Scald Hazards Associated with Low-Flow Showerheads

A White Paper

Developed by the American Society of Sanitary Engineering Scald Awareness Task Group

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Executive Summary

The American Society of Sanitary Engineering (ASSE) is an organization that is concerned about the safety and welfare of the public and the preservation of the environment through development of consensus plumbing product performance standards. The purpose of this document is to point out a safety hazard with low-flow showerheads when they are used in conjunction with non-automatic compensating type shower valves (see page #12 for definition). ASSE has a motto: "Prevention Rather Than Cure". In this case, ASSE is working to prevent scald injuries rather than deal with the burn injuries associated with low-flow showerheads on non-automatic compensating type shower valves that do not compensate for sudden changes in incoming pressure or temperature.

This white paper discusses the increased risk of scalding and thermal shock associated with low-flow showerheads used in conjunction with non-automatic compensating type shower valves and tub/shower valves in older homes and buildings. In recent years, there have been various water conservation programs that have promoted the use of water saving products, such as low-flow showerheads. The ASSE Scald Awareness Task Group was formed in the fall of 2009 to make the public aware of scald hazards associated with domestic hot water systems

The first task chosen by the ASSE Scald Awareness Task Group is to educate the plumbing industry and the public on the risks to personal safety that are associated with low-flow showerheads when they are used in conjunction with non-automatic compensating type shower and tub/shower valves. Non-automatic compensating shower valves and tub/shower valves are valves that do not compensate for any change in incoming water pressures or incoming water temperatures. When a non-automatic compensating type shower valve is used, any change in incoming water pressure or incoming water temperature will result in a change in outlet water temperature. A reduction in flow through a non-automatic compensating type shower valve or tub/shower valve can also influence the outlet temperature of the shower valve. The use of low-flow showerheads will decrease the flow rate through a non-automatic compensating type shower valve and the shower outlet of a tub/shower valve. Under most conditions, the magnitude of the change in outlet water temperature will increase as the flow rate through the non-automatic compensating type shower valve or tub/shower valve decreases. The magnitude of the change in outlet water temperature can be significant.

Automatic compensating type shower valves are temperature, pressure or combination temperature and pressure compensating type shower valves that react to changes in incoming pressure or temperature and adjust to compensate for changes in incoming pressure or temperature. Automatic compensating type shower valves conform to one of the industry standards: ASSE 1016, *Performance Requirements for Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations*, or ASME A112.18.1 /CSA B125.1-05, *Plumbing Supply Fittings*.

Section 2

Purpose

The Scald Awareness Task Group was formed in order to educate the plumbing industry and the general public on various ways someone can be exposed to scalding and thermal shock hazards. One of the first items the Task Group decided to take on was educating the public about the increased scalding dangers associated with low-flow showerheads when they are used in conjunction with non-automatic compensating type shower and tub/shower valves in older homes and buildings. Non-automatic compensating type shower and tub/shower valves are valves that do not compensate for sudden changes in incoming pressures and/or temperatures. These are generally the traditional two and three-handle type shower and tub/shower valves with the cold water handle to the right and the hot water handle to the left. There are also some models of single-handle shower valves that are not automatic compensating type shower valves. This white paper is intended to educate the public on the difference in types of shower and tub/shower valves and explain why there is an increased danger associated with installing a low-flow showerhead on a non-automatic compensating type shower or tub/shower valve.

Prior to 1992, many showerhead flow rates were in the range of three to seven gallons per minute. In 1992, the Energy Policy Act of 1992 mandated that the maximum flow rate from a showerhead shall not exceed 2.5 gallons per minute (GPM). Since the advent of the water conservation movement, many newer showerhead flow rates have been reduced to flow rates less than 2.5 gallons per minute (GPM).

NOTE:
LOW-FLOW SHOWERHEADS SHOULD NEVER BE USED WITH NON-AUTOMATIC COMPENSATING TYPE SHOWER OR TUB/SHOWER VALVES.

NON-AUTOMATIC COMPENSATING TYPE SHOWER VALVES SHOULD NOT BE USED IN ANY SHOWERING APPLICATIONS.

Restricting the water flow rate through a non-automatic compensating type shower valve or tub/shower valve is not recommended. A low-flow showerhead restricts the flow through these non-automatic compensating type valves and can lead to significant pressure imbalances, which can cause thermal shock and scalding issues.

NOTE:
THE MAXIMUM FLOW RATE OF A SHOWERHEAD SHOULD BE MATCHED WITH AN AUTOMATIC COMPENSATING SHOWER VALVE WITH A MINIMUM FLOW RATE EQUAL TO OR LOWER THAN THAT OF THE SHOWERHEAD. BOTH OF THESE FLOW RATES WILL BE QUOTED AT 45 psi.

The Problem

With a non-automatic compensating type shower or tub/shower valve, any change in incoming water pressure or temperature will result in a sudden change in outlet water temperature from the showerhead. The severity of the change in the outlet water temperature is dependent on many system related factors, such as: friction loss, pressure, incoming temperatures and pipe size. The user of a non-automatic compensating type shower or tub/shower valve could, without warning, be exposed to extreme variations in water temperatures, either cold or hot, when a low-flow showerhead is installed in the shower.

Additionally, sudden changes in pressures are often caused by water flowing from a nearby plumbing fixture, causing a pressure drop in the cold or hot water piping being used during a shower. The sudden change in temperature is also known as thermal shock. The most common instance of thermal shock occurs when someone is in a shower and a nearby cold water fixture (such as a flushed toilet) is used, which causes the cold water pressure to drop lower than the hot water supply pressure.

Non-automatic compensating type shower and tub/shower valves **DO NOT** have the safety features that are commonly found on automatic compensating type valves. These safety features include automatic adjustment for changes in incoming pressure or temperature, check valves on the inlets to prevent crossover of flow (when required) and adjustable temperature limit stops, which when properly set, can limit the maximum temperature of the water flowing from the showerhead.

Many well intentioned, yet uninformed entities and web sites are recommending turning the thermostat down on the water heater to prevent scalding. Water heater thermostats cannot be relied upon for controlling the outlet temperature of the water heater because the thermostat is located near the bottom of the water heater and only senses the incoming cold water temperature. The thermostat is placed near the bottom of the heater to sense incoming cold water and anticipate when to cycle the burner “on” and “off”. A water heater thermostat set at 120 degrees Fahrenheit will cycle “on” around 105 degrees Fahrenheit and cycle “off” around 135 degrees Fahrenheit. The hot water rises to the top of the heater and it is not uncommon to find 155 degree hot water in the top of a water heater that is set at 120 degrees Fahrenheit. Therefore, the water heater thermostat cannot be relied upon to control the outlet temperature of a water heater.

Section 4

Examples of the Problem

EXAMPLE 1:
An individual is taking a shower and has adjusted their two-handle non-automatic compensating type shower valve to the desired mixed water temperature by proportioning the hot and cold water supplies with the shower or tub/shower valve handles. Moments into the shower, another individual in the same home flushes a toilet or uses cold water at another plumbing supply fitting outlet. The loss of cold water pressure caused by the flushing of a toilet can result in an immediate increase in the shower water temperature. This immediate increase in shower water temperature can cause scalding or thermal shock to the individual.

EXAMPLE 2:
An individual is taking a shower and has adjusted their single-handle non-automatic compensating type shower valve to the desired mixed water temperature by rotating the shower control handle to the desired shower water temperature. Moments into the shower, another individual in the same apartment building turns on the dishwasher or clothes washer which draws hot water only. A dishwasher or clothes washer can use a significant amount of hot water and the increased hot water demand can cause a reduction in the hot water pressure at another plumbing fixture, such as the shower in the same building if used simultaneously. The loss of hot water pressure at the shower can cause an immediate decrease in the shower water temperature. This can thermally shock the individual and cause them to react quickly to the sudden change in water temperature in an attempt to avoid or move out of the shower stream. These types of quick movements in a wet, soapy and slippery shower compartment can cause the individual to slip and fall, which may result in serious injury. It is not uncommon for someone who experiences thermal shock to slip and fall in a bathtub and shower.

EXAMPLE 3:
When a thermal shock incident occurs with either hot or cold water, it can turn into a scalding incident if they grab the shower controls on their way down and inadvertently adjust the water to a very hot water temperature. If their slip and fall injury incapacitates them with a head injury or a broken bone, they may not be able to get out of harm’s way and a thermal shock injury can turn into a scald injury.

Additional Issues

Water Heater Thermostats Cannot Control the Water Heater Outlet Temperatures!

The latest editions of the model plumbing codes do not allow the thermostat on the water heater to be used for controlling the final temperature at plumbing fixtures for scald prevention purposes.

A water heater thermostat that is set at 120 degrees is capable of delivering hot water in excess of 155 degrees Fahrenheit from the top of a storage type water heater. The water heater thermostat is located near the bottom of a water heater and senses the incoming cold water near the bottom of a water heater. The water heater thermostat is simply a burner control and it can allow the temperature to fluctuate as much as 35 degrees above the thermostat set point because hot water rises inside the hot water tank.

It is not possible to set a water heater thermostat at a given temperature and get a relatively constant temperature of hot water.

Most water heater manufacturers recommend installing thermostatic mixing valves conforming to ASSE 1017, *Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems*, or ASSE 1070, *Performance Requirements for Water Temperature Limiting Devices*, on the outlet of the water heater for tempering of the hot water to a safe temperature if the hot water is going to be used for bathing, showering or washing purposes.

Temperatures over 151 degrees Fahrenheit are extremely high temperatures and can cause serious second and third degree scald burns in an instant of contact with adult skin.
See Section 7 - "Water Temperature Effects on Adult Skin".

The Solution to the Problem

Safety and water conservation are very important issues to ASSE. However, safety is more important than water conservation in some cases. When a shower or tub/shower valve is being retrofitted with a new water conserving showerhead, it is extremely important to make sure that the new low-flow showerhead is installed on an automatic compensating type shower valve that conforms to ASSE 1016, *Performance Requirements for Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations*, or ASME A112.18.1016/CSA B125.16, *Plumbing Supply Fittings*, that will compensate for changes in incoming pressures and/or temperatures at the lower flow rates. We need to save water wisely by matching the flow rate of the showerhead with the flow rate of the shower valve in order to prevent a serious injury to someone using a shower.

For the safety of you, your family and the public, it is recommended that a properly trained and licensed plumbing contractor be hired to inspect your shower valve to make sure it is an automatic compensating type shower valve that meets the code required industry standards for shower valves. Follow the manufacturer's recommended installation instructions for proper installation and adjust the maximum temperature limit stop to a safe temperature. The plumbing contractor should also perform a flow test with the new low-flow showerhead attached by flowing water from nearby fixtures that utilize hot and cold water to see if there is a sudden change in temperature while the shower is flowing and the other fixtures are being used. All work should be completed in accordance with local codes.

The installer should check the manufacturer's recommended minimum flow rate for the shower or tub/shower valve when installing only a new water saver showerhead. If the recommended minimum flow rate of the shower or tub/shower valve is greater than the flow rate of the new water saver showerhead, replace the valve with one that matches the flow rate of the showerhead.

YOU SHOULD NEVER RELY ON SIMPLY TURNING THE THERMOSTAT ON YOUR WATER HEATER TO A LOWER TEMPERATURE TO CONTROL THE WATER TEMPERATURE AT A SHOWERHEAD OR TUB SPOUT.

Tables

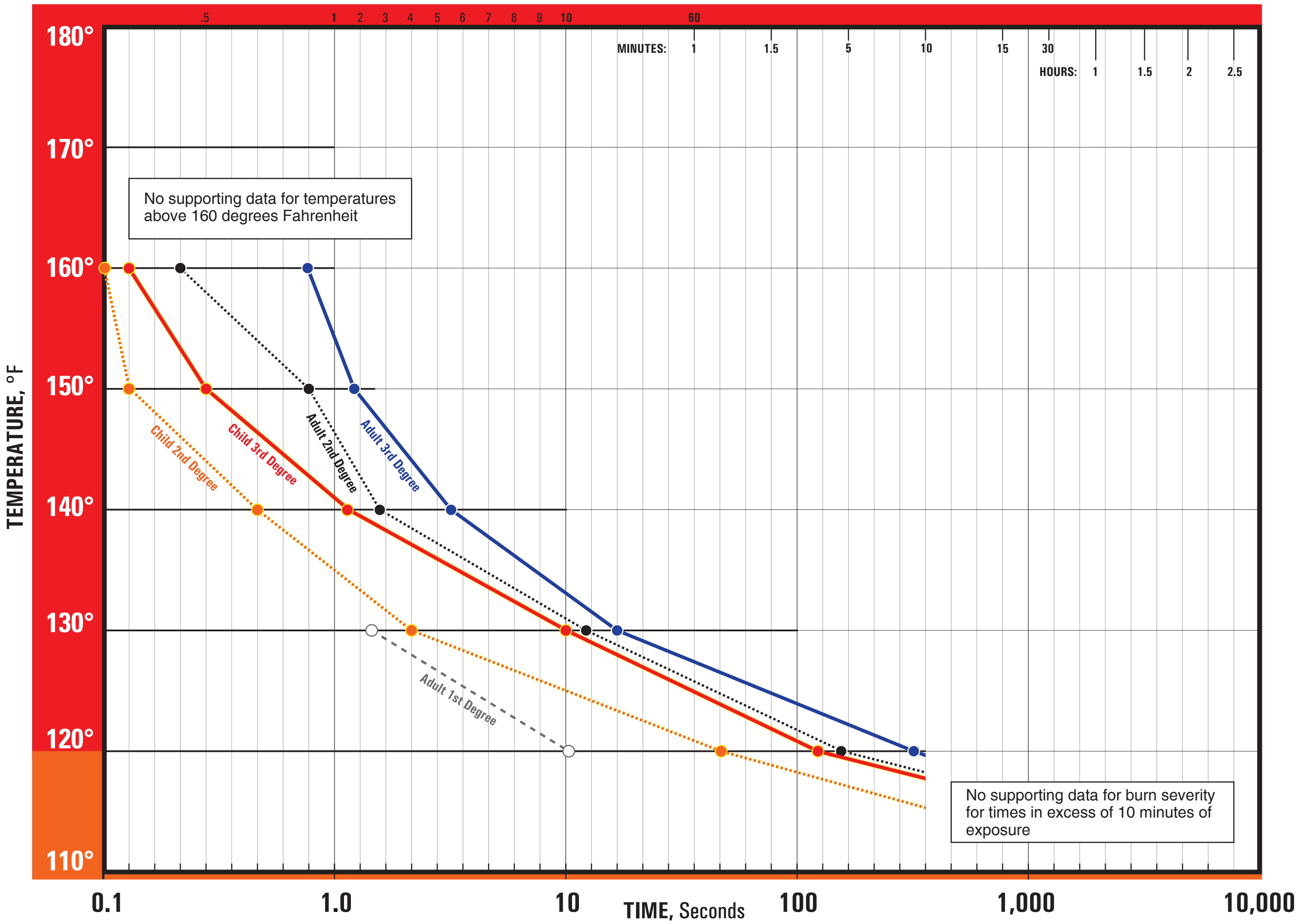
Table 1 - Water Temperature Effects on Adult Skin
(Source: Report prepared by Dr. Moritz and Dr. Henriques at Harvard Medical School in the 1940s)

TEMPERATURE Degrees Fahrenheit	TIME EXPOSURE FOR EACH TYPE OF BURN INJURY 2nd Degree Burn	 3rd Degree Burn
111	220 Minutes	400 Minutes
113	120 Minutes	180 Minutes
115	30 Minutes	60 Minutes
118	15 Minutes	20 Minutes
120	5 Minutes	10 Minutes
124	2 Minutes	4.2 Minutes
130	18 Seconds	30 Seconds
140	3 Seconds	5 Seconds
150	Instant	<2 Seconds
158	Instant	<1 Second

2nd Degree Burns include blistering and scarring
3rd Degree Burns cause irreversible damage to epidermis and sub-dermal tissue

Graph 1 - Time vs. Burn Type and Temperature

TIME VS. BURN TYPE AND TEMPERATURE



DEGREES F:	110	115	120	130	140	150	160
	HOURS	MINUTES		SECONDS			
ADULT, 3rd Degree	6.7	60	9.3	30	5.4	1.8	0.9
ADULT, 2nd Degree	3.6	30	4.8	18	2.8	0.9	0.4
ADULT, 1st Degree			0.2	2.3			
CHILD, 3rd Degree	2.8	20	3.1	10	1.5	0.5	0.2
CHILD, 2nd Degree	2.5	11	1.2	4	0.7	0.2	0.1
REF: Pain Threshold for Adults is 106 - 108 Degrees F							

Graph and chart modified from data gathered by Dr. D. Bynum, Jr. from a 1993 ASSE EJ Zimmer Refresher Course presentation 'The Anti-Scald Issue' by R.L. Martin & J. Richardson

U. S. Burn Statistics

BURN STATISTICS:

1. Hot tap water accounts for nearly one-fourth of all scald burns among children and is associated with more deaths and hospitalizations than other hot liquid burns. Tap water burns most often occur in the bathroom, and tend to be more severe and cover a larger portion of the body than other scald burns. The average bathtub scald burn covers 12% of the body surface with a full thickness, third-degree burn. Approximately 42% of scald burns involve more than 10% of a child's total body surface area and most likely involve the trunk, arms and legs.

2. An average of 12 children ages 14 and under die from scald burn-related injuries each year. Children ages 4 and under account for nearly all of these deaths.

3. Among children ages 4 and under hospitalized for burn-related injuries, it is estimated that 65% are treated for scald burns.

(Source: National Safe Kids)

INCREASED RISK OF SCALDING TO THE ELDERLY

The National Burn Information Exchange states the elderly are at an increased risk of scalding because their reactions are slower and their skin is thinner. The National Burn Information Exchange web site indicates that after the age of 60, the risk of a burn injury is greater than at any time since childhood and the average size of the burn is larger than any other age group.

(Source: http://www.burnsurvivor.com/burn_statistics.html)

INCREASED RISK OF SCALDING TO CHILDREN

In 1999, an estimated 99,500 children ages 14 and under were treated in hospital emergency rooms for burn-related injuries. Of these injuries, 23,620 were scald burns.

(Source: Oregon Safe Kids)

THE NATIONAL COALITION TO PREVENT CHILDHOOD INJURY

A group of 80 civic, health and professional groups based in Washington, DC, say scald burns account for about 100 deaths a year, most of them children under 5, or adults over 65. Accidental or non-accidental (as in cases of child abuse) scald injuries often cover a large area of the body, leading to high rates of illness and death. Certain segments of the population are more susceptible to scald injuries, particularly children under 5 years of age, adults over 65 years of age and persons who are physically or mentally challenged.

Section 9

Definitions

Automatic Compensating Type Shower Valve – One of three types of valves that compensate for changes in incoming pressure, temperature or pressure and temperature. These valves conform to the following consensus industry standards: ASSE 1016, *Performance Requirements for Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations*, or ASME A112.18.1 /CSA B125.1-05, *Plumbing Supply Fittings*.

See the three types of valves below:

1. **Pressure Balancing Type Shower Valve** - A pressure balancing valve (Type P) which senses incoming hot and cold water pressures and compensates for fluctuations in either hot or cold water to stabilize outlet temperature.

2. **Thermostatic Type Shower Valve** - A thermostatic balancing valve (Type T) which senses outlet temperature and compensates for fluctuations in either incoming hot and cold water temperatures and/or pressure to stabilize the outlet temperature.

3. **Combination Thermostatic and Pressure Balancing Type Shower Valve** - A combination thermostatic/pressure balancing valve (Type TP) which senses outlet temperature and incoming hot and cold water pressures and compensates for fluctuations in incoming hot and cold water temperatures and/or pressures to stabilize the outlet temperature.

Compensating Type Shower Valve – See "Automatic Compensating Type Shower Valve".

Low-Flow Showerhead – Any showerhead that flows less than 2.5 gallons per minute (GPM).

Non-Automatic Compensating Type Shower Valve and/or Tub/Shower Combination Valve – A non-automatic compensating type shower valve and/or tub/shower combination valve is a valve that does not compensate for changes in incoming pressure, temperature or pressure and temperature. Non-automatic compensating type valves do not prevent crossover flow between the hot and cold water supplies and they do not have a maximum temperature limit adjustment to limit the hot water to a maximum of 120 degrees Fahrenheit. Non-automatic compensating type shower valves can be single-handle valves, two-handle shower valves, or three-handle shower valves without a pressure balancing element to compensate for fluctuations in incoming pressures or a thermostatic element to compensate for incoming temperature changes. Non-automatic compensating type shower valves increase the risk of thermal shock and scalding, and the risk is more severe as the flows through the valve are reduced allowing a very minor pressure disturbance to significantly affect the outlet temperature of the shower head served by these types of valves.

Scald Prevention Type, Shower Valve – See "Automatic Compensating Type Shower Valve".

Scalding – Hot water exposure for a time period long enough to cause a thermal injury. Scald burn injuries can increase in severity at higher hot water temperatures or with longer exposures to a given hot water temperature. *(See Section 7 - Water Temperature Effects on Adult Skin)*

Thermal Shock – A significant sudden change in temperature from hot to cold, cold to hot, or hot to hotter that causes a bather to violently react, which can lead to a slip and fall injury. Sudden changes in temperature have also been known to cause seizures in persons who have a history of neurological disorders or epilepsy.

First-Degree Burn - First-degree burns are red and very sensitive to touch, and the skin will appear bleached when light pressure is applied. First-degree burns involve minimal tissue damage and involve the epidermis (skin surface). These burns affect the outer-layer of skin, causing pain, redness and swelling. Sunburn is a good example of a first-degree burn.

Second-Degree Burn - Second-degree burns affect both the outer-layer (epidermis) and the under-lying layer of skin (dermis) causing redness, pain, swelling and blisters. These burns often affect sweat glands and hair follicles. If a deep second-degree burn is not properly treated, swelling and decreased blood flow in the tissue can result in the burn becoming a third-degree burn.

Third-Degree Burn - Third-degree burns affect the epidermis, dermis and hypodermis, causing charring of skin or a translucent white color, with coagulated vessels visible just below the skin surface. These burn areas may be numb, but the person may complain of pain. This pain is usually caused by second-degree burns. Healing from third-degree burns is very slow due the skin tissue and structures being destroyed. Third-degree burns usually result in extensive scarring.

At the 2009 Annual Meeting, *the subject of doing something to make the general public more aware of the potential scald issues relating to plumbing systems was discussed and the Scald Awareness Task Group was formed. A call was made asking for volunteers to assist in the development of a white paper on this subject.*

Recognition is given to the 24 individuals who volunteered their time and expertise to this project. This group is made up of: 7 manufacturers, 5 engineers, 3 consultants, 2 master plumbers, 2 members of general interest, 2 industry associations, 1 inspector, 1 test laboratory and 1 member of labor.

ASSE extends its sincerest gratitude to all of the members of this group for their dedication to this project.