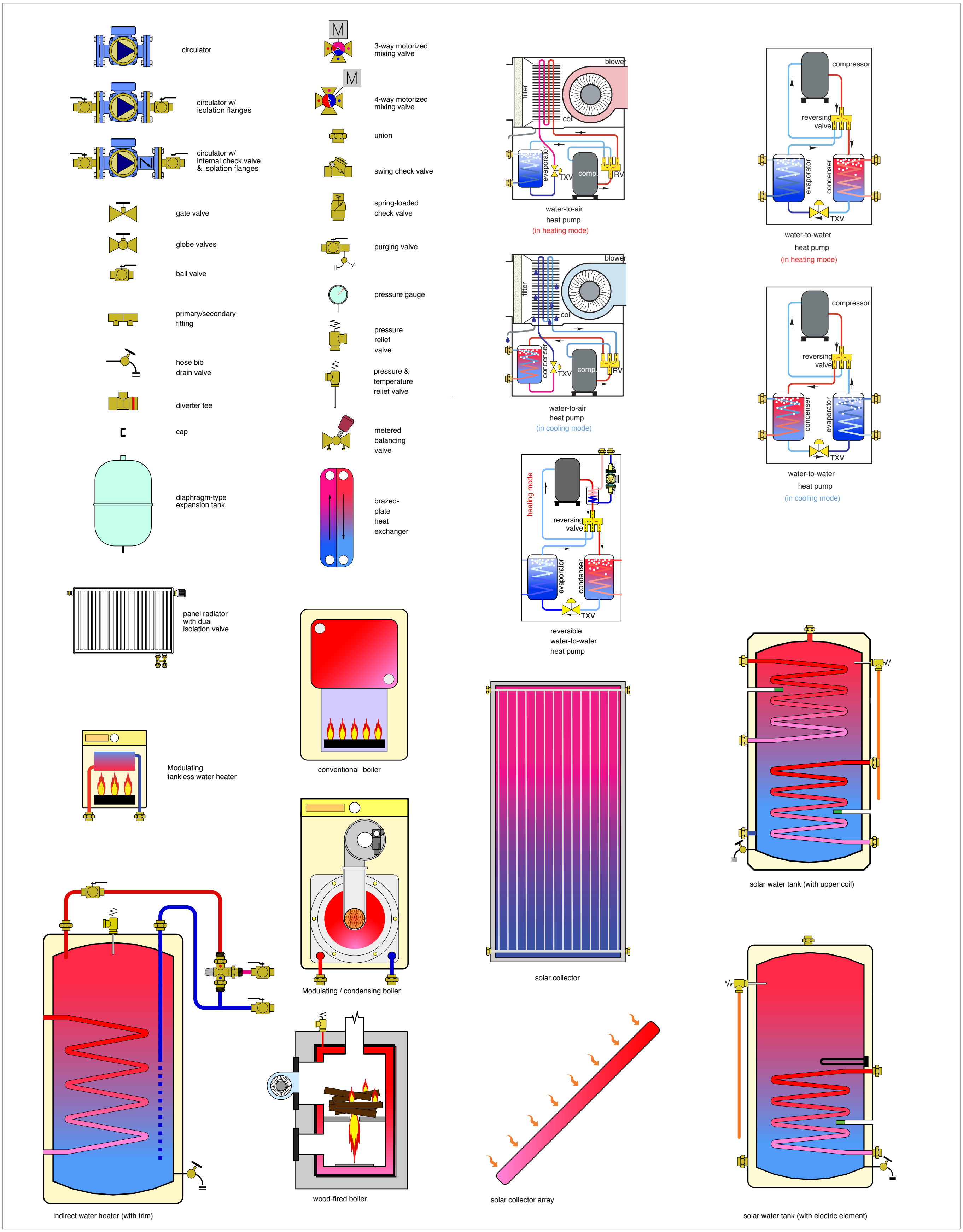
1. Center for Clinical Standards and Quality/Survey & Certification Group Ref: S&C 17-30-Hospitals/CAHs/NHs REVISED 06.09.2017

2.https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Downloads/Survey-and-Cert-Letter-17-30.pdf

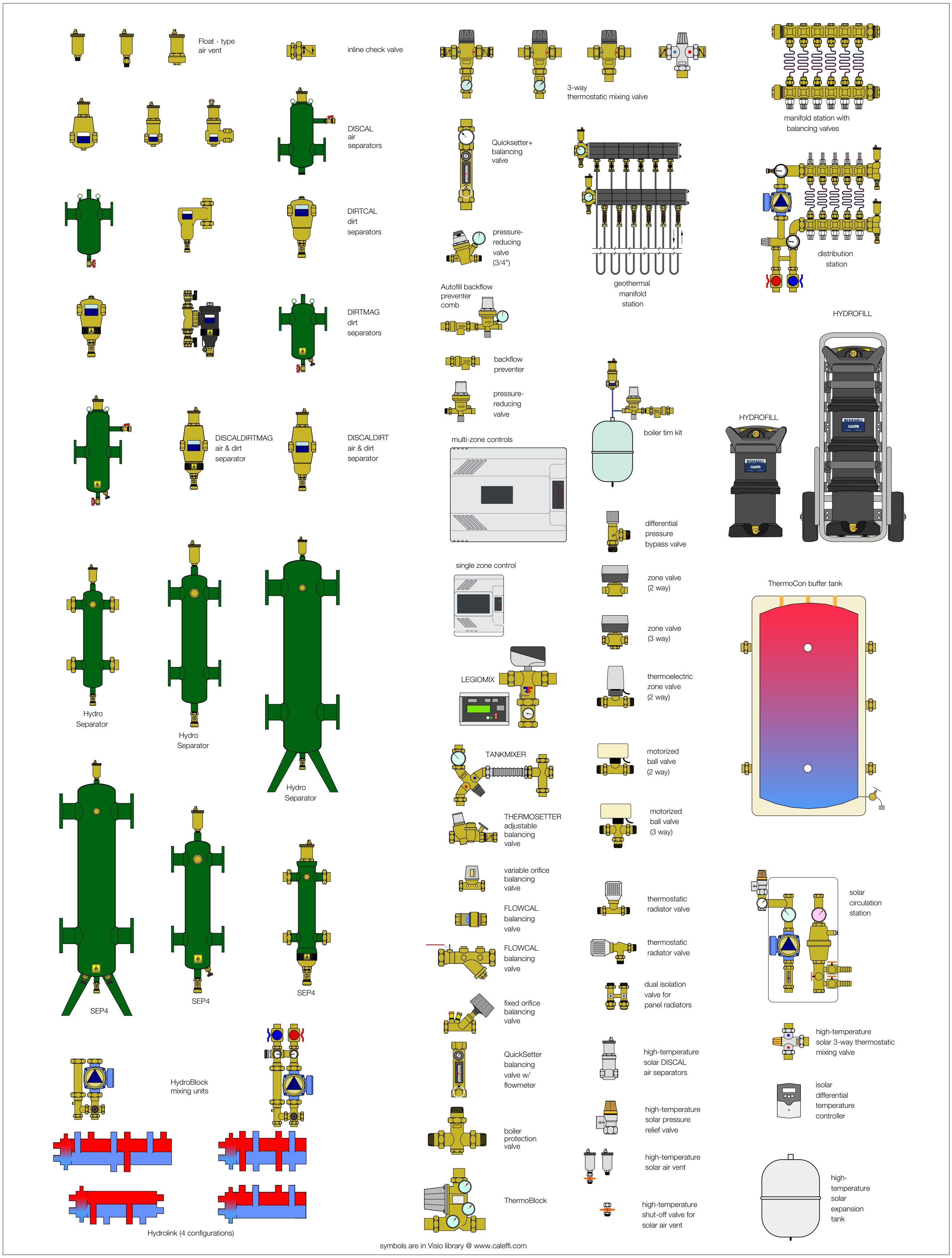
3. Simon, Jonathan, *Common water-treatment methods may cause premature plumbing failures*, Radiant & Hydronics, September 28, 2017.

APPENDIX A: PIPING SYMBOL LEGEND

GENERIC COMPONENTS



CALEFFI COMPONENTS



LEGIOMIX® electronic mixing valve

6000 series

ASSE 1017

Function

The electronic mixing valve is used in centralized systems that produce and distribute domestic hot water. It maintains the temperature of the domestic hot water delivered to the user when there are variations in the temperature and pressure of the hot and cold water at the inlet or in the draw-off flow rate. The LEGIOMIX® electronic mixing valve provides precise temperature control over very low and very high flow rate demand, minimal pressure drop with a ball valve control element, automatic self-cleaning to prevent scale formation and easy-to-use digital interface with data logging, alarming and status indication. The LEGIOMIX® electronic mixing valve is furnished with a controller with LCD user interface that provides a set of programs for circuit thermal disinfection against Legionella, configurable via keypad, or local or remote computer. Depending on the type of system and habits of the user, temperature levels and operation times can be programmed as desired. In addition, it comes standard with monitoring and remote control connections.

Product range

6000 series	Electronic mixing valve with programmable thermal disinfection and male NPT connections	sizes 1", 1¼" 1½", & 2"
6000 series	Electronic mixing valve with programmable thermal disinfection and sweat connections	sizes 1", 1¼" 1½", & 2"
NA10520	Modbus-to-BACnet gateway	

Technical specifications

Valve body

Materials: - Body: DZR low-lead brass (<0.25% Lead content)
- Ball: low-lead brass, chrome-plated
- Hydraulic seals: Peroxide-cured EPDM

Max. working pressure: 150 psi (10 bar)
Max. inlet temperature: 212°F (100°C)
Temperature gauge scale: 30 - 210°F
Suitable fluids: water
Main connections: -NPT male and sweat union 1", 1¼" 1½", & 2"

Actuator, 3-wire floating

Electric supply: 24 VAC - 50/60 Hz
Power consumption: 6 VA
Protection cover: self-extinguishing VO
Protection class: IP 65 (NEMA 4/4X)
Ambient temperature range: 14–130° F (-10–55° C)
Electric supply cable length: 31½" (0.8 m)

Controller, LCD user interface/display

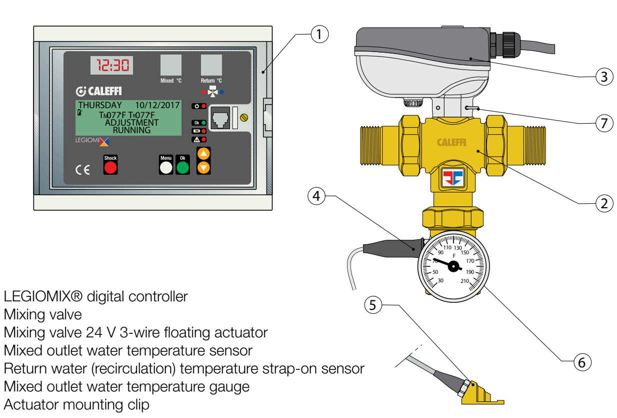
Materials: - Housing: self-extinguishing ABS, color white RAL 1467
- Cover: self-extinguishing SAN, smoked transparent
Electric supply: 24 VAC - 50/60 Hz
Power consumption: 6.5 VA
Adjustment temperature range: 70–185° F (20–85° C)
Disinfection temperature range: 100–185° F (40–85° C)
Ambient temperature range: 32–120° F (0–50° C)
Protection class: IP 54 (wall mounting) Class II appliance
Contact rating (R1, R3, R4): 5 (2) A / 24 V
Mixing valve control: 5 (2) A / 24 V
Alarm relay (R2): 5 (2) A / 24 V
Fuses: 1 (main): 80 mA
2 (mixing valve): 1 A
Charge reserve: 15 days in the event of electric supply failure, with a 3 cell rechargeable 150 mAh buffer battery
Battery recharging time: 72 hours

Temperature sensors

Body material: stainless steel
Type of sensitive element: NTC
Working temperature range: 14–260° F (-10–125° C)
Resistance: 1000 Ohms at 77° F (25° C)
Time constant: 2.5
Max. distance for mixed outlet or return (recirculation) sensor:
500 ft (150 m) cable 2 conductor x AWG 18
800 ft (250 m) cable 2 conductor x AWG 14

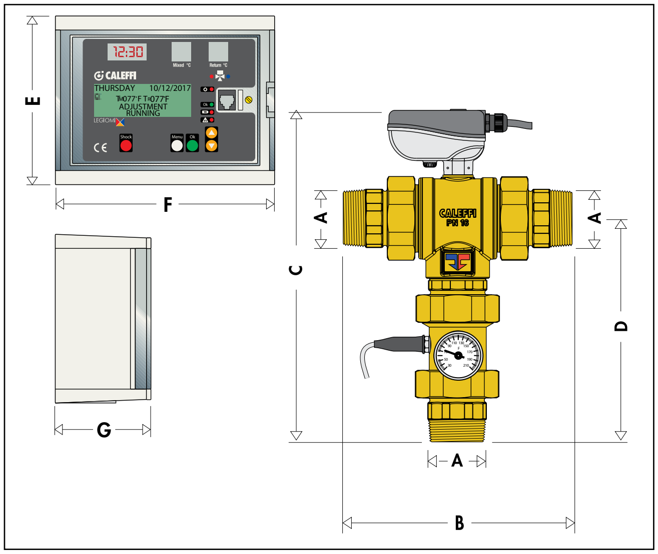
Mixing valve performance

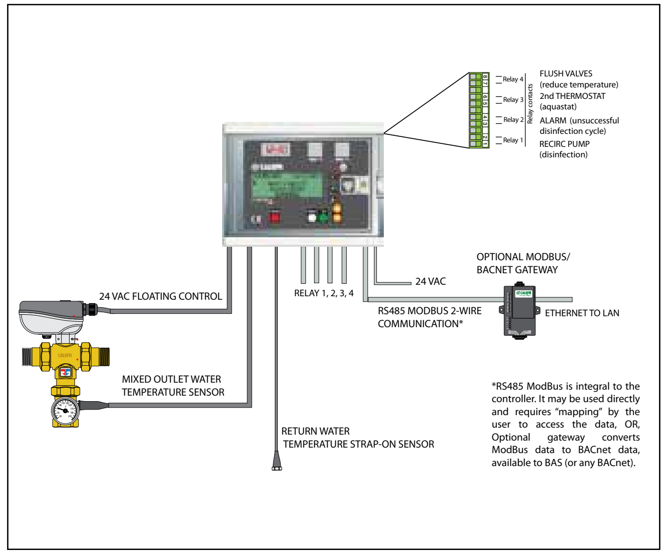
Max. working pressure (dynamic): 70 psi (5 bar)
Max. ratio between inlet pressures (H/C or C/H) with G_{min} = 0.6 Cv: 2:1



1) LEGIOMIX® digital controller
2) Mixing valve
3) Mixing valve 24 V 3-wire floating actuator
4) Mixed outlet water temperature sensor
5) Return water (recirculation) temperature strap-on sensor
6) Mixed outlet water temperature gauge
7) Actuator mounting clip

Dimensions





Code	A	B	C	D	E	F	G	Wt (lb)
600064A	1" MNPT	6¼"	11"	6"	5½"	7"	4"	7.3
600069A	1" sweat	4¾"	10¼"	5¼"	5½"	7"	4"	7.3
600074A	1¼" MNPT	7¼"	11 7/8"	6¼"	5½"	7"	4"	8.2
600079A	1¼" sweat	5¾"	11 1/8"	5½"	5½"	7"	4"	8.2
600084A	1½" MNPT	9 1/8"	14 3/8"	9½"	5½"	7"	4"	21
600089A	1½" sweat	7 7/8"	13 1/8"	8¼"	5½"	7"	4"	21
600094A	2" MNPT	9½"	14½"	7 5/16"	5½"	7"	4"	21.5
600099A	2" sweat	7 3/8"	13 11/16"	6½"	5½"	7"	4"	21.5

	Recommended Flow Rates (gpm/lpm)			
Size	1"	1¼"	1½"	2"
Minimum*	3 / 11.4	4.4 / 16.6	6.6 / 25	8.8 / 33.3
Maximum	58 / 220	124 / 470	172 / 651	213 / 806
Cv	12.3	24.6	37.7	47.6

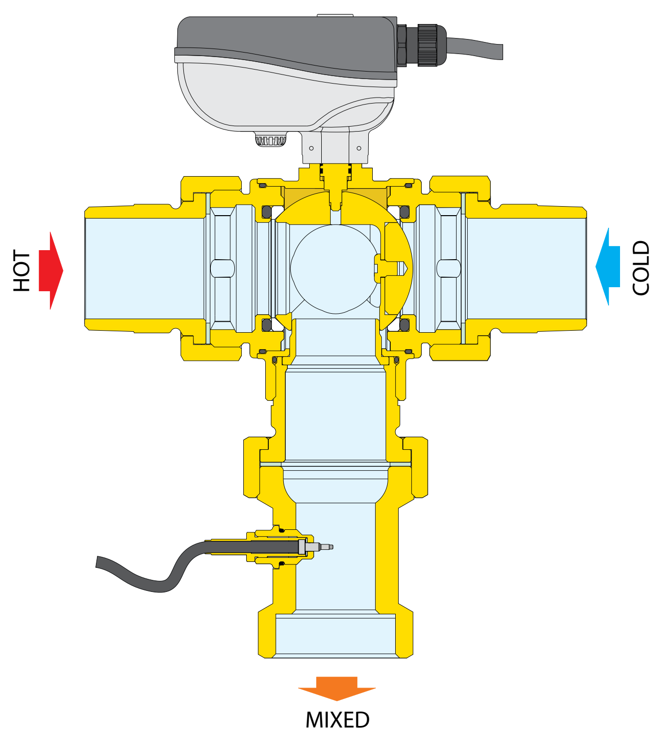
*to ensure stable operation and accurate temperature control.
Minimum flow rate is 0 gpm when recirculation flow rate is greater than or equal to the valve size minimum flow rating.

Operating principle

The electronic mixing valve mixes hot water from storage and cold water from the main supply to maintain a constant controlled set temperature of mixed water at the outlet. The controller measures the temperature of the mixed water at the valve outlet with temperature sensor and modulates the mixing valve position to maintain the desired set temperature. Despite variations in pressure or hot and cold water usage or variations in inlet temperatures, the LEGIOMIX® automatically controls the water temperature to meet the temperature setting.

A built-in clock is used to enable optional disinfection cycle programs. The system is disinfected by raising the water temperature to a specific value for a specific time duration. Using the recirculation temperature sensor, water returning from the distribution circuits can be measured for thermal distribution control. This measured temperature is used to check and control the temperature reached over all or part of the distribution network with this sensor placed at the most distant point in the system.

The LEGIOMIX® can be used to confirm that the correct temperature and time for thermal disinfection have been reached before taking the appropriate corrective action. All the parameters are updated every day and logged, with temperatures recorded every hour. There is an RS-485 connection for remote monitoring and configuration and, with specific relays, makes alarm signals and controls available to other interconnected system devices. A Modbus-to-BACnet gateway is available separately.



ThermoSetter™
Recirculation thermal balancing valve

116 series

Function

The ThermoSetter™ adjustable thermal balancing valve is used for automatic balancing of recirculation loops in domestic hot water systems, to speed hot water delivery and reduce water waste and save energy. The internal thermostatic cartridge automatically modulates flow to ensure a constant temperature in the recirculation piping system. The ThermoSetter™ has an adjustment knob with 95°F to 140°F (35°C to 60°C) temperature scale indication. An integral dry-well holds a slide-in temperature gauge for local indication, or a sensor for remote temperature sensing. The optional check valve protects against circuit thermo-syphoning.

The 116**2** Series is available with a “disinfection” by-pass cartridge, for use in systems which are designed to perform thermal disinfection for prevention of Legionella. When the disinfection cartridge senses 160°F (70°C) water, indicating disinfection control mode, it automatically opens a by-pass flow path to allow sufficient flow for disinfection to occur. When the temperature drops back to normal range, the disinfection by-pass cartridge closes to return flow control to the balancing cartridge.

The 116**3** Series is also available with a "disinfection" valve that is controlled by a 24V spring return thermo-electric actuator, rather than thermostatically, thus allowing thermal disinfection mode to be controlled remotely by a building automation system.

Product range

1161_0A series	Thermal balancing valve	size ½” & ¾” NPT female
1161_0AC series	Thermal balancing valve with check valve	size ½” & ¾” NPT female
1161_1A series	Thermal balancing valve with temperature gauge	size ½” & ¾” NPT female
1161_1AC series	Thermal balancing valve with temperature gauge and check valve	size ½” & ¾” NPT female
1162__A series	Thermal balancing valve with thermostatic bypass cartridge and temperature gauge	size ½” & ¾” NPT female
1162__AC series	Thermal balancing valve with thermostatic bypass cartridge, temperature gauge and check valve	size ½” & ¾” NPT female
1163__A series	Thermal balancing valve with actuator bypass valve and temperature gauge	size ½” & ¾” NPT female
1163__AC series	Thermal balancing valve with actuator bypass valve, temperature gauge and check valve	size ½” & ¾” NPT female

Technical specifications

Materials:

- Body:	DZR low-lead brass
- Adjustable cartridge:	stainless steel & copper
- Springs:	stainless steel AISI 302 (EN 10270-3)
- Hydraulic seals:	EPDM
- Adjustment knob:	ABS

Performance:

Suitable fluid:	water
Max. working pressure:	230 psi (16 bar)
Max. differential pressure:	15 psi (1 bar)
Max. inlet temperature:	195°F (90°C)
Adjustment temperature range:	95-140°F (35–60°C)
Flow Cv (Kv) max:	2.1 (1.8)
Flow Cv (Kv) min:	0.23 (0.2)
Flow Cv (Kv) design:	0.52 (0.45)

Disinfection performance:

Disinfection temperature:	160°F (70°C)
Balancing temperature:	170°F (75°C)
Flow Cv (Kv) disinfection:	1.2 (1.0)

Connections:

Main connections:	½" NPT female ¾" NPT female
Temperature gauge/sensor dry-well:	0.40 inch (10 mm)

Temperature gauge code 116010

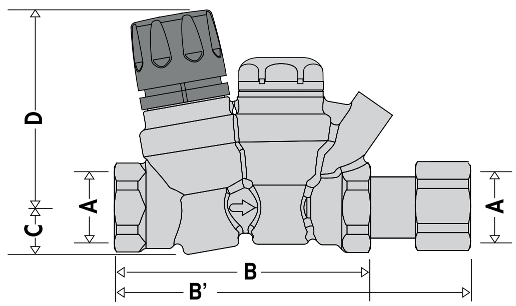
Scale:	30–180°F (0–80°C)
Diameter:	1½" (40 mm)
Stem diameter:	0.35" (9 mm)

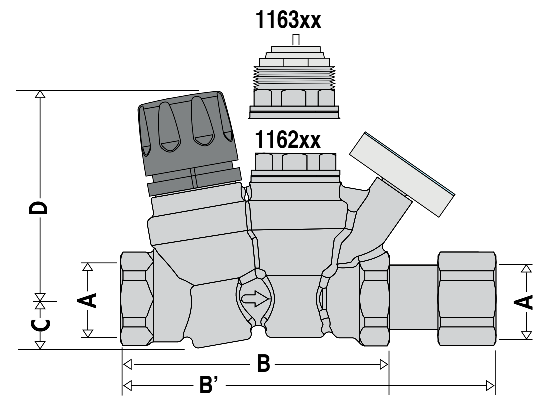
Technical specifications of insulation

Materials:	closed cell expanded PE-X
Thickness:	½ inch (13 mm)
Density: -internal part:	1.9 lb/ft³ (30 kg/m³)
-external part:	5.0 lb/ ft³ (80 kg/m³)
Thermal conductivity (DIN52612):	
- at 32°F (0°C):	0.82 BTU · in/hr · ft² · °F (0.0345 W/(m · K))
- at 105°F (40°C):	0.94 BTU · in/hr · ft² · °F (0.0398 W/(m · K))
Coefficient of resistance to the diffusion of vapor:	> 1,300
Working temperature range:	32–212°F (0–100°C)
Flammability (ASTM D 635):	Class VO

Certifications: NSF/ANSI 372-2011, low lead certified by ICC-ES, file PMG-1360.

Dimensions





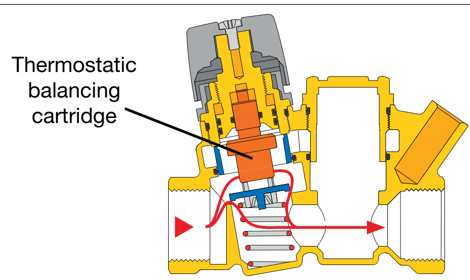
Code	A	B	B'*	C	D	Wt (lb/kg)
116140A(C)	½" NPT F	4"	5 7/16"	¾"	3"	1.7 / 0.75
116141A(C)**	½" NPT F	4"	5 7/16"	¾"	3"	1.7 / 0.75
116150A(C)	¾" NPT F	4"	5 5/8"	¾"	3"	1.5 / 0.70
116151A(C)**	¾" NPT F	4"	5 5/8"	¾"	3"	1.5 / 0.70

*Models with check valve (C) end-to-end dimension is B'.
**with integral outlet temperature gauge.

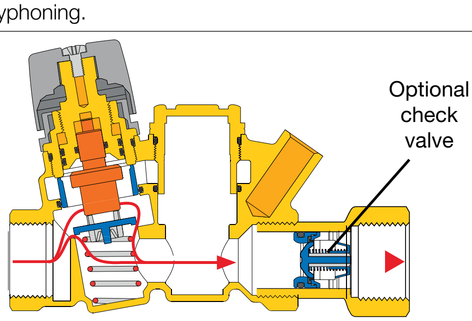
Code	A	B	B'*	C	D	Wt (lb/kg)
116240A(C)	½" NPT F	4"	5 7/16"	¾"	3"	1.7 / 0.75
116250A(C)	¾" NPT F	4"	5 5/8"	¾"	3"	1.5 / 0.70
116340A(C)	½" NPT F	4"	5 7/16"	¾"	3"	1.7 / 0.75
116350A(C)	¾" NPT F	4"	5 5/8"	¾"	3"	1.5 / 0.70

Operating principle

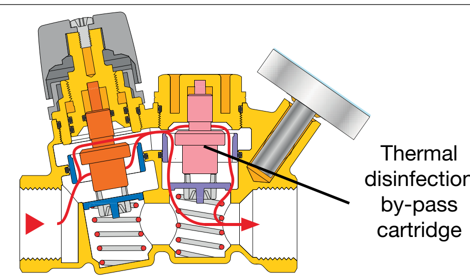
The ThermoSetter™ adjustable thermal balancing valve, 116 series models, installed at the end of each branch of the domestic hot water recirculation system, automatically maintains the set temperature. It controls the water flow rate according to the inlet temperature with the internal adjustable thermostatic cartridge. The thermostatic cartridge modulates the valve opening in response to changing water temperature, and when reaching the temperature setting, closes the valve to minimum flow position. A recirculation pump distributes flow to all the branches resulting in effective automatic thermal balancing. The automatic response allows each hot water branch to deliver hot water to each fixture. The ThermoSetter™ works perfectly with variable speed recirculation pumps for optimal energy usage.



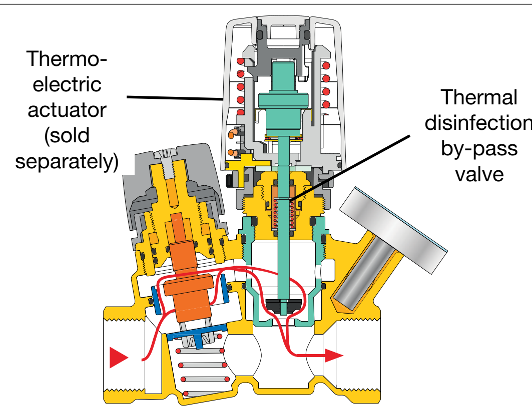
Optional check valve is available for all models, which protect against circuit thermo-syphoning.



For systems using thermal disinfection for Legionella growth protection, the 1162 series models incorporate a second thermostatic by-pass cartridge that activates at 160°F. A second flow path opens providing flow for the disinfection process which is independent of the primary balancing cartridge.



Alternately, the 1163 series models incorporate a by-pass valve for thermal disinfection which is activated by a optional field mounted thermo-electric actuator, code 656 series, controlled by an automation system.



Scald protection point-of-use thermostatic mixing valve

5213 series

ASSE 1070

ICC ES PMG LOW LEAD

Function

Thermostatic mixing valves are used in applications where the user must be protected from the danger of scalding caused by hot water. The Caleffi 5213 series provides water at a safe and usable temperature in situations where the control of the temperature of the water discharging from a terminal fitting is of the utmost importance, i.e. within hospitals, schools, nursing homes, etc. The valve is designed to prevent the flow of water discharging from the mixed water outlet in the event of the failure of hot or cold supply. The Caleffi 5213 series is a high performance combination thermostatic and pressure balanced mixing valve and is ASSE 1070 listed (temperature can not exceed 120°F). The valve is complete with check valve at both hot and cold inlets. Certified to ASSE 1070 and Low Lead Plumbing Law by ICC-ES.

Product range

5213_2A series	Scald protection and anti-chill point-of-use thermostatic mixing valve	connections ½", ¾", 1" NPT male union
5213_7A series	Scald protection and anti-chill point-of-use thermostatic mixing valve	connections ½", ¾", 1" PEX crimp union
5213_9A series	Scald protection and anti-chill point-of-use thermostatic mixing valve	connections ½", ¾", 1" sweat union
521333A	Scald protection and anti-chill point-of-use thermostatic mixing valve	connection 3/8" compression union

Technical specifications

Materials

- Body: low-lead brass (<0.25% Lead content)
- Regulating spindle: low-lead brass (<0.25% Lead content)
- Shutter, seats and slide guides: PPO
- Springs: stainless steel
- Seals: Peroxide-cured EPDM
- Cover: ABS

Performance

Setting range: 85–120° F (30–50° C)
Temperature set: must be commissioned on site to achieve desired temperature
Temperature control: ±3° F (±2° C)

Min. cold inlet temperature: 39° F (4° C)
Max. cold inlet temperature: 85° F (29° C)
Min. hot water inlet temperature: 120° F (49° C)
Max. hot water inlet temperature: 185° F (85° C)

Max. working pressure (static): 150 psi (10 bar)
Max. working pressure (dynamic): 70 psi (5 bar)
Min. working pressure (dynamic): 1.5 psi (0.1 bar)

Max. unbalanced dynamic supply ratio (H/C or C/H) : 6:1

Minimum temperature difference between hot water inlet and mixed water outlet to ensure stable operation: 18° F (10° C)
Minimum temperature difference between ,ixed water outlet and cold water inlet to ensure stable operation: 9° F (5° C)
Minimum flow to ensure stable operation: 0.5 gpm (2 L/min)

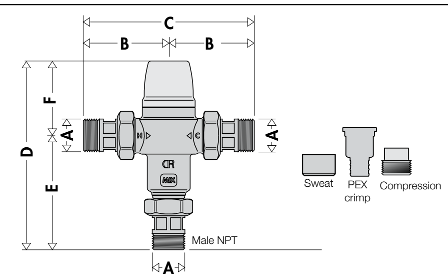
Connections

- NPT male union: ½", ¾", 1"
- sweat union: ½", ¾", 1"
- PEX crimp union: ½", ¾", 1"
- compression: 3/8"

Certifications

1. ASSE 1070/CSA B125.3, certified by ICC-ES, file PMG-1357.

2. NSF/ANSI 372-2011, Drinking Water System Components-Lead Content Reduction of Lead in Drinking Water Act, California Health and Safety Code 116875 S.3874, Reduction of Lead in Drinking Water Act, certified by ICC-ES, file PMG-1360.

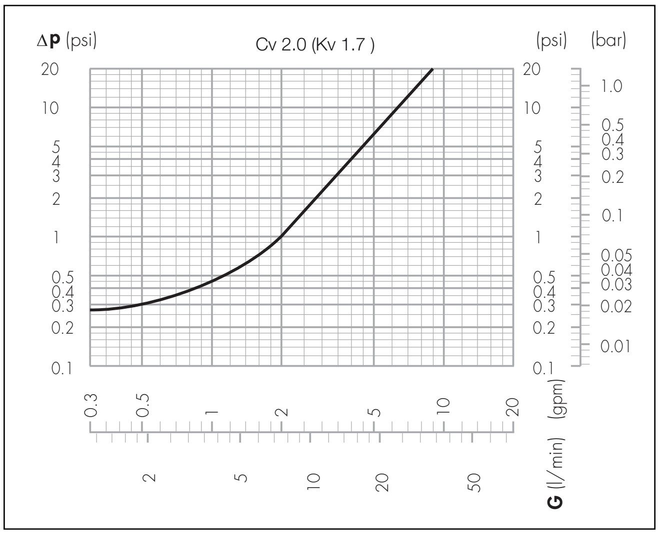


Code	A	B	C	D	E	F	Wt (lb)
521342A	½" MNPT	2 13/16 "	5 11/16 "	4 5/16 "	3"	1 15/16 "	2.0
521352A	¾" MNPT	2 13/16 "	5 11/16 "	4 5/16 "	3"	1 15/16 "	2.0
521362A	1" MNPT	2 15/16 "	5 7/8 "	5 3/16 "	3 ¼"	1 15/16 "	2.0
521347A	½" PEX crimp	3"	6"	5½"	3 5/8 "	1 15/16 "	2.0
521357A	¾" PEX crimp	3"	6"	5½"	3 5/8 "	1 15/16 "	2.0
521367A	1" PEX crimp	3 1/16 "	6 1/8 "	5 9/16 "	3 11/16 "	1 15/16 "	2.0
521349A	½" sweat	2 11/16 "	5 7/16 "	4 5/8 "	2 11/16 "	1 15/16 "	2.0
521359A	¾" sweat	2 7/8 "	5 ¾"	4 13/16 "	2 15/16 "	1 15/16 "	2.0
521369A	1" sweat	3 1/8 "	5 5/16 "	5 3/8 "	3 ¼"	1 15/16 "	2.0
521333A	3/8 " compression	2 11/16 "	5 3/8 "	5 3/16 "	3 5/16 "	1 15/16 "	2.0

Operating principle

The thermostatic mixing valve mixes hot and cold water in such a way as to maintain constant set temperature of the the mixed water at the outlet. A thermostatic element is fully immersed into the mixed water. This element then contracts or expands causing movement of the piston, closing either the hot or cold inlets, regulating the flow rates entering the valve. If there are variations of temperature or pressure at the inlets, the internal element automatically reacts to restore the original temperature setting. In the event of a failure of either the hot or cold supply, the piston will shut off, stopping water discharging from the mixed water outlet. The Caleffi 5213 series thermostatic mixing valve requires a minimum temperature differential from hot inlet to mixed water outlet of 18°F (10°C) to ensure the correct operation of the thermal shutoff function.

Flow curve



Use

The Caleffi 5213 series is a thermostatic mixing valve suitable for point of use application. For this reason, the flow rate through the valve is the same as that of the final outlet, e.g. thermostatic mixing valve or tap for washbasin, shower or bath. In order to ensure the set temperature, the thermostatic mixing valve must have a minimum flow rate of 0.5 gpm (2 l/min). The system must be sized in accordance with local regulations with regard to the nominal flow rate of each outlet.

Installation

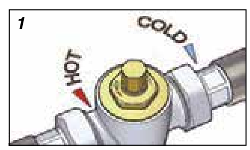
Before installing a Caleffi 5213 series three-way thermostatic mixing valve, the system must be inspected to ensure that its operating conditions are within the range of the mixing valve, checking, for example, the supply temperature, supply pressure, etc. Systems where the Caleffi 5213 series thermostatic mixing valve is to be fitted must be drained and cleaned out to remove any dirt or debris which may have accumulated during installation. The installation of strainers of appropriate capacity at the inlet of the water from the mains supply is always advisable. Caleffi 5213 series thermostatic mixing valves must be installed by qualified personnel in accordance with the diagrams in the product brochure, taking into account all current applicable standards.Caleffi 5213 series thermostatic mixing valves can be installed in any position, either vertical or horizontal, or upside down.
The following are shown on the thermostatic mixing valve body:
- Hot water inlet, marked “H” (Hot).
- Cold water inlet, marked “C” (Cold).
- Mixed water outlet, marked “MIX.

Temperature adjustment

Temperature setting can be adjusted by removing the cap from the valve body and reversing the cap onto the temperature adjustment spindle. In accordance with the scald-protection requirements, mixed water at the outlet of the sanitary fixtures must not exceed the following values:

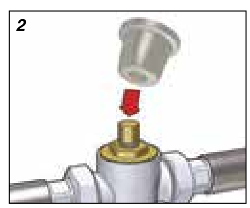
120°F (49°C) for domestic or normal buildings
110°F (43°C) for hospitals or special buildings
100°F (38°C) for children

Temperature setting can then be locked at the desired value using the locking nut.

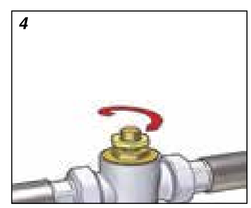


View of temperature adjustment

Temperature adjustment cap in place

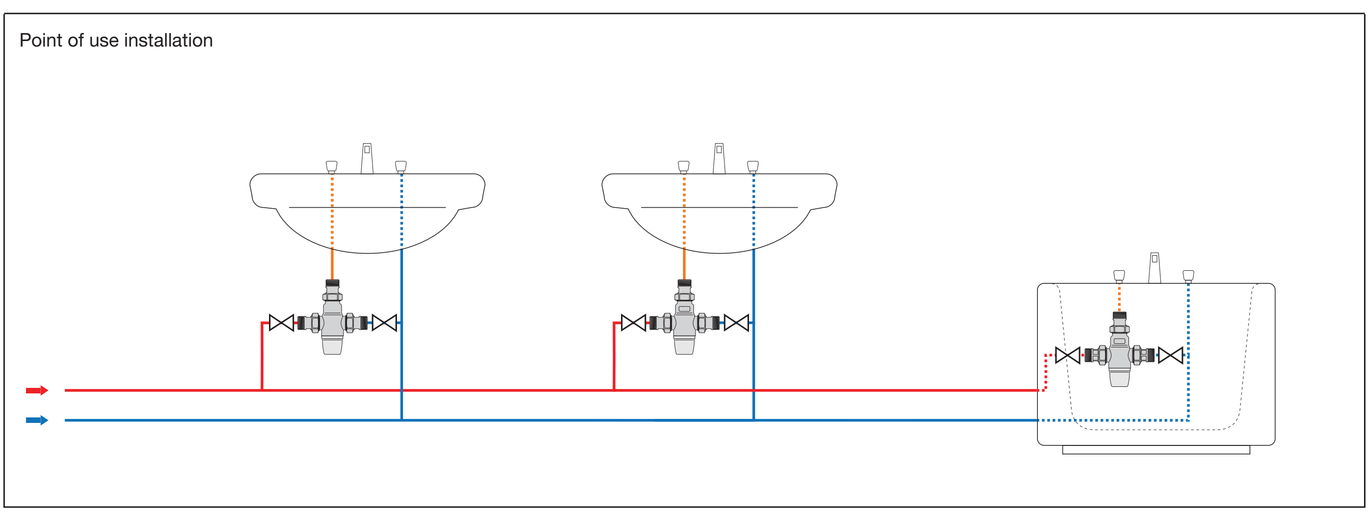


Fitting temperature adjustment cap



Locking adjustment spindle with locking nut

Application diagram



Adjustable three-way thermostatic mixing valves, high-flow

5231 series

ASSE 1017

Function

The thermostatic mixing valve is used in systems producing domestic hot water or in radiant heating systems. Its function is to maintain the temperature of the mixed water supplied to the user at a constant set value when there are variations in the supply pressure and temperature of the incoming hot and cold water or in the flow rate.

The 5231 series thermostatic mixing valves are ASSE 1017 approved for point of distribution and are designed specifically for systems requiring high flow rates and precise, stable temperature control. Optional stainless steel inlet port check valves are available separately, for field installation only.

This valve is certified by ICC-ES to be in compliance with the International Plumbing Code (IPC), International Residential Code (IRC), Uniform Plumbing Code (UPC), National Plumbing Code of Canada (NPC), and standards ASSE 1017-2009, and CSA B125.3-2012. It is certified by ICC-ES to be in compliance with standard NSF/ANSI 372-2011, Drinking Water System Components – Lead Content Reduction of Lead in Drinking Water Act, California Health and Safety Code 116875 S.3874, Reduction of Lead in Drinking Water Act.

Product range

Code 5231_0A Thermostatic mixing valve (ASSE 1017) with threaded connections................sizes 1", 1-1/4", 1-1/2", 2" union NPT male
Code 5231_8A Thermostatic mixing valve (ASSE 1017) with sweat connections................ sizes 1", 1-1/4". 1-1/2", 2" union sweat
Code 5231_9A Thermostatic mixing valve (ASSE 1017) replacement body without fittings or union nuts................sizes 1-1/2", 2" union thread
Code 523177A Thermostatic mixing valve (ASSE 1017) with sweat connections and outlet temperature gauge................sizes 1-1/4" union sweat

Technical specification

Materials

- Body: DZR low-lead brass
- Shutter: PPSG40
- Springs: Stainless steel
- Seals: EPDM
- Check valve extension (field installed): Stainless steel

Performance

Suitable fluds: Water, glycol solutions
Maximum percentage of glycol: 30% glycol solution
Setting range: See table on page 2
Temperature stability: ± 3°F (± 2°C)
Max working pressure (static): 200 psi (14 bar)
Max operating differential pressure: 75 psi (5 bar)
Hot water inlet temperature range: 120 – 195°F (49 – 91°C)
Cold water inlet temperature range: 39 – 80°F (3.9 – 26.6°C)
Mixed temperature adjustment range: 95 – 150°F (35 – 66°C)
Maximum inlet pressure ratio (H/C or C/H) for optimum performance: 2:1
Minimum temperature difference between hot water inlet and mixed water outlet for optimum performance: 20°F (11°C)
Maximum water hardness: 10 grains

Certifications

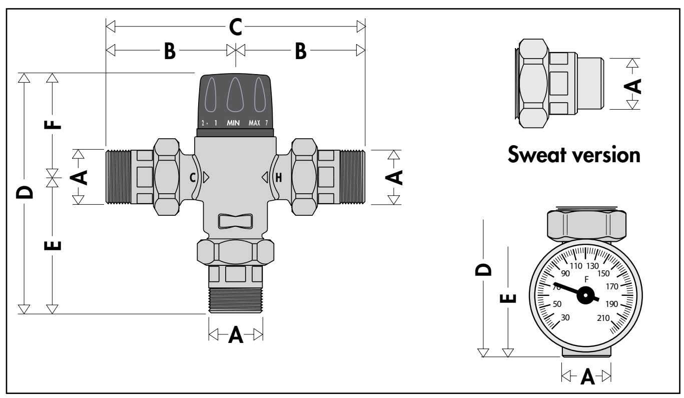
1. ASSE 1017/CSA B125.3, certified by ICC-ES, file PMG-1357

2. NSF/ANSI 372-2011, Drinking Water System Components-Lead Content Reduction of Lead in Drinking Water Act, California Health and Safety Code 116875 S.3874, Reduction of Lead in Drinking Water Act, certifed by ICC-ES, file PMG-1360.

Connections

- NPT male union: 1", 1-1/4", 1-1/2", 2"
- sweat union: 1", 1-1/4", 1-1/2", 2"

Dimensions



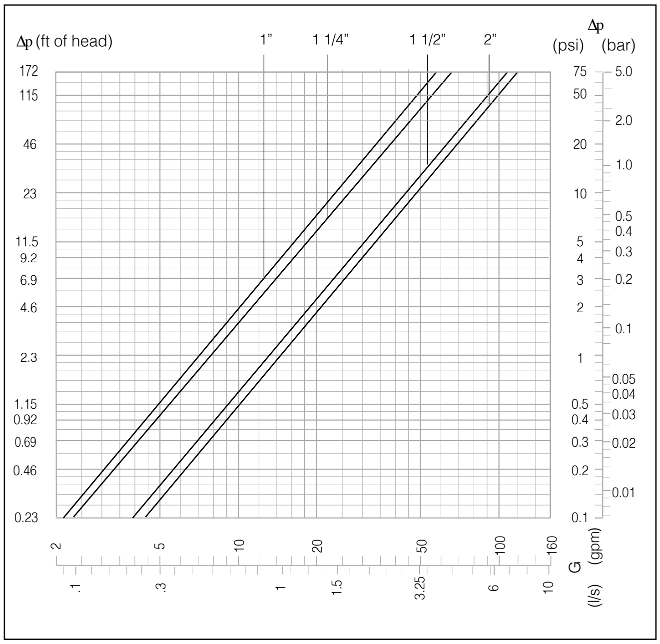
Code	A	B	C	D	E	F	Wt (lb)
523160A	1" NPT	4"	8"	7 5/8"	4 3/16"	3 3/8"	7.0
523168A	1" SWT	3 5/16"	6 5/8"	7"	3 1/2"	3 3/8"	7.0
523170A	1 1/4" NPT	4 1/8"	8 1/4"	7 3/4"	4 5/16"	3 3/8"	7.0
523177A	1 1/4" SWT	3 3/8"	6 3/4"	7 5/8"	4 1/8"	3 3/8"	9.0
523178A	1 1/4" SWT	3 3/8"	6 3/4"	7"	3 1/2"	3 3/8"	7.0
523180A	1 1/2" NPT	5 1/8"	10 1/4"	9 3/16"	5 7/16"	3 3/4"	17
523188A	1 1/2" SWT	4 1/16"	8 1/8"	8 1/8"	4 3/8"	3 3/4"	17
523190A	2" NPT	5 1/8"	10 1/4"	9 1/2"	5 3/4"	3 3/4"	18
523198A	2" SWT	4 5/16"	8 5/8"	8 5/8"	4 7/8"	3 3/4"	18

Operating principle

A thermostatic mixing valve mixes hot and cold water in such a way as to maintain a constant set temperature of the mixed water at the outlet. A thermostatic element is fully immersed into the mixed water. It then contracts or expands causing movement of the piston, closing either the hot or cold inlets, regulating the flow rates entering the valve. If there are variations of temperature or pressure at the inlets, the internal element automatically reacts attempting to restore the original temperature setting.

The Caleffi 5231 series mixing valves require a minimum temperature differential from hot inlet to mixed water outlet of 20°F (11°C) to ensure the correct operation, and maximum pressure difference between the hot and cold inlet parts no greater than 2:1 ratio. Softened water use is highly recommended as the warranty is voided if used on water with hardness greater than 10 grains.

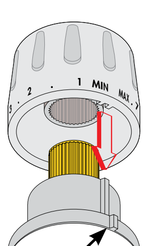
Flow curve



Flow should never exceed standards for pipe size and material.

Size	Connection	Model	Min. Flow* (GPM)	Max. Flow* (GPM)	CV
1"	NPT	523160A	4.4	40	7
1"	Sweat	523168A	4.4	40	7
1 ¼"	NPT	523170A	4.4	40	7.6
1 ¼"	Sweat w/ temp gauge	523177A	4.4	40	7.6
1¼"	Sweat	523178A	4.4	40	7.6
1 ½"	NPT	523180A	8.8	70	13
1 ½"	Sweat	523188A	8.8	70	13
2"	NPT	523190A	8.8	70	14.2
2"	Sweat	523198A	8.8	70	14.2

*Recommended flow rates for temperature stabilty: ± 3°F (± 2°C).



Index Point

Locking the setting

Position the handle to the number required with respect to the index point. Unscrew the head screw, pull off the handle and reposition it so that the handle fits into the internal slot of the knob. Tighten the head screw.

Installation

Before installing a Caleffi 5231 series three-way thermostatic mixing valve, the system must be inspected to ensure that its operating conditions are within the range of the mixing valve, checking, for example, the supply temperature, supply pressure, etc.

Systems where the 5231 series thermostatic mixing valve will be installed must be drained and cleaned out to remove any dirt or debris which may have accumulated during installation.

The installation of appropriately sized filters at the inlet from the main water supply is always advisable.

Caleffi 5231 series thermostatic mixing valves can be installed in any position, either vertical or horizontal.

The following are shown on the thermostatic mixing valve body:
- Hot water inlet, color red and marked "HOT".
- Cold water inlet, color blue and marked "COLD".
- Mixed water outlet, marked "MIX".

Check valves

In order to prevent undesirable backsiphonage, check valves should be installed in systems with thermostatic mixing valves. The 5231 is approved to ASSE 1017, and as such does not contain integral check valves. Caleffi offers inlet port check valve assemblies separately, for field installation only to the 5231 series valve.

Temperature adjustment

The temperature is set to the required value by means of the knob with the graduated scale, on the top of the valve.

Pos.	Min	1	2	3	4	5	6	7	Max
T (°F)	95	104	109	117	122	129	136	142	150
T (°C)	35	40	43	47	50	54	58	61	66

with: T_{HOT} = 155°F (68°C) · T_{COLD} = 55°F (13°C) · P_{INLET} = 43 psi (3 bar)

Construction details

Double seat

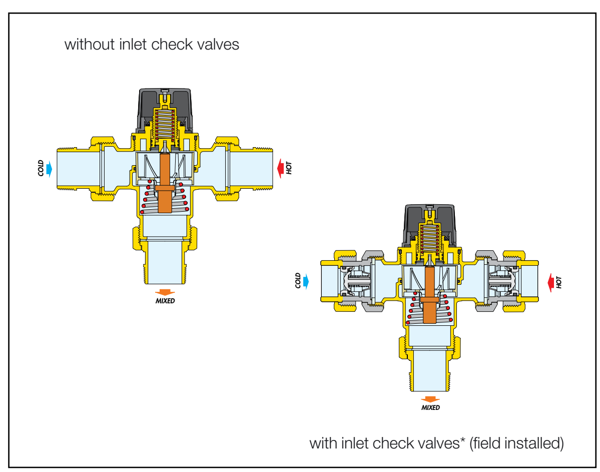
The mixing valve has a special actuator which acts on a double water passage seat. This produces a high flow rate with a reduced resistance, at the same time maintaining accurate temperature control.

Anti-wear surfaces

The materials of construction in the 5231 series thermostatic mixing valve reduces the problem of jamming caused by mineral deposits. All the working parts, such as the PPSG40 shutter and EPDM seals, are made of a special anti-scale material, with a low friction coefficient, providing long term high performance.

Low inertia thermostat

The temperature-sensitive element, the "motor" of the thermostatic mixing valve, is characterized by a low heat inertia; this means that it reacts rapidly to variations in the incoming temperature and pressure conditions, reducing the valve response times.



***Caleffi code NA10366: 1" , 1¼"; code NA10367: 1½", 2".**

DELTA2™ High-Low mixing valve

NA52367HL

Function

The Caleffi DELTA 2™ high-low thermostatic mixing valve system delivers tempered water for a wide range of flows in a single assembly, applicable for institutional and commercial applications such as hotels, nursing homes, hospitals and schools. The NA52367HL is furnished assembled and pressure tested with high range and low range thermostatic mixing valves along with a pressure reducing valve, to function as one system in providing a broad flow range from 1* gpm to 50 gpm. This one-piece assembly also contains an outlet thermometer, cold water inlet check valves, and shut-off ball valves.

ASSE 1003 ASSE 1017 ICC-ES PMG LOW LEAD

Product range

NA52367HL Adjustable thermostatic high-low mixing valve system ....connections 1" copper inlet, 1¼" copper outlet

Technical specifications

Materials

- Valve body:
  - 521101A: low-lead brass
  - 523179A: DZR low-lead brass
  - 535870A: DZR low-lead forged brass
- Shutter, seats and slide guides: PPSG40 & PPO
- Springs: stainless steel
- Seals (diaphgram 535870A): peroxide-cured EPDM

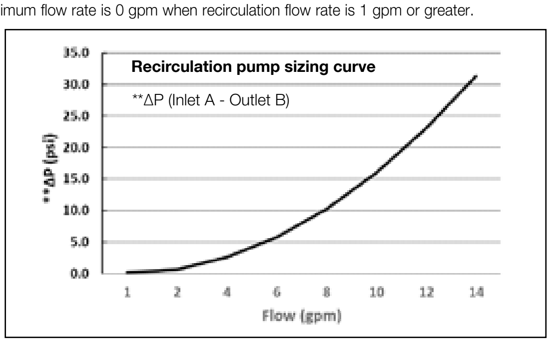
Performance

Suitable fluids:	water
Max. working pressure (static):	200 psi (14 bar)
Max. hot water inlet temperature:	180° F (80° C)
Mixed temperature setting range:	95 to 150° F (35 - 66° C)
Flow range:	1* to 50 gpm (3.8 to 190 l/min)
Connections:	- inlets: 1" copper; - outlet: 1¼" copper

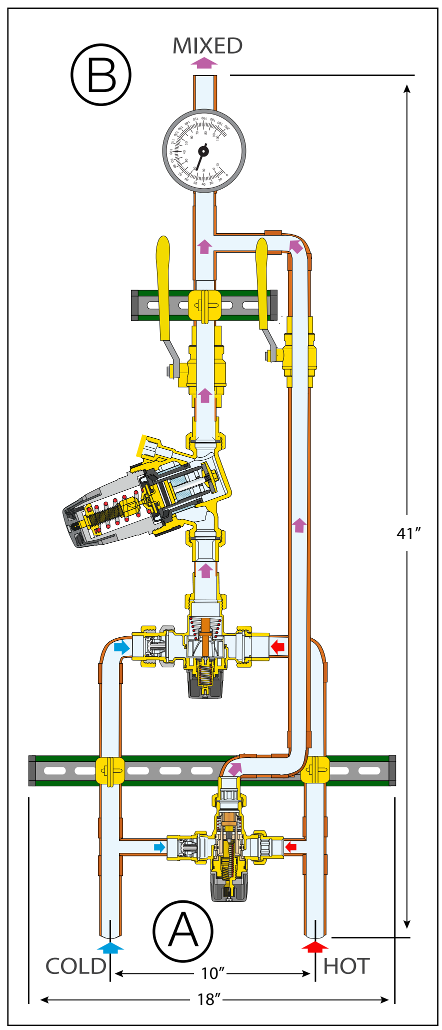
Thermostatic mixing valves meet requirements of ANSI/NSF 372-2011 and certified to ASSE 1017, CSA B125.3, UPC, IPC, Low Lead Laws and listed by ICC-ES for use in accordance with the U.S. and Canadian plumbing codes. Pressure reducing valve is certified to ASSE 1003, CSA B356, NSF61, NSF 372 Low Lead Laws and listed by ICC-ES.

Min Flow*	Pressure Drop (Inlet A - Outlet B)						
	5	10	15	20	25	30	PSI
	0.3	0.7	1.0	1.4	1.7	2.1	BAR
1.0	16	28	36	42	47	50	gpm
3.7	60	105	135	160	180	190	l/min

*Minimum flow rate is 0 gpm when recirculation flow rate is 1 gpm or greater.



Dimensions



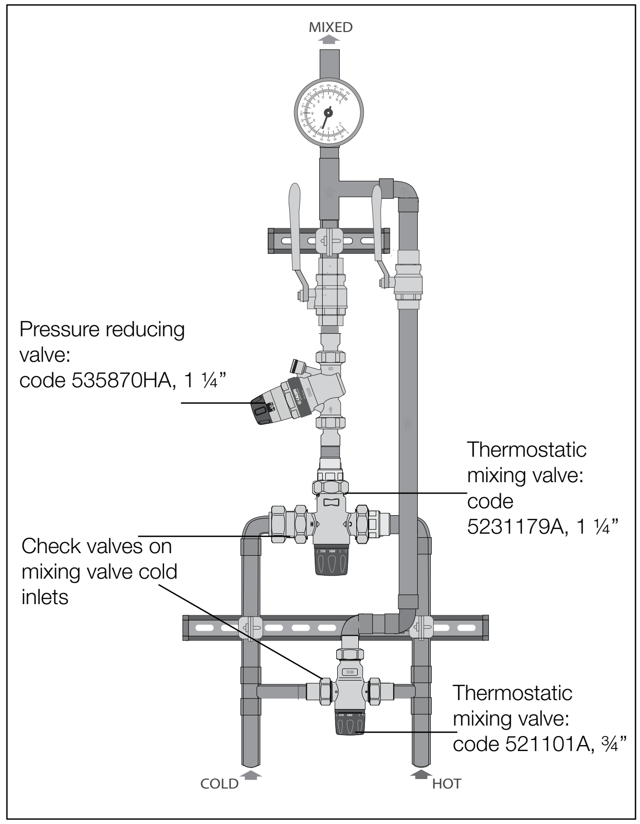
Operating Principle

The mixing valves are piped in parallel to the hot and cold inlet lines and the pressure reducing valve is piped on the outlet (mixed temperature) side of the larger thermostatic mixing valve. When demand is low, the small thermostatic mixing valve provides the needed water flow. When demand increases, indicated by increasing differential pressure in the system, the pressure reducing valve sees this differential and opens to allow flow through the larger thermostatic mixing valve.

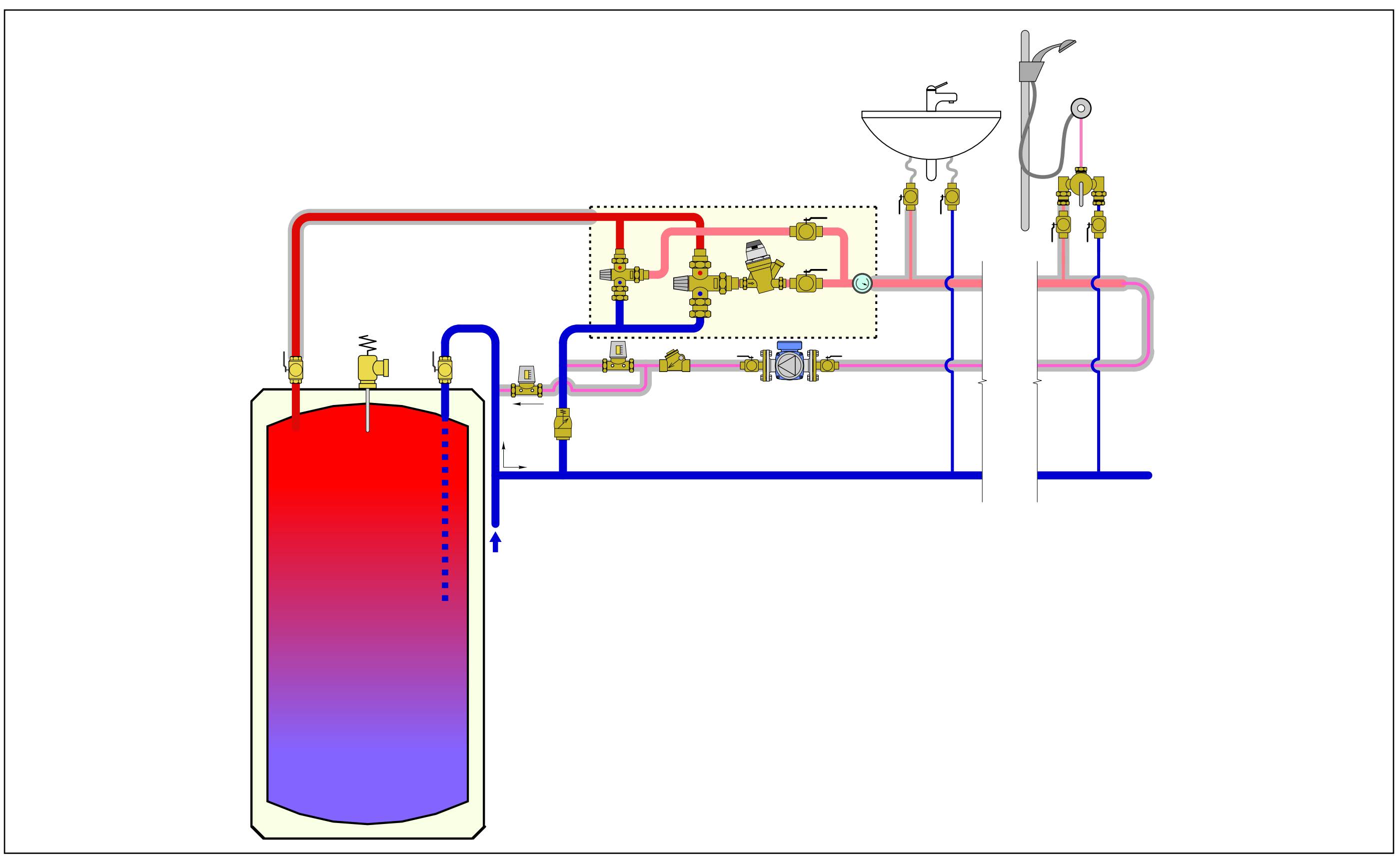
Use

Caleffi Delta2™ code NA52367HL high-flow thermostatic mixing valve is designed to be installed at the hot water heater. It is not designed to provide scald protection. For safety reasons, it is advisable to limit the maximum mixed water temperature to 120°F when anti-scald devices are not used at each fixture.

Construction details



Application diagram



Pre-adjustable pressure reducing valves

535H series

ASSE 1003

ICC ES PMG LOW LEAD

Function

Pressure reducing valves are devices which, when installed on water systems, reduce and stabilize the pressure of the water entering from the water supply main. This pressure often is too high and variable for domestic systems to operate correctly.

The 535H series pressure reducing valves, ideal for residential and commercial applications, feature a dial indicator with direct readout allowing easy pressure pre-adjustment. After installation, the valve will control at the pre-adjusted pressure setting.

The valve is constructed of DZR low-lead forged brass and incorporates a unique noise reducing and high flow seat design, is easily serviced with a replaceable cartridge and has an integral stainless steel filter (35 mesh), suitable for water systems that may contain sediment and debris.

The valve is ICC-ES certified to ASSE 1003, CSA B356, NSF 61, NSF 372, low lead laws and listed by ICC-ES. It meets codes IPC, IRC and UPC for use in accordance with the US and Canadian plumbing codes.

Product range

5353H series Pre-adjustable pressure reducing valve with or without pressure gauge and union NPT female threaded connections.. sizes ½", ¾", 1", 1¼" , 1½" & 2"

5356H series Pre-adjustable pressure reducing valve with or without pressure gauge and union press connections..sizes ¾" & 1"

5357H series Pre-adjustable pressure reducing valve with or without pressure gauge and union PEX crimp connections..sizes ¾" & 1"

5359H series Pre-adjustable pressure reducing valve with or without pressure gauge and union sweat connections... sizes ½", ¾", 1", 1¼" , 1½" & 2"

Technical specifications

Materials

- Body:	DZR low-lead forged brass EN 12165 CW724R
- Cover:	glass reinforced nylon PA66M40/1I
- Control stem:	stainless steel EN 10088-3 (AISI 303)
- Moving parts:	DZR low-lead brass EN 12165 CW724R
- Diaphragm:	peroxide-cured EPDM
- Seals:	peroxide-cured EPDM
- Compensation piston rings:	PTFE
- Filter:	stainless steel EN 10088-2 (AISI 304)
- Seat:	stainless steel EN 10088-3 (AISI 303)
- Shuttle:	PPSG40

Performance

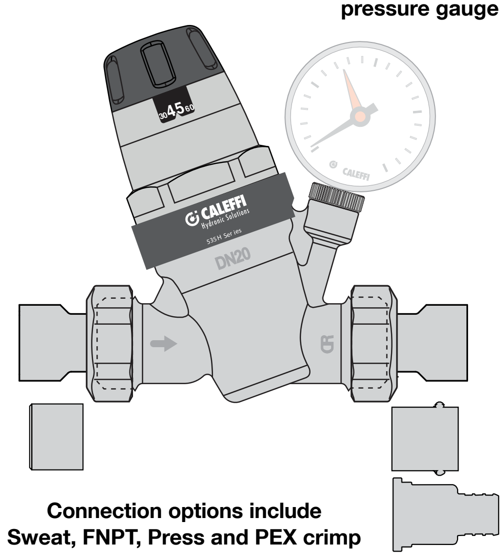
Suitable fluids:	water
Max. working pressure:	300 psi (20 bar)
Downstream pressure setting range:	15 - 90 psi (1 - 6 bar)
Factory setting:	45 psi (3 bar)
Maximum working temperature:	180°F (80°C)
Flow rates at 6 fps (gpm):	½": 7.3; ¾": 12.5; 1": 19.0; 1¼": 34.0; 1½": 44.0; 2": 70.0
Pressure gauge scale:	0 - 100 psi (0 - 7 bar)
Filter mesh size:	0.51 mm (35 mesh)

Certifications

1. ICC-ES certified to ASSE 1003, CSA B356, NSF 61 and NSF 372.
2. NSF/ANSI 372-2011, Drinking Water System Components-Lead Content Reduction of Lead in Drinking Water Act, California Health and Safety Code 116875 S.3874, Reduction in Drinking Water Act, certified by ICC-ES, file PMG-1360.
3. PEX crimp fittings comply with ASTM F 1807.

Connections

Main connections:	½", ¾", 1", 1¼", 1½" & 2" NPT female and sweat union ¾" & 1" press and PEX crimp union
Lay length (for ¾" press connection pipe cutout):	4¼"
Lay length (for 1" press connection pipe cutout):	5¾"
Pressure gauge connection:	1/8" NPT female



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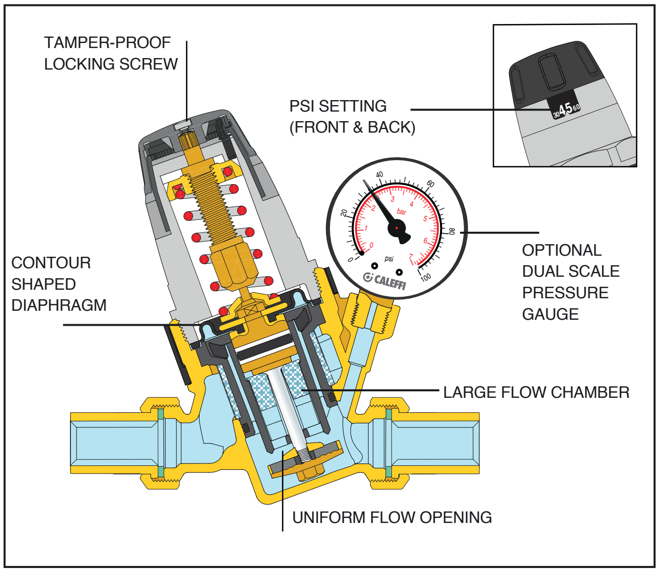
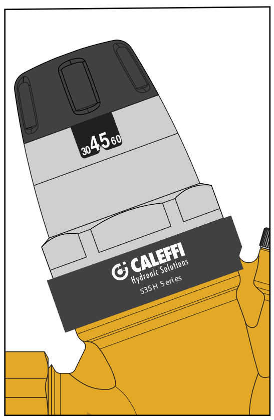
Construction details

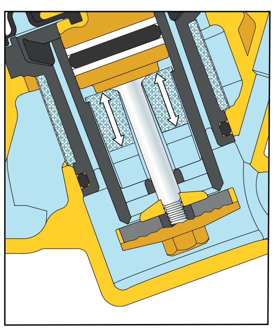


Pre-adjustment
Caleffi 535H series pressure reducing valves have an operating knob and a pressure setting indicator which is visible on both sides. This pressure indicator features incremental step operation, where the pressure can be adjusted continuously with the value displayed at 15 psi increments. The pressure can be pre-set to the desired value, even before the pressure reducing valve is installed.

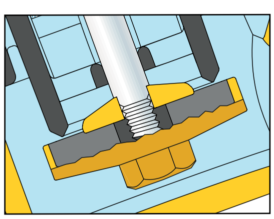


Adjustment lock
Tighten the screw in the top of the set point knob to prevent tampering.

Pressure balanced seat
Caleffi 535H series pressure reducing valves are designed with pressure balanced seats. This means the setting pressure value remains constant, regardless of variations in the upstream pressure value. In the figure, the thrust towards the opening is counterbalanced by the force created by the closing pressure acting on the compensating piston. Since the piston has a surface area equal to that of the shuttle, the two forces cancel out each other.

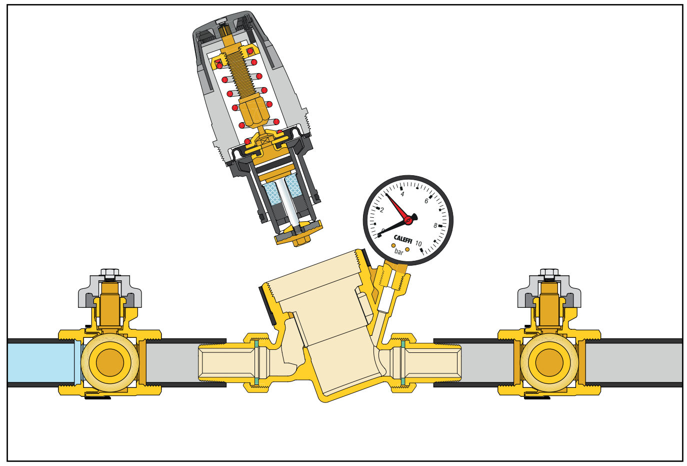


The special cross-section of the flow path between the seat and shuttle seal stablizes upstream pressure fluctuations and high flow rates, reducing noise levels caused by the flowing water.



Low head losses
The large cross-section flow chamber of the 535H series pressure reducing valve minimizes pressure drop within the valve which results in superior falloff pressure, enabling more flow capacity to fixtures.

Removable self-contained cartridge
The cartridge containing the diaphragm, filter, seat, shuttle and compensating piston is a pre-assembled self-contained unit with a cover, and can be removed to facilitate inspection and maintenance procedures. The special construction of the regulating element does not require any modification of the setting pressure value, which may be left unchanged.

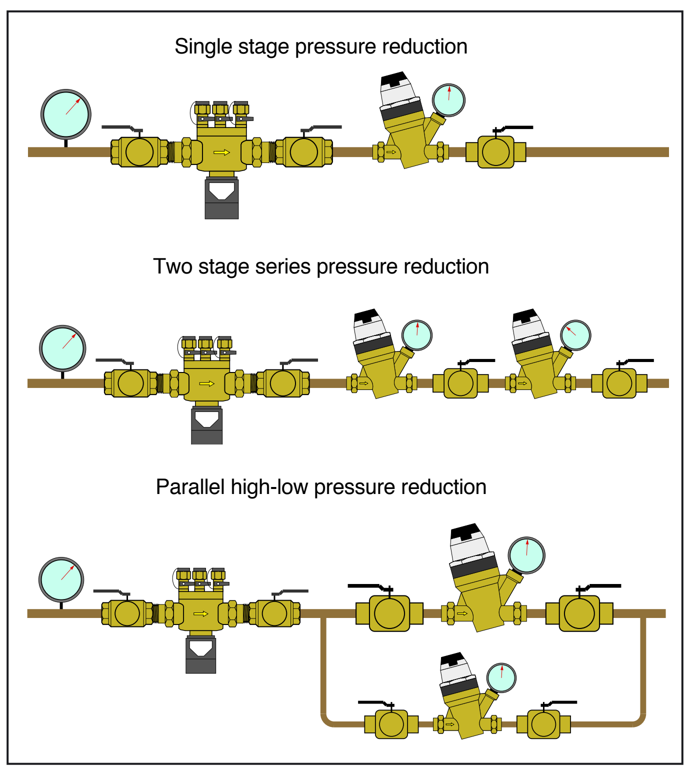


Contoured diaphram
The diaphragm is designed with a special shape to assure more accurate pressure regulation in accordance with downstream pressure fluctuations. This feature also extends the life of the valve, since the diaphragm is more resistant to sudden pressure fluctuations and to normal wear.

High temperatures
The materials used for the construction of the 535H series pressure reducing valves allow installation also on hot water booster circuits with temperatures up to 180°F (80°C).

Pressure gauge
The pressure gauge (optional) shows the exact downstream pressure value regardless of the adjusted knob pressure setting. For special conditions, e.g. in the presence of a downstream water heater, the pressure may rise above the set value.

Application diagram



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High Performance DHW Temperature Control

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- Automatically self-cleans to prevent scale formation.
- Exclusive NPT or sweat union connections.
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