Plumbing System Design to Prevent Scalds

Domestic Hot Water Systems

- *Water Heaters*
- *Mixing Valves*
- *Circulators*
- *Tanks*
- *Specialties*
- *Scalding & Legionella Prevention*

October 16, 2012 Troy, MI

Common Plumbing Design Problems

Sustainable vs Unsustainable Hot Water Systems

Instructor:

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Domestic Hot Water System Design Issues

- **Hot Water Fixtures**
- Demand in GPM, GPH or Fixture Units/# People
- Water Heater Sizing
- Temperature Controls (Mixing Valves, Etc)
- Pipe routing to minimize dead legs.
- Hot Water Temperature Maintenance.
  - Pumps
  - Heating Cables
- Hot Water Velocity/Pipe Sizing
- Max. and Min. Temperatures Per ASHRAE 188

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Hot Water Usage Fixtures

- Bathtub
- Shower
- Tub/Shower
- Kitchen Sink
- Sink
- Lavatory
- Clothes Washer
- Dishwasher
- HW Hose Station

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Most manufacturers have sizing guides

- GPM flow rates
- Gallons per hour flow rate based on input of building type, fixture types and fixture quantities.
- Fixture Unit Values
- Number of people in a residential application.

Per Person Sizing Method

Residential Water Heater Sizing Guide			
Family Size	**Demand**	**Gallon Capacity Required**	
		Electric	Gas
 **5+**	High	-	**75**
	Regular/Low	**80**	**50**
 **3-4**	High	**80**	**50-75**
	Regular/Low	**50**	**40**
 **2-3**	High	**50**	**40-50**
	Regular/Low	**40**	**40**
 **1-2**	High	**40-50**	**40-50**
	Regular/Low	**30**	**30**

This chart is for determining appropriate water heater capacity in response to individual family requirements. Individual use may vary. Sizing is based on 3 gallons per minute shower head and standard bathtub. Accommodations for larger capacity and higher recovery water heaters should be made for high demand conditions.

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  - **Pumps,**
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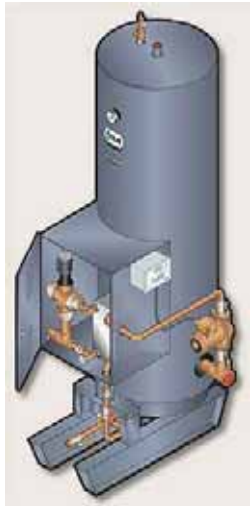
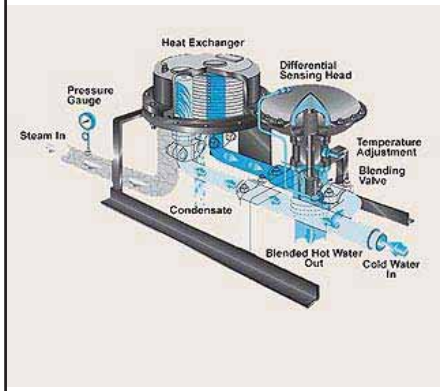
Water Heaters

Water Heaters





ASSE 1016 shower valves

310

3000

4000

7000

ASSE 1017 Master Thermostatic Mixing Valves

61

66

67

802

801

805

ASSE 1070 Point-of-use Temperature Limiting Valves

310

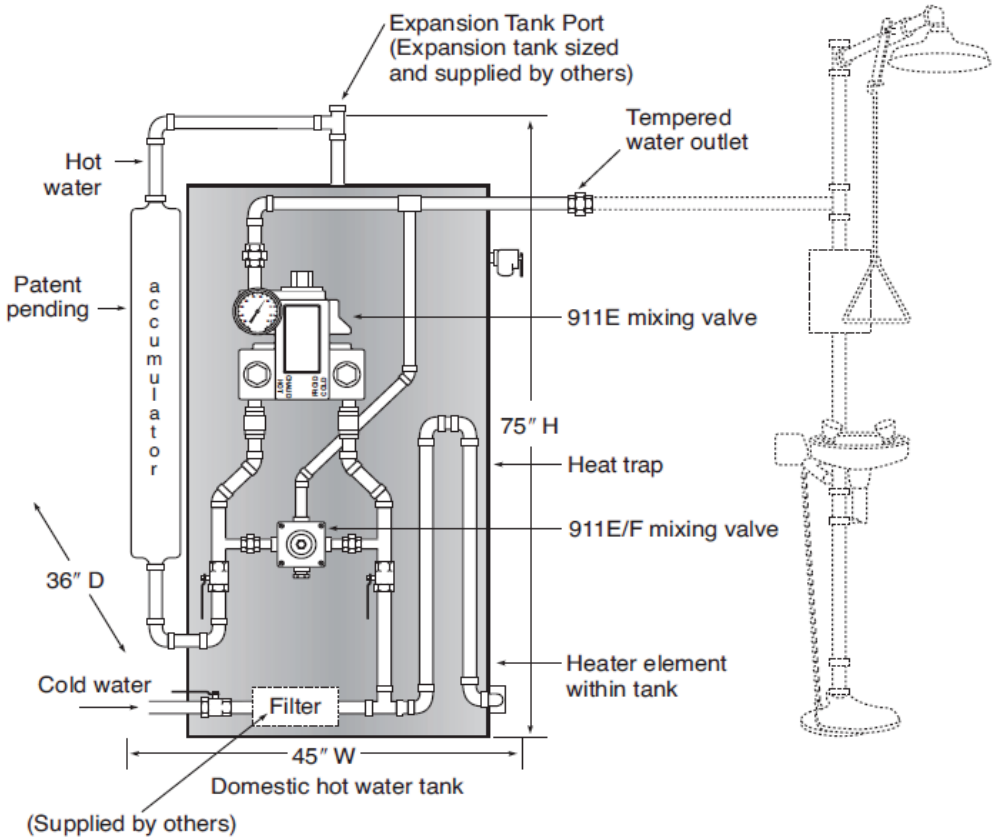
516

570

TMM1070

ASSE 1071 Emergency Shower Valves

ASSE 1071 Emergency Shower valves



Circulating Pumps

Residential and Light Commercial Circulators

- Wet Rotor Circulators
- Closed impeller design improves operating efficiency

- Easily handles dirty water conditions
- Rugged, compact design
- Close-coupled dry motor
- Permanently lubricated Sealed precision bearings
- Quiet operations in hydronic, radiant and geothermal heating and cooling systems
- Available in **cast iron** and **bronze pump body**

Glass Lined Steel Tanks

Water Storage Tanks
- Insulation and Topcoat (PDF)
- Chilled Water Buffer Tanks (PDF)
- Air Eliminator Tanks (PDF)
- Solar Tanks

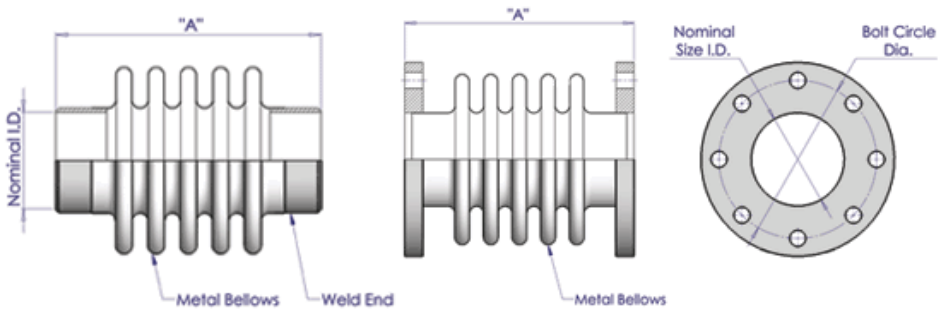
Hot Water Generators
- Specifications
- Performance Ratings
- Indirect Water Heaters

General Process Tanks
- Air Receivers
- Boiler Blow-Off Tanks
- Surge Tanks
- All Purpose Storage Tanks
- Chemical Mixers, Reactors & Storage Vessels
- Stainless Steel Tanks

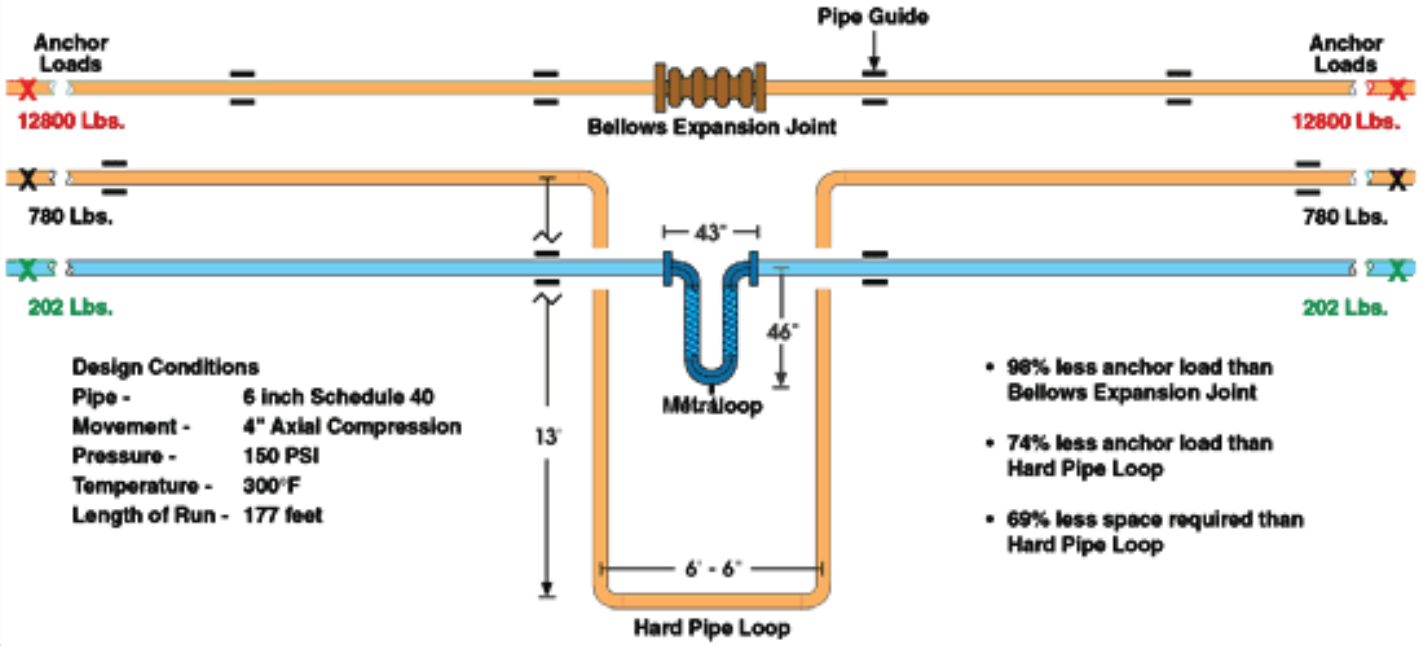
Pipes and Fittings
- Reglassing Services
- Skid Mounted Systems
- Linings Ultonium
- Ultonium II
- Epoxy
- Niles Steel Shield
- Sludge Block
- Specifications
- Sparge-a-tron 2000

Thermometers, Gauges, Accessories

Expansion Joints & Loops



Drawn to Scale

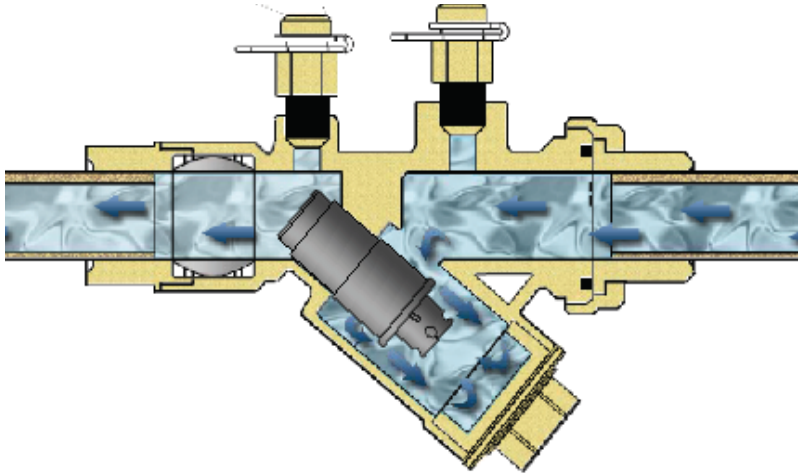


Design Conditions

Pipe -	6 inch Schedule 40
Movement -	4" Axial Compression
Pressure -	150 PSI
Temperature -	300°F
Length of Run -	177 feet

- 96% less anchor load than Bellows Expansion Joint
- 74% less anchor load than Hard Pipe Loop
- 69% less space required than Hard Pipe Loop

Flow Control/Balancing Valves



Chimneys Not PVC flues

Plumbing Engineer

A TWB Publication

The Authoritative Source for Plumbing, Hydronics, Fire Protection and PVF

SEARCH

Code Update

Email Page

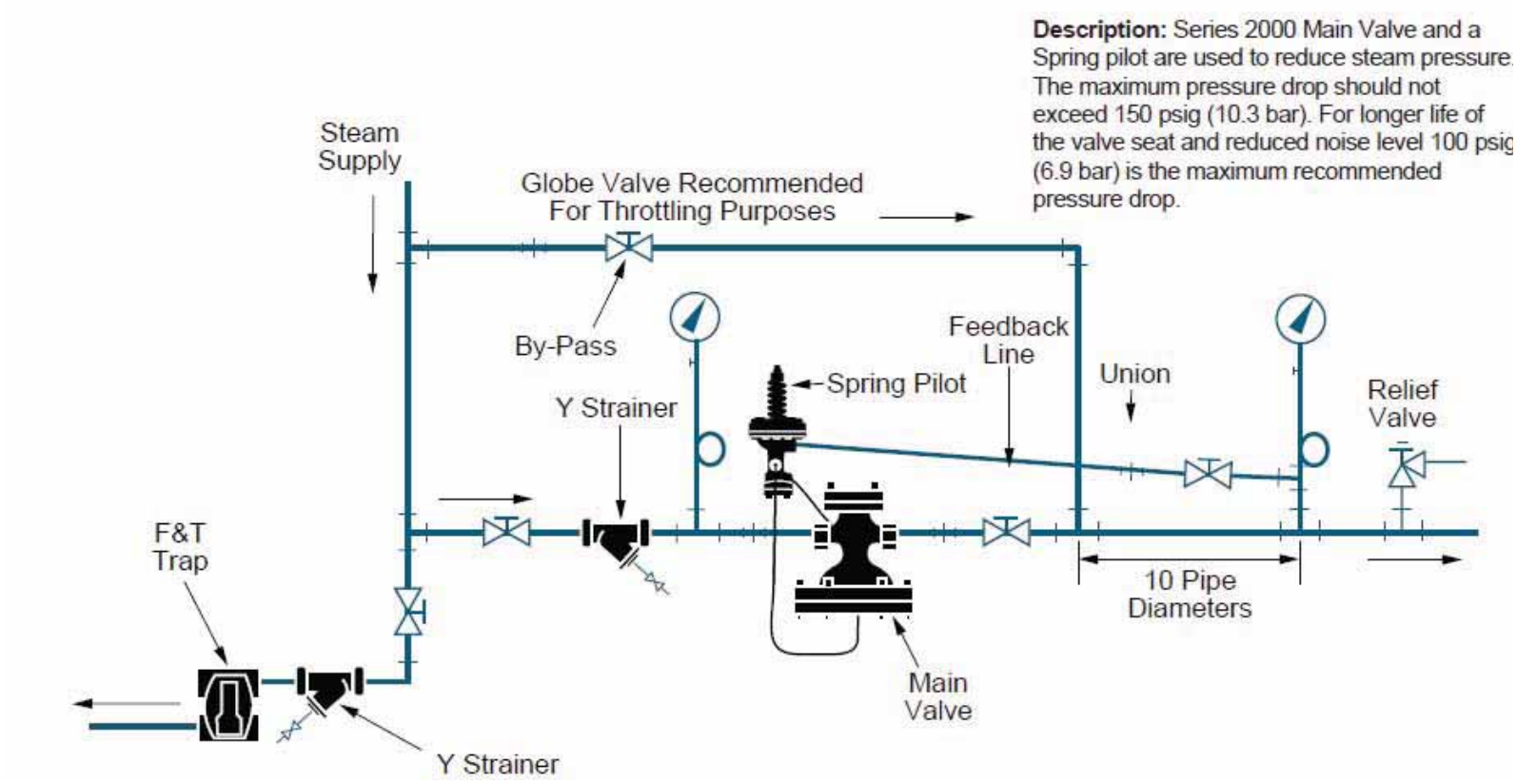
Is PVC an acceptable vent material for flue gases?

By Ron George,CPD,
President, Ron George Design & Consulting Svcs.

I recently inspected the mechanical systems in student housing at a Midwest university. The school had hundreds of apartments in numerous buildings with high efficiency water heaters that were installed more than 10 years ago. There were reported problems of not having enough hot water.

My inspection revealed a high efficiency water heater with purple/brownish PVC pipes and yellowish PVC flue pipe fittings. The flue pipes were obviously deformed from heat, and they were sagging. A maintenance man for the university said that some really bad pipes had come apart at the fittings and melted. This set off the carbon monoxide alarm and prompted a maintenance call. The water heater had scaled up due to minerals in the water supply; this caused the flue gas temperatures to rise, which created the noted problems.

Steam Control Valves



Domestic Hot Water Systems

The following slides address scald injuries related to domestic hot water System problems.

These slides show why it is important to design a domestic hot water system Properly to prevent scalding.

Domestic Hot Water System Problems

- Scalding can occur when the delivery temperatures exceed 120 degrees F.
- Thermal Shock can occur in several ways. One way is if the fixtures are too far from water heater with no temperature maintenance system or if there is HW Recirculation Pump failure a sudden burst of HW can reach fixtures after a period of use. (Close Apts/Recent use)
- Thermal Shock can occur if there is a sudden change in pressure between hot & cold water supplies to a fixture & there is no Safety Type Shower Valve installed.
- A Combination Press. Balance/Thermostatic valve protects against both temperature and pressure fluctuations.
- Thermal shock often leads to slip & fall injuries.

Scald Injuries

- Often a Scald Victim is left scarred for life and traumatized by their burns.
- The pain is continuous and the psychological effects last their lifetime.

Definition - **Thermal Shock**

- **Thermal Shock** occurs when there is a pressure or temperature disturbance in the piping system that will cause a sudden change in the shower temperature. The sudden change in the shower temperature can cause a slip and fall injury that an lead to broken bones or a head injury from a fall. Sometimes the bather will grab the temperature controls on the way down and it can lead to a scalding incident.

Definition - **Scalding**

- **Scalding** can occur when the skin is exposed to temperatures in excess of 120 degrees Fahrenheit. Scalding can occur in varying degrees based on the temperature of the water and the exposure time.

Thermal Shock & Scalding Concerns

There is a Major Concern in Older Homes with Two-Handled & Non-compensating Shower Controls.

- **"Thermal shock"** and **"scalding"** is a **health and safety issue** related to the **restriction of flow at shower heads** with **non-compensating type shower valves**. This is a matter of **Physics.**

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Why should we be concerned about Scald Burns ?

- **Scald Burns are extremely painful and life altering injuries that can be deadly!**
- We must take every precaution to prevent the increased risk of thermal shock and scalding. If there is any possibility of an increased risk we must make corrections to the plumbing system or warn consumers and the building owner of the potential increased risk of scalding.
- Warnings should be included on products, packaging and in installation and maintenance literature with low flow showerheads (Below 2.5 GPM)
- Ignoring the problem and Increasing the risk of thermal shock and scalding should not be allowed.

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Hot Water Burns Like Fire

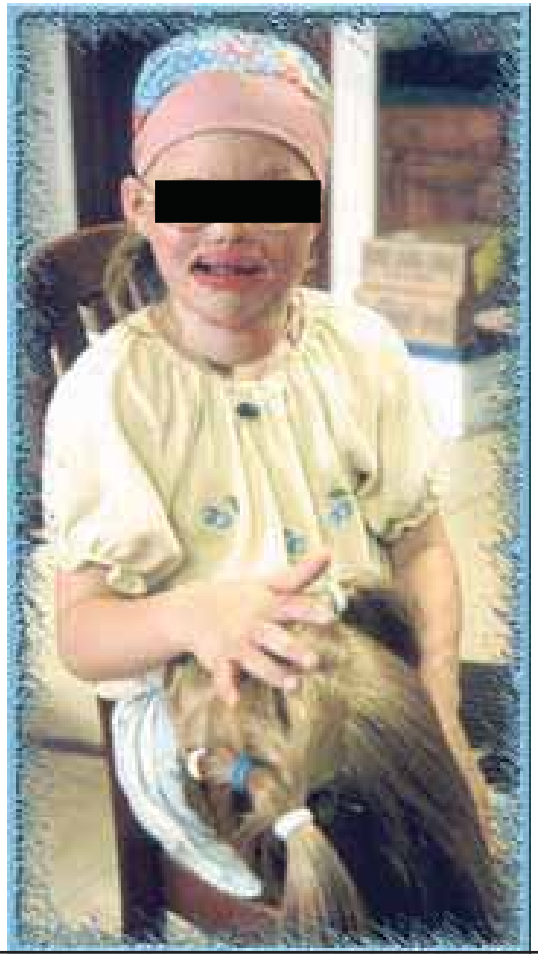
Scald Burn to Back

Hot Water Burns Like Fire

Infant with scald burns

Hot Water Burns Like Fire

Elementary school child with scald burns



Hot Water Burns Like Fire

Amputation of big toe because of dead tissue from scald burn from a Bathtub Faucet

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Hot Water Burns Like Fire

Scald Burn/Death (Small child in a Kitchen Sink)

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Contraction of skin grafts and scars during healing can cause deformities from swelling.

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Hot Water Burns Like Fire

Shower Scald Burn to Face, Chest and Body

Hot Water Burns Like Fire

Shower Scald Burn to Face, Chest and Body

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Scald Burn to teenager's shoulder

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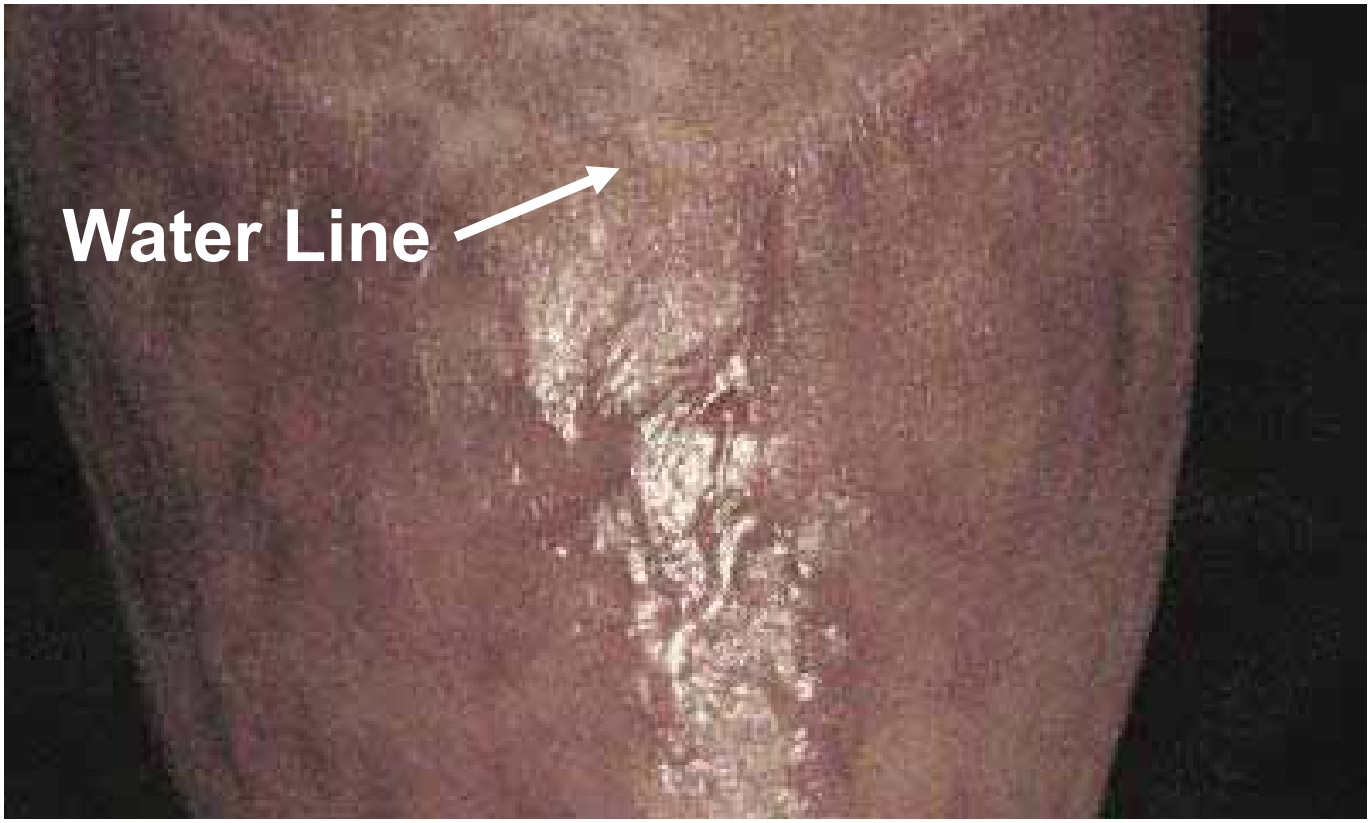
Scald Burn to an adult's thigh



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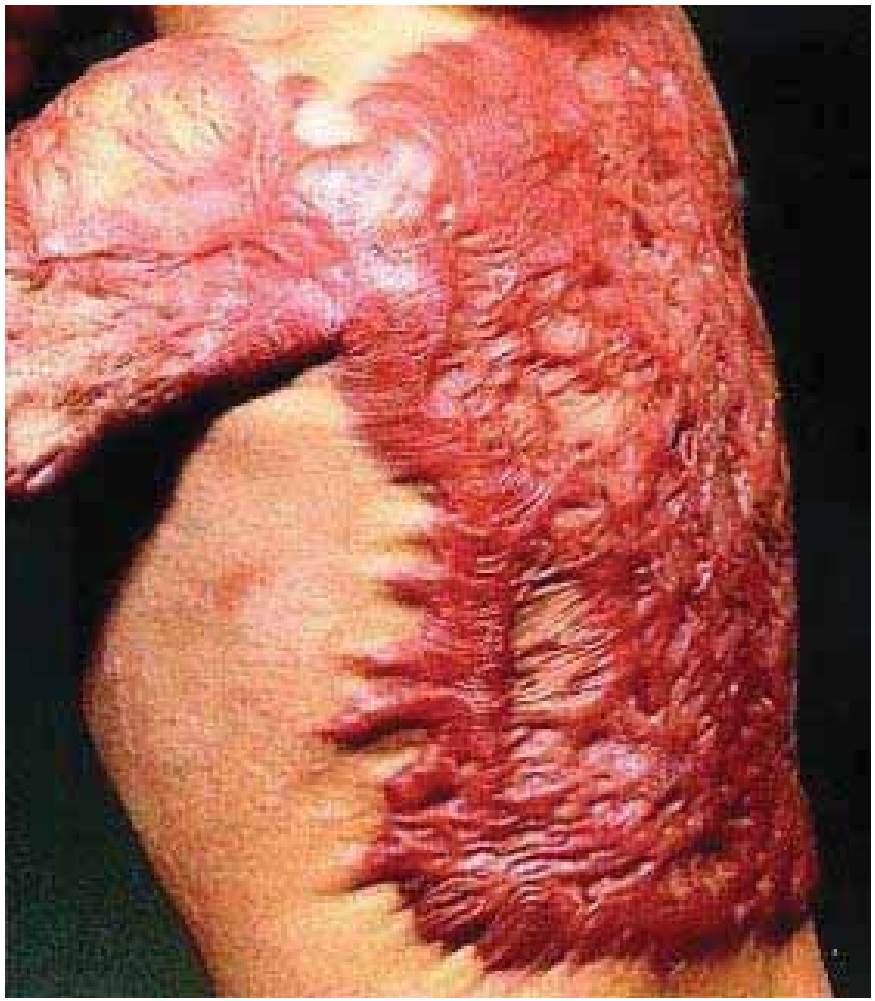
Hot Water Burns Like Fire

Scald burn

Scald burn
on an adult
from a shower



Scald burn

8-year-old boy with scald burns from a shower

45

Scald burn

Burned leg area
after receiving skin graft

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Scald burn to hand

47

Skin graft donor area

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Hot Water Burns Like Fire

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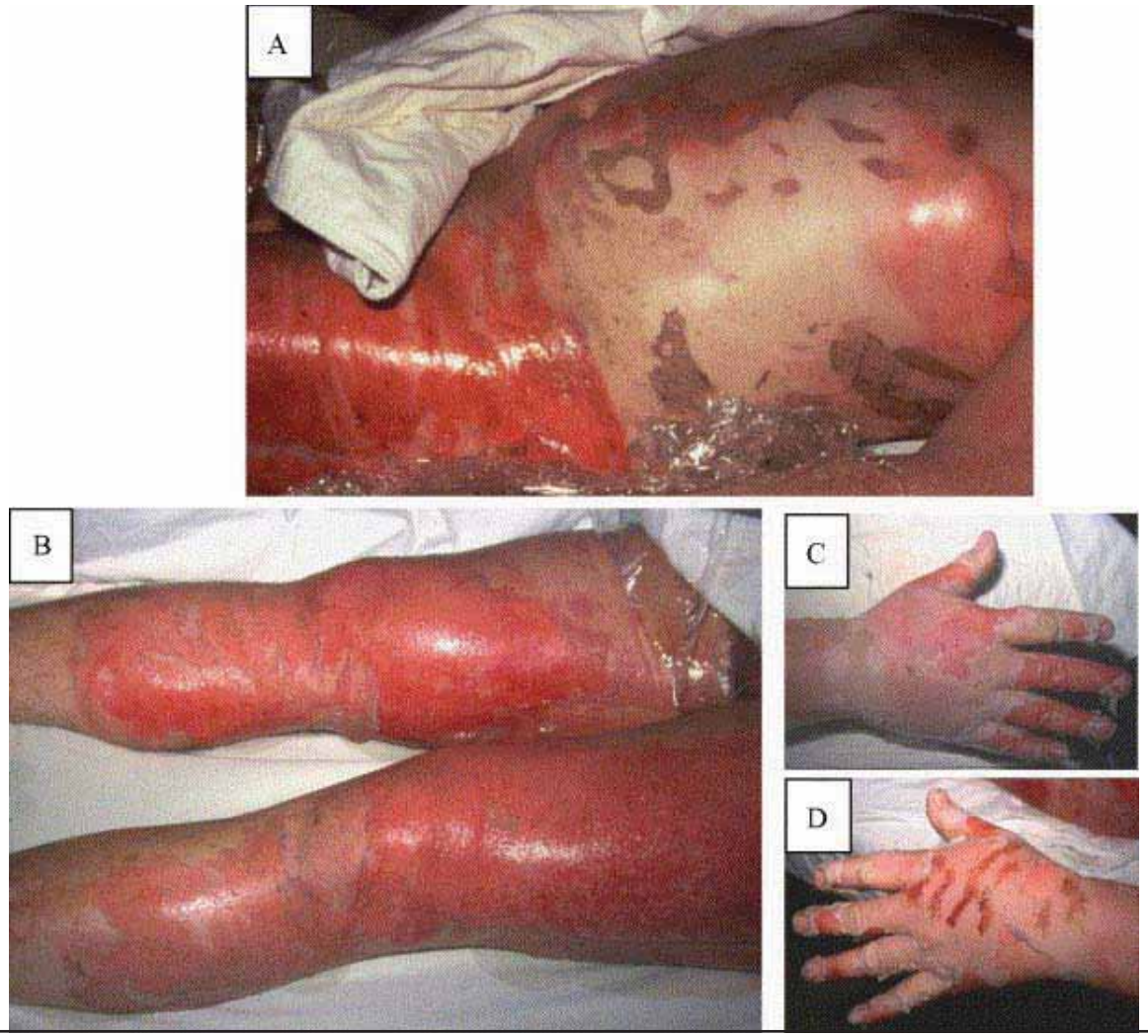
Hot Water Burns Like Fire

Hot Water Burns Like Fire



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Hot Water Burns Like Fire

52

Hot Water Burns Like Fire

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Scald Injuries

- Often a Scald Victim is left scarred for life and traumatized by their burns, the ongoing pain and the stigma of their Burns causing them to look awkward when in Public and causes lifelong psychological issues.

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Scald Burns and low flow shower heads

- **Scald Burns are extremely painful and life altering injuries!**
- We must take every precaution to prevent the potential to increase the risk of thermal shock and scalding. If there is any possibility of an increased risk we must warn consumers and building owner of the potential increased risk of scalding.
- Warnings must be included on products, packaging and in installation and maintenance literature with low flow showerheads (Below 2.5 GPM)
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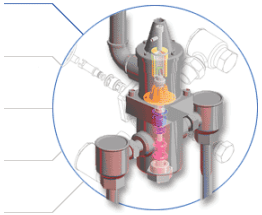
What could have prevented these scald burns?

1. A Thermostatic mixing valve with the proper piping arrangement.



2. Setting the Temperature limit stop on an ASSE 1016 Pressure or Temperature Compensating type Shower Valve.

3. A Temperature Actuated Flow Reduction (TAFR) device that conforms to ASSE 1062. It shuts down the flow of water if the temperature flowing through the device exceeds 115 F - 117 F.

Thermal Shock & Scalding Concerns

- No manufacturer can build a low-flow shower head that will not be susceptible to thermal shock and scalding IF,

  1. The Shower Head is connected to a two-handled or non-compensating shower valve
  2. It is connected to an ASSE 1016 shower valve that has not been designed and tested for low flows.

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Thermal Shock & Scalding Concerns in older homes

- Many water conservation programs and other utility sponsored water conservation programs are ignoring the dangers of existing Non-Compensating shower valves which make up over 50% of all existing installations.
- Validation is needed through testing low flow shower heads with shower valves.

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Thermal Shock & Scalding Concerns

- Currently ALL recent low-flow showerhead testing for water conservation programs has been done with newer code compliant buildings *(hotels and dormitories)* with code compliant **compensating type** shower valves and engineered plumbing system installations. *(In systems with properly sized water heaters, ASSE 1016 shower valves and in most cases with ASSE 1017 Master mixing valves)*
- Real world risk of thermal shock and scalding do exist in the test buildings. A significant portion of existing buildings have older non-code compliant fixtures..

Domestic Hot Water Systems

Scalding is one of the largest areas for litigation in plumbing & mechanical systems.

The codes have minimal requirements for hot water system sizing, controls, safety devices and system design.

This often leaves dangerous hot water system sizing, temperature settings and installations to people without proper training or guidance with tragic results.

Domestic Hot Water Systems

Scalding Facts:

Each year, approximately 3,800 scald injuries are reported and 34 deaths occur in homes in the United States due to scalding from excessively hot tap water, according to the Consumer Product Safety Commission. The majority of those injured are the elderly and children under the age of 5.

These numbers will soon rise sharply because of the proliferation of low flow shower heads without the codes mandating temperature controls in existing buildings.

Domestic Hot Water Systems

Scalding Facts:

- **Severe damage occurs to adult skin instantly when it is exposed to hot water over 151 Degrees Fahrenheit**

151 F + = Immediate scald burn with irreversible injuries

- **Severe damage to an adult's skin can occur in 30 seconds when exposed to water temperatures at 130 degrees Fahrenheit.**

130 F = 30 Seconds plus or minus until irreversible scald injury occurs depending on the skin thickness.

- **It takes up to five minutes for a severe burn injury to occur if the hot water system is distributed at the recommended maximum HW Temperature of 120 Fahrenheit, allowing people time to react and remove themselves from the hot water.**

120 F = 5 minutes Plus or minus

Temperature/Time Burn Chart

Table 1 – Estimated Time & Temperature Effects on Adult Skin

Water Temperature		Time for a Mild	Time for a Permanent
Deg. F	Deg. C	First degree Burn	Second Degree Burn
110	43	Normal Hot Shower	
116	47	Pain Threshold Approx	
116	47	35 Minutes	45 Minutes
120	49	3 Minutes	9 Minutes
122	50	1 Minute	5 Minutes
126	52	30 Seconds	90 Seconds
131	55	5 Seconds	25 Seconds
140	60	2 Seconds	5 Seconds
159	65	1 Second	2 Seconds
154	68	Instantaneous	1 Seconds

SOURCE: Moritz and Henriques, "Study of Thermal Injury: II"
American Journal of Pathology 1947; 23: 695-720
Technical Bulletin 34, US Government Memorandum, C.P.S.C.

DOMESTIC HOT WATER

Scalding Facts:

- **According to Paul Taheri, M.D., MBA, Medical Director of the University of Michigan Trauma Burn Center ,**
- *"The exposure time for each temperature can be cut in half for children or the elderly because their skin is thinner and more sensitive. Also, they are unable to react as quickly due to their age or physical limitations."*

Water Heater Thermostat Accuracy

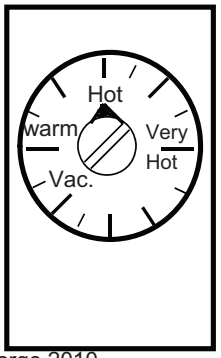
A common source of the scalding problem is many homeowners, code officials and industry professionals think the dial on a water heater controls the outlet temperature of the water heater. The water heater thermostat or burner control thermostat does NOT accurately control the outlet temperature of a water heater. There must be additional temperature controls downstream of the water heater to prevent scalding.

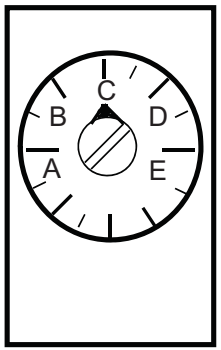
Ron George

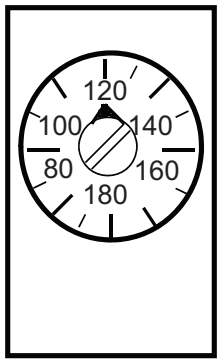
Water Heater Thermostats

A “water heater thermostat” or a “combination gas control valve” is sometimes also referred to as a “gas burner control thermostat”. This device will **NOT** control the outlet temperature of a water heater because of the thermostatic element location in the bottom of the heater and the inherent delays in heat transfer to the thermal element. Therefore the water heater thermostat cannot accurately control the outlet temperature of a water heater. Many manufacturers do not put numbers for this reason.

I have witnessed a water heater thermostat is set at 120 F and the water temperature at the bottom of the tank near the thermostat varied between 102 degrees Fahrenheit and 138 degrees Fahrenheit.



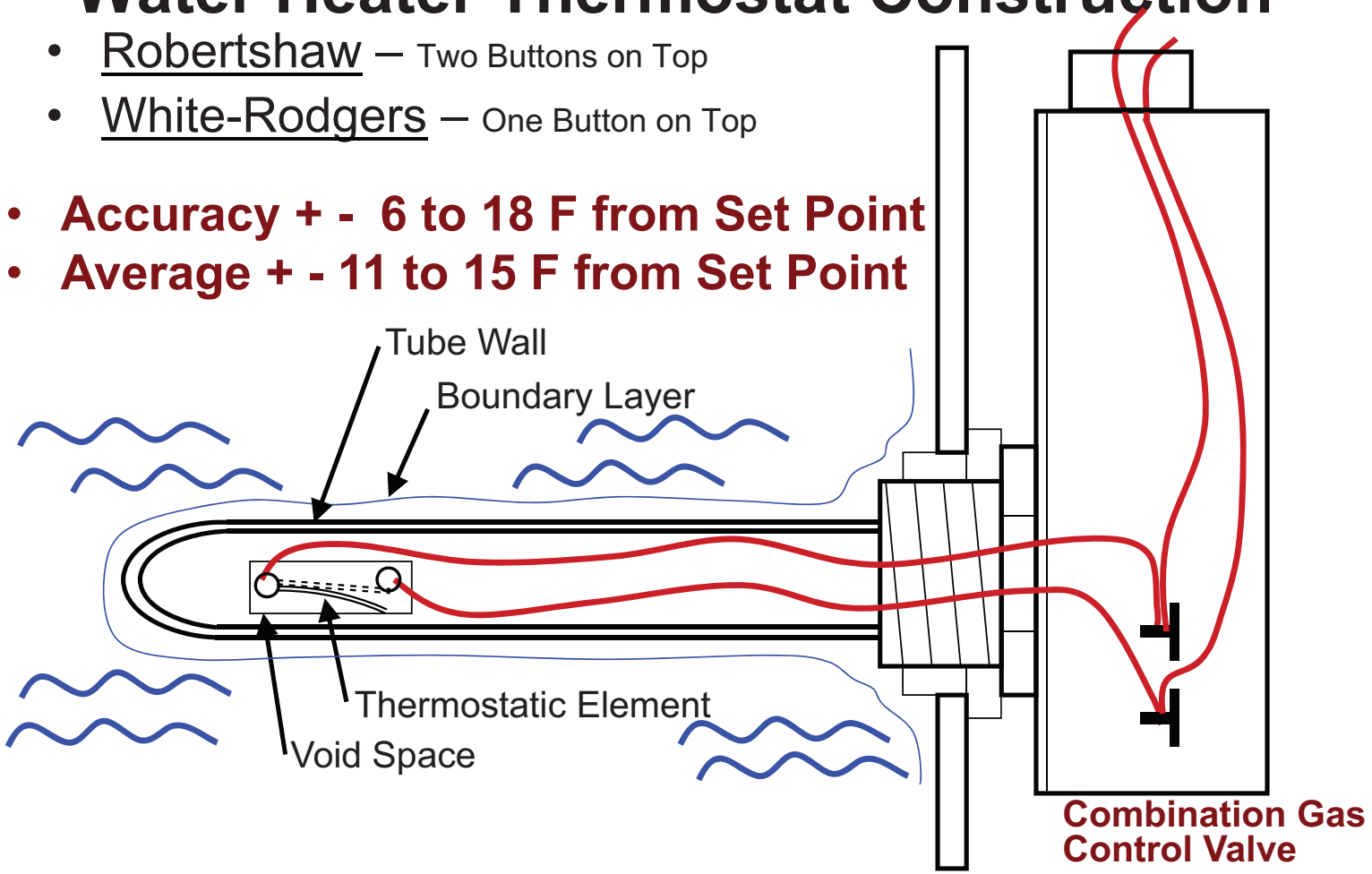




Water Heater Thermostat Construction

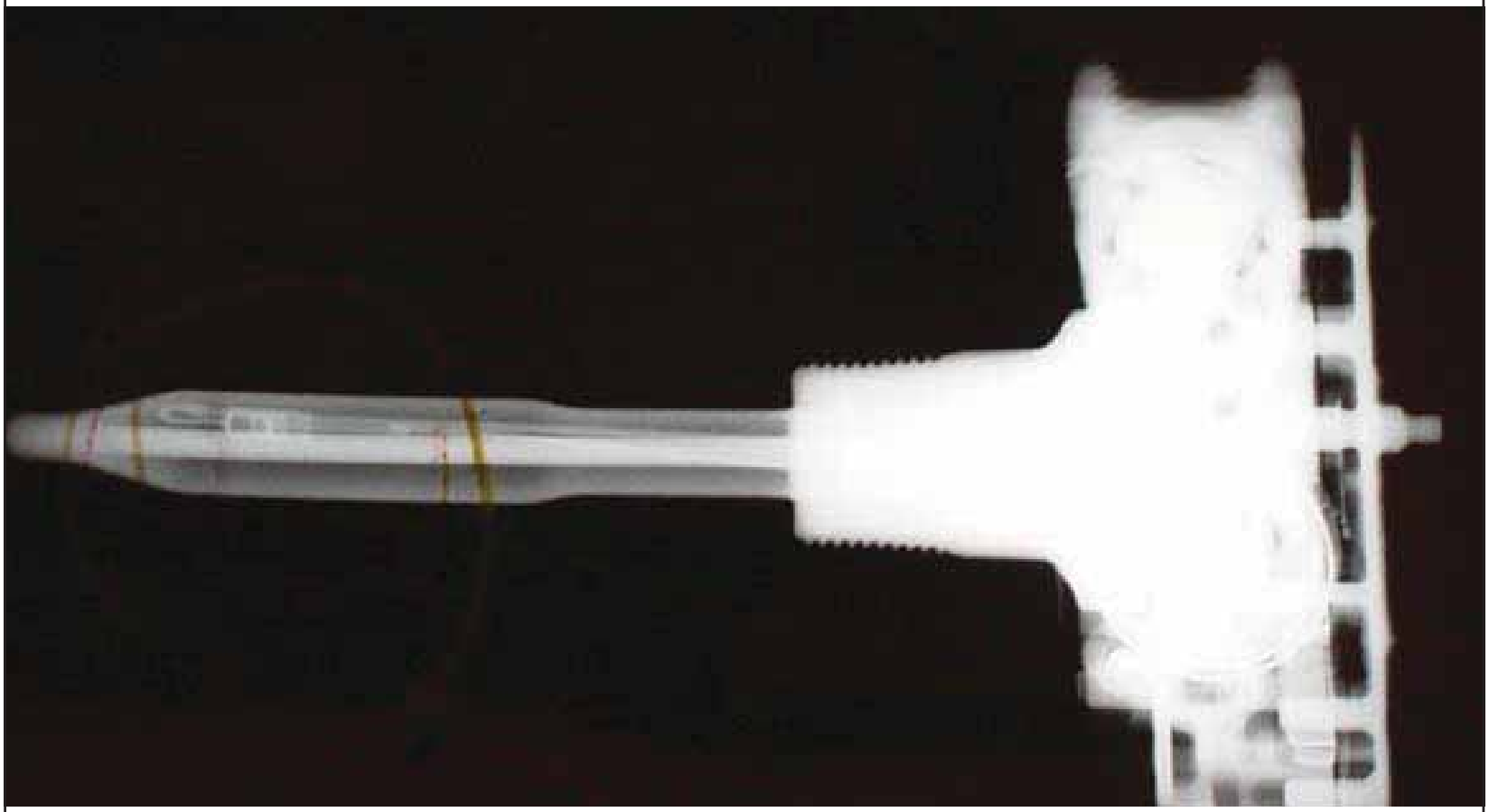
- Robertshaw – Two Buttons on Top
- White-Rodgers – One Button on Top

- **Accuracy + - 6 to 18 F from Set Point**
- **Average + - 11 to 15 F from Set Point**



- The boundary layer of water, the tube wall and the void space all contribute to a delay in temperature sensing.

X-Ray WH Thermostat



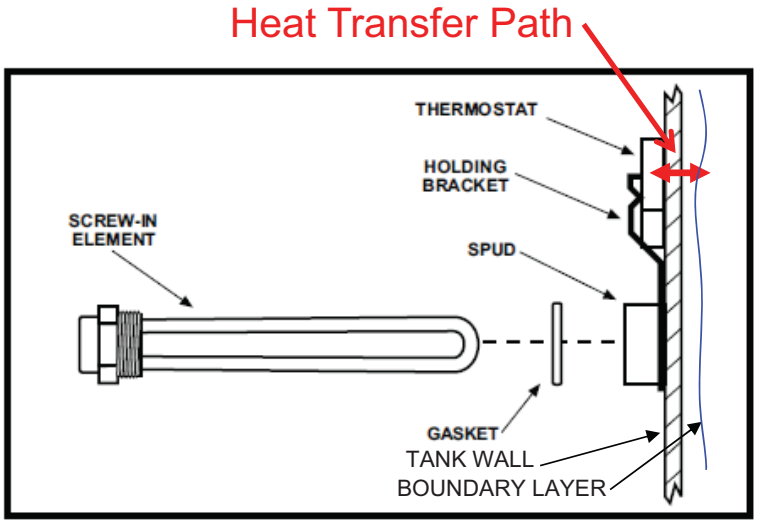
Combination Gas Control Valves
WH Thermostat

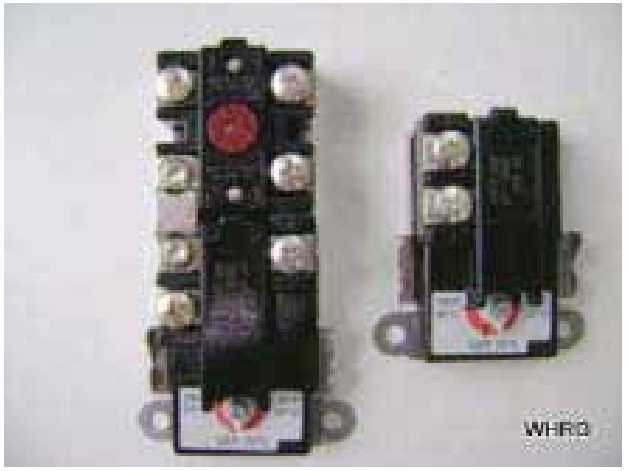
White Rodgers
One Knob
Accuracy = + - 11-14 Deg F

Robertshaw (Unitrol)
Two Knobs
Accuracy = + - 15-18 Deg F

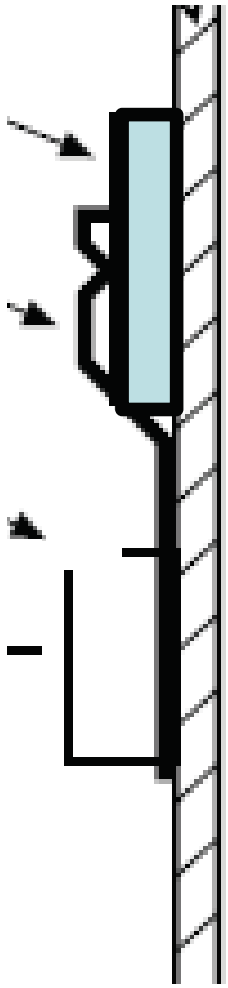
Electric Water Heater Thermostats

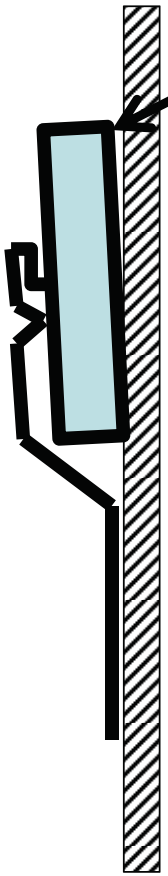
- Electric Water heater thermostats are typically manufactured by Emmerson Electric and they sense the temperature of the water by attaching to the outside of the tank wall and reading the water temperature through the tank wall. Again a delay in temperature sensing is from the boundary layer and the tank wall material heat transfer rate.





Electric Water Heater Thermostats





Air Gap Prevents heat transfer which causes overheating

HW System Problems

- **Problem:**

  The plumbing system is design so that the thermostat setting on Water Heater is relied upon for system temperature controls with no further safety controls downsteam of the water heater.

  1. Explanation of the Stacking effect

  2. 11 degrees +- for a 22 degree swing

  3. Most model code do not allow the thermostat on the water heater to be the final temperature control for a HW system.

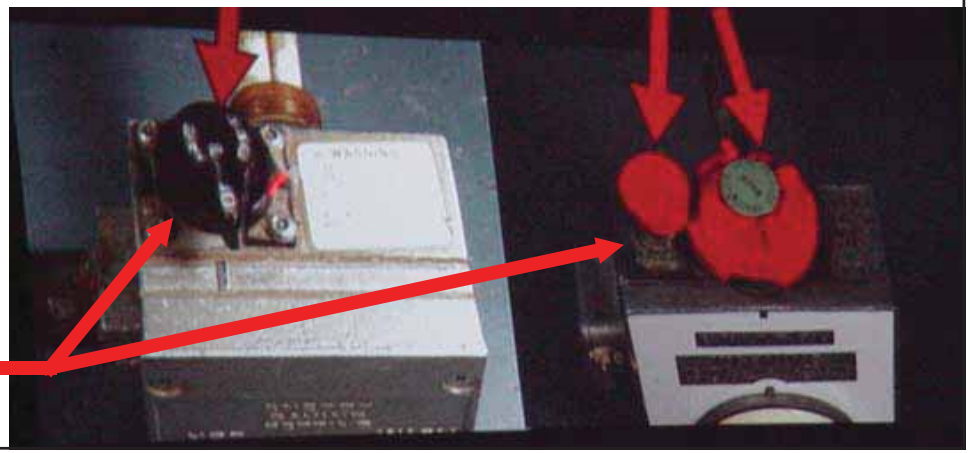
Water Heater Gas Control Valve

Water Heater Thermostat Setting

- **Water Heater Thermostat Setting - Instead of just setting the thermostat on the water heater to 120 F, A major Midwest University's Trauma Burn Center recommends that anti-scald mechanical devices such as thermostatic mixing valves be installed near the water heater to mix the hot and the cold water to deliver it at a maximum safe temperature of 120 F. This is especially important when one system supplies hot water to numerous apartments or units.**

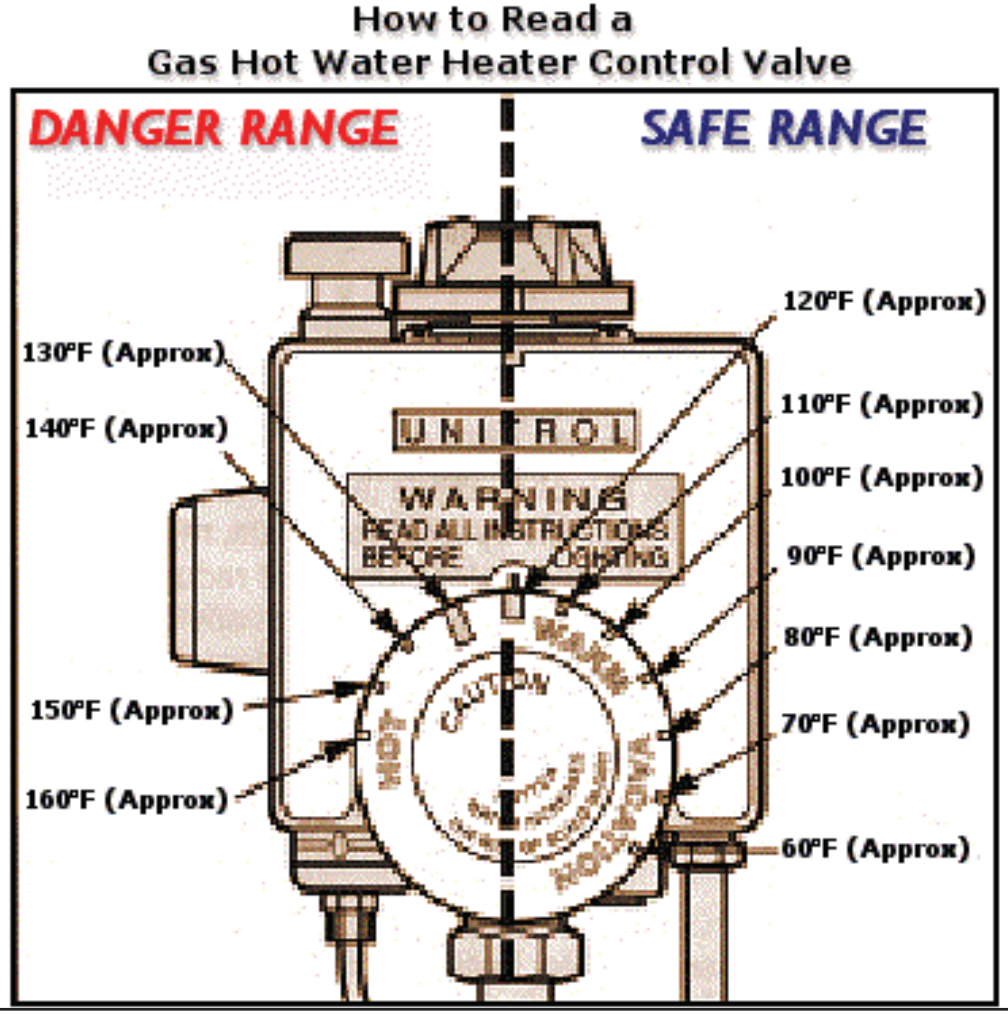
ASSE 1017 / ASSE 1070 Thermostatic Mixing Valve

The Thermostat on a water heater should never be used as the final temperature control for a hot water system.



Water Heater Gas Control Valve

Misleading Manufacturer Literature leads users to believe thay can control the outlet temperature of a water heater with the burner control thermostat



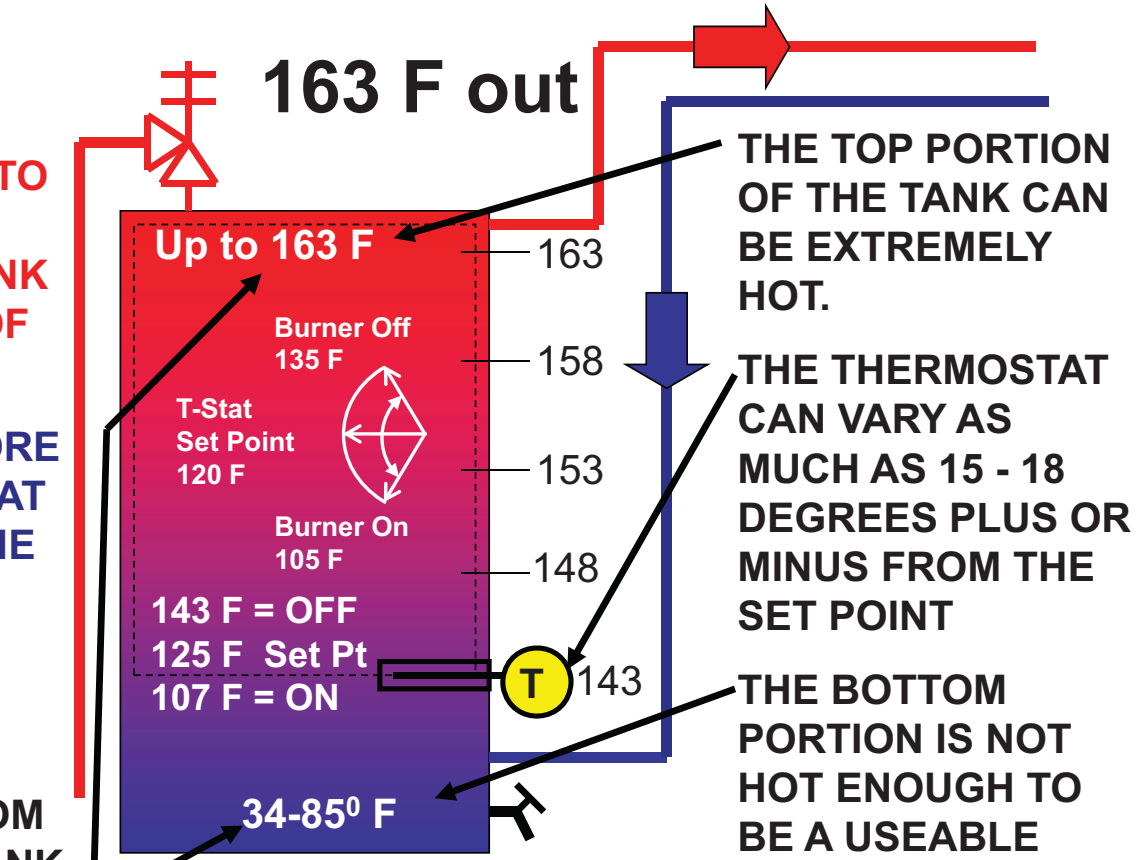
A Water heater Thermostat should not be used as the final temperature control for the domestic hot water system!

The temperature swing from "burner on" to "burner off" can be as much as 30 degrees F.

74

Water Heater Storage Temp's

The "Stacking Effect" or "Thermal Layering" in Un-circulated Storage Type Water Heaters



HOT WATER RISES TO THE TOP OF AN UNCIRCULATED TANK DURING PERIODS OF NON-USE.

COLD WATER IS MORE DENSE AND STAYS AT THE BOTTOM OF THE TANK.

THERE CAN BE A SIGINIFICANT DIFFERENCE IN TEMPERATURE FROM THE TOP OF THE TANK TO THE BOTTOM.

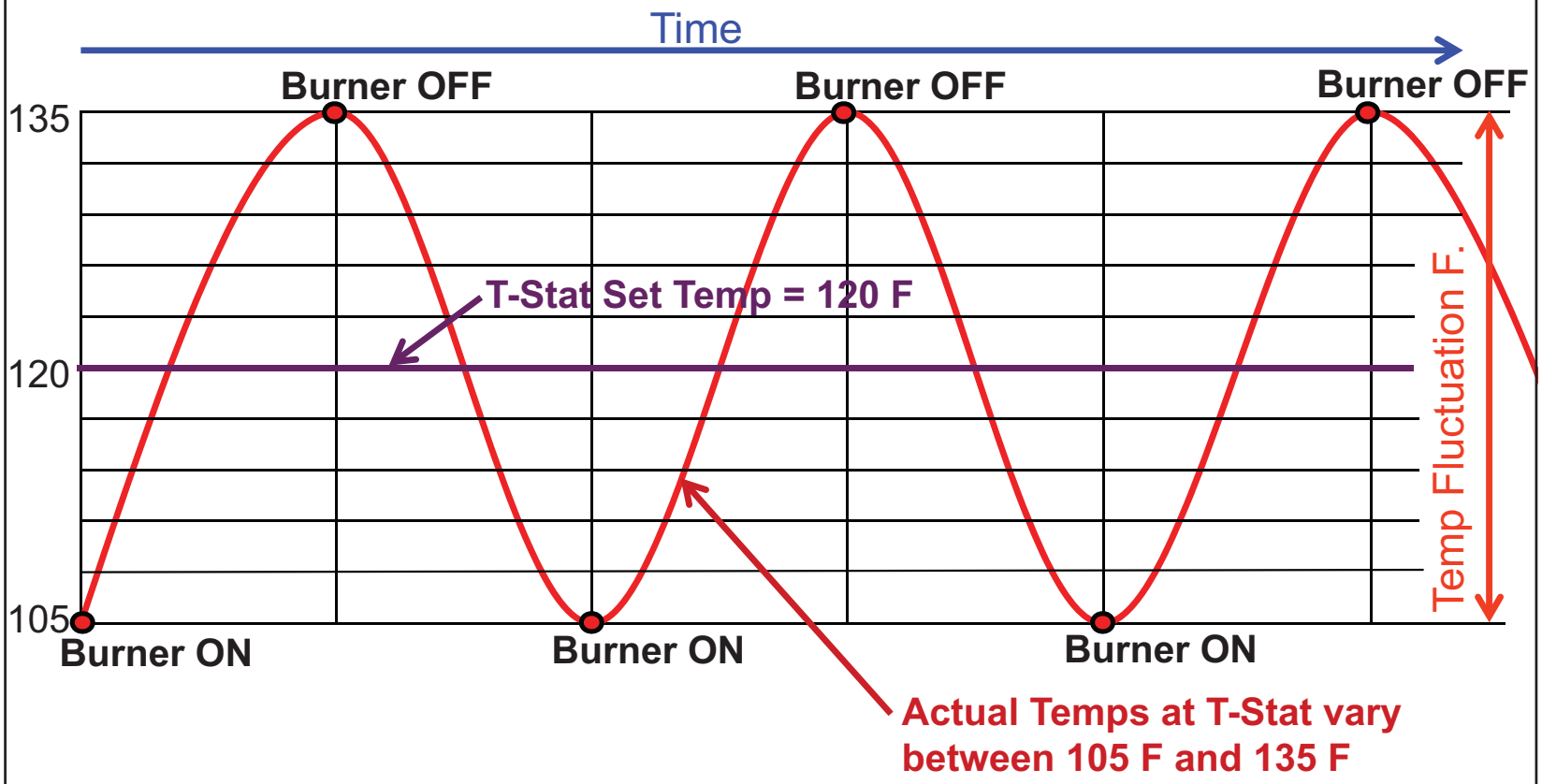
THE TOP PORTION OF THE TANK CAN BE EXTREMELY HOT.

THE THERMOSTAT CAN VARY AS MUCH AS 15 - 18 DEGREES PLUS OR MINUS FROM THE SET POINT

THE BOTTOM PORTION IS NOT HOT ENOUGH TO BE A USEABLE TEMPERATURE.

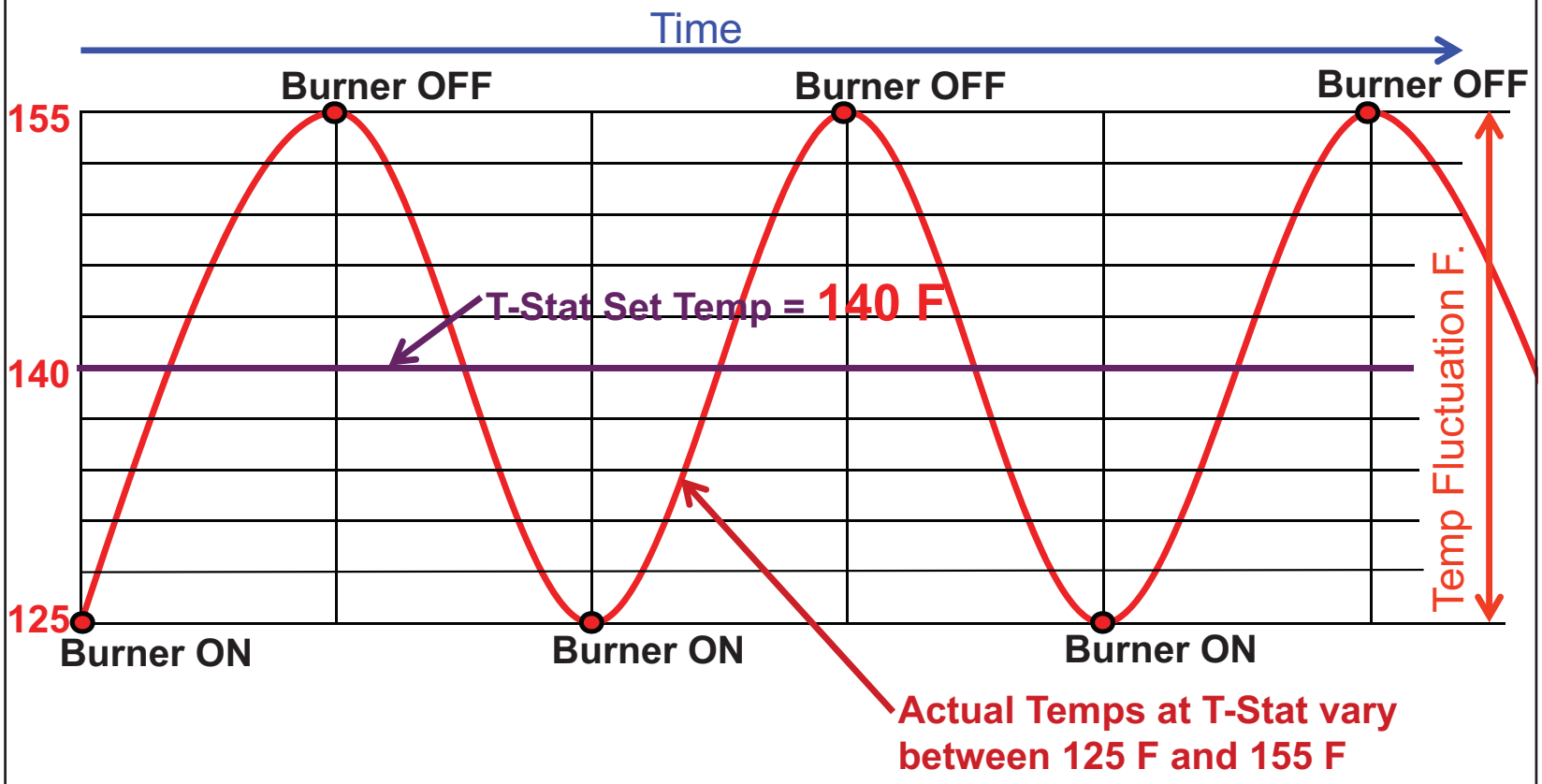
WH Set at 125 F

Water Heater Burner Control at 120 F



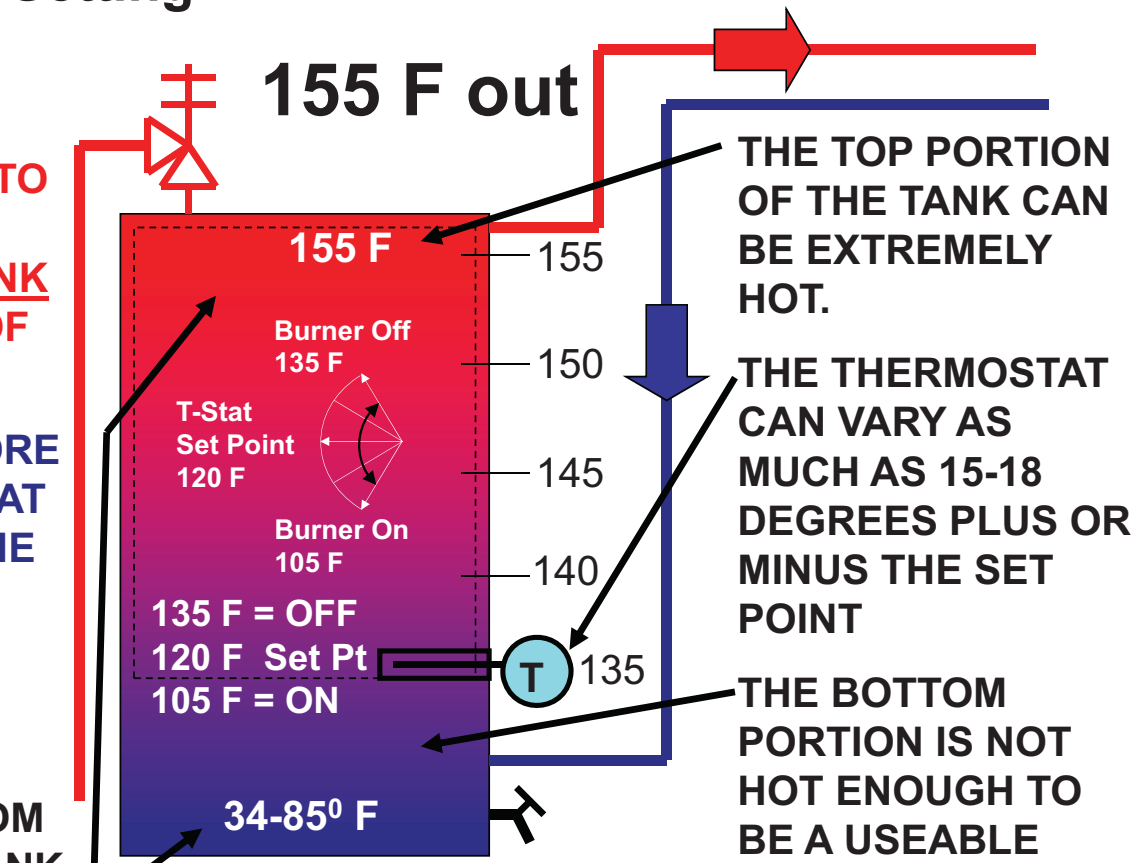
With HW rising to the top of the heater and multiple short draws of HW the temp can significantly increase above 135 F

Water Heater Burner Control at 140 F



With HW rising to the top of the heater and multiple short draws of HW the temp can significantly increase above 155 F

You will get Scalding Hot Water out of an Un-circulated Storage Type Water Heater with the Thermostat Set at the 120 F Factory Setting



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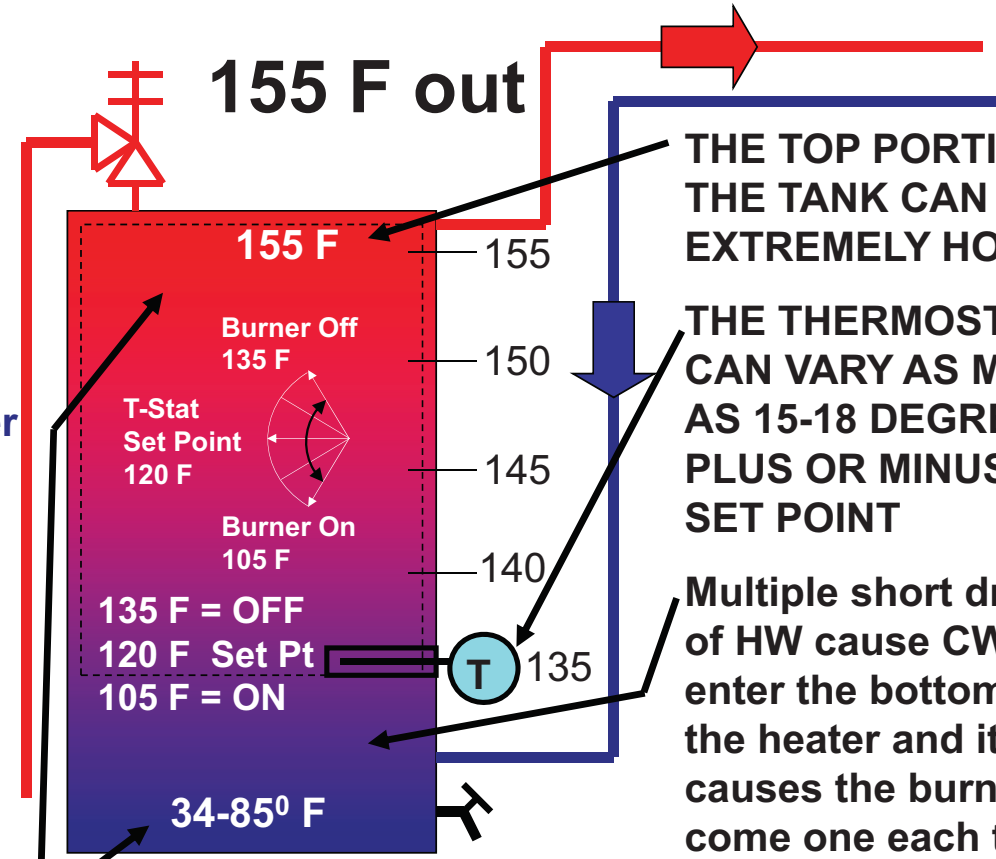
THE BOTTOM PORTION IS NOT HOT ENOUGH TO BE A USEABLE TEMPERATURE.

WH Set at 120 F

With "Thermal Layering" or Stacking, The water temperature at the top of the tank can be significantly higher that the water temperature at the thermostat level.



HOT WATER RISES TO THE TOP OF AN UNCIRCULATED TANK

Short draws of hot water cause the thermostat to sense the cold water at the bottom of the tank.

The burner comes on and even though the water at the top of the heater is very hot.

THE TOP PORTION OF THE TANK CAN BE EXTREMELY HOT.

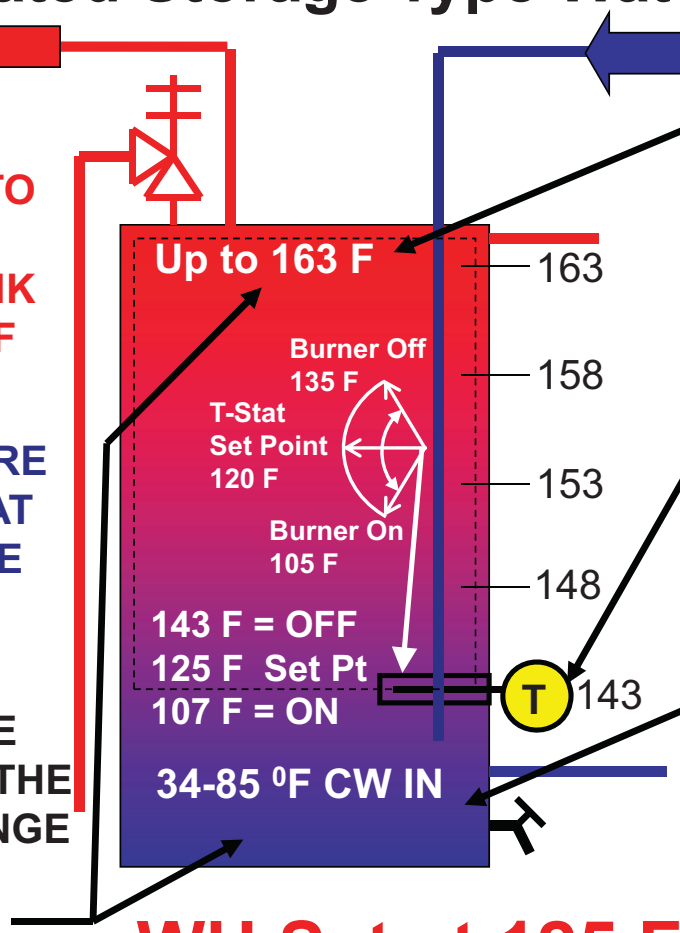
THE THERMOSTAT CAN VARY AS MUCH AS 15-18 DEGREES PLUS OR MINUS THE SET POINT

Multiple short draws of HW cause CW to enter the bottom of the heater and it causes the burner to come one each time, overheating HW at the top.

WH Set at 120 F

Water Heater Storage Temp's

The "Stacking Effect" or "Thermal Layering" in Un-circulated Storage Type Water Heaters



HOT WATER RISES TO THE TOP OF AN UNCIRCULATED TANK DURING PERIODS OF NON-USE.

COLD WATER IS MORE DENSE AND STAYS AT THE BOTTOM OF THE TANK.

THE BOTTOM 1/3 OF THE TANK CAN HAVE TEMPERATURES IN THE IDEAL GROWTH RANGE FOR BACTERIA.

THE TOP PORTION OF THE TANK CAN BE EXTREMELY HOT.

THE THERMOSTAT CAN VARY AS MUCH AS 15 - 18 DEGREES PLUS OR MINUS FROM THE SET POINT FOR THIS REASON THE THERMOSTAT CANNOT BE RELIED UPON TO CONTROL THE OUTLET TEMPERATURE OF A WATER HEATER.

THE BOTTOM PORTION IS NOT HOT ENOUGH TO BE A USEABLE TEMPERATURE.

WH Set at 125 F

Stacking

The following is language from a water heater installation & Maintenance manual:

Stacking occurs when a series of short draws of hot water (3 gallons or less) are taken from the water heater tank. This causes increased cycling of the heater elements and can result in increased water temperatures at the hot water outlet. An anti-scald device is recommended in the hot water supply line to reduce the risk of scald injury.

The Anti-Scald Device they are referring to is an ASSE 1017 or ASSE 1070 thermostatic mixing valve

Note:

You cannot set a water heater at 120 F degrees and expect to accurately control the outlet temperature of the water heater for purposes of preventing scalding!

Most Residential Water Heaters are designed to store and deliver hot water at 140 Degrees F. Residential water heater sizing is based on gallons stored in the water heater relative to number of bedrooms. If The thermostat is turned down to minimize the risk of scalding, the following problems can occur:

1. Less hot water is available for peak hot water loads.

2. Condensation can form in the flues causing corrosion of the heater.

3. When Hot Water runs out users often turn the thermostat back up, higher than the original setting. This increases the risk of scalding.

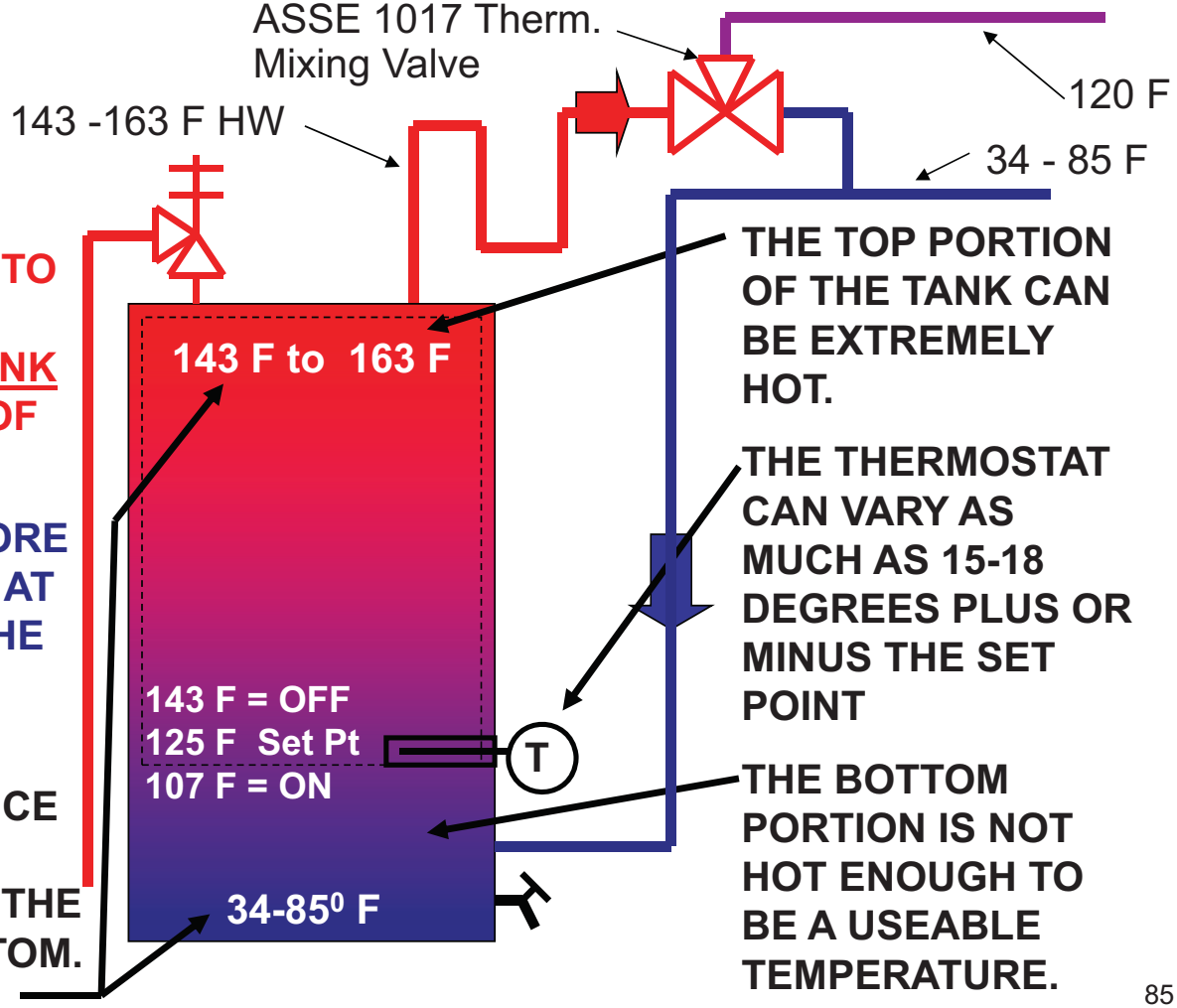
4. When the water heater thermostat is adjusted, the maximum temperature limit stops on all ASSE 1016 shower valves must be readjusted most of the time this is not done. This increases the risk of scalding.

Install a Thermostatic Mixing Valve to:

- Prevent temperature swings in the hot water distribution system
- Prevent scalding and
- Prevent Legionellae Bacteria growth in the hot water tank.

How Do We Control the Temperature Swings?

Use ASSE 1017 Thermostatic Mixing Valves at the Water Heater!



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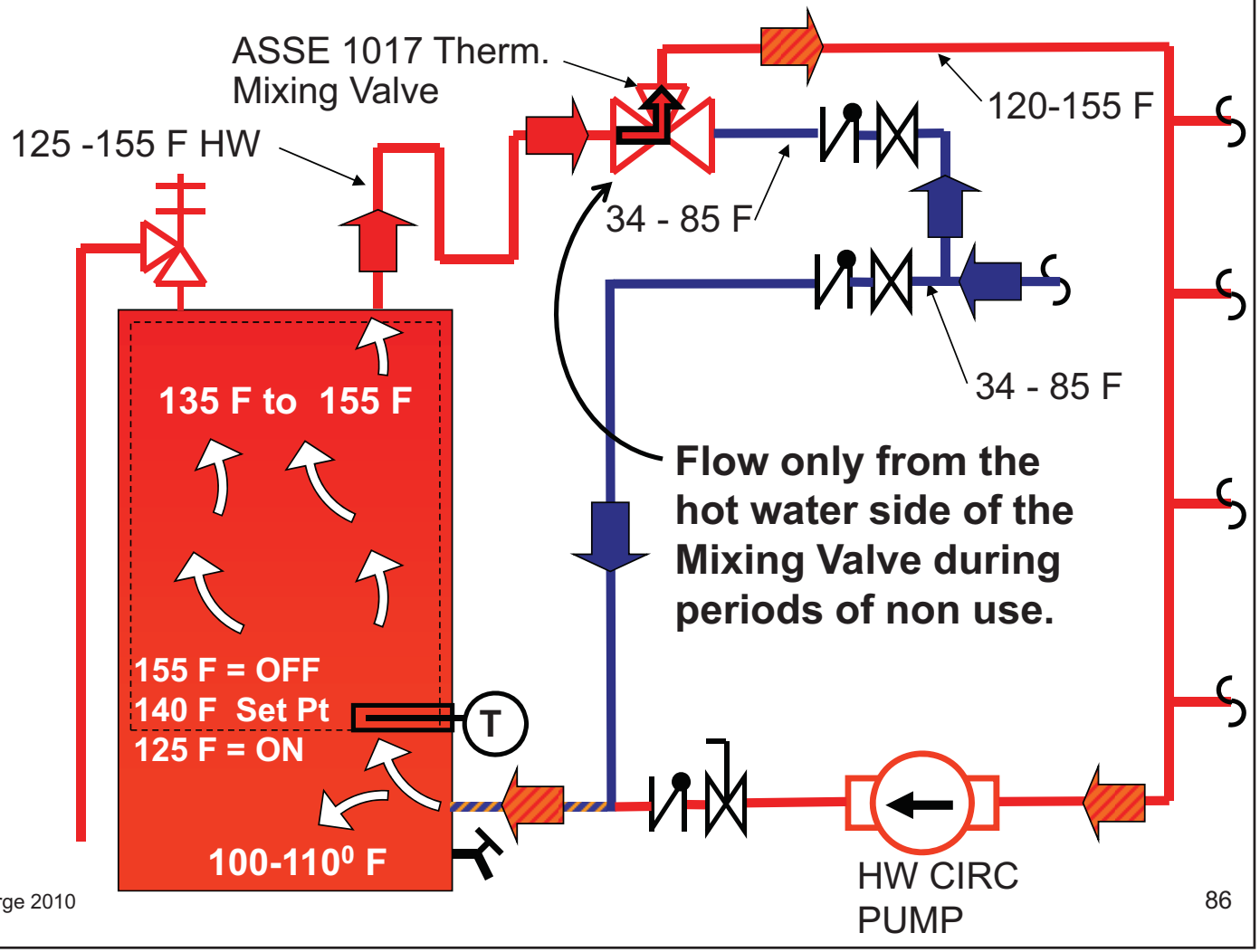
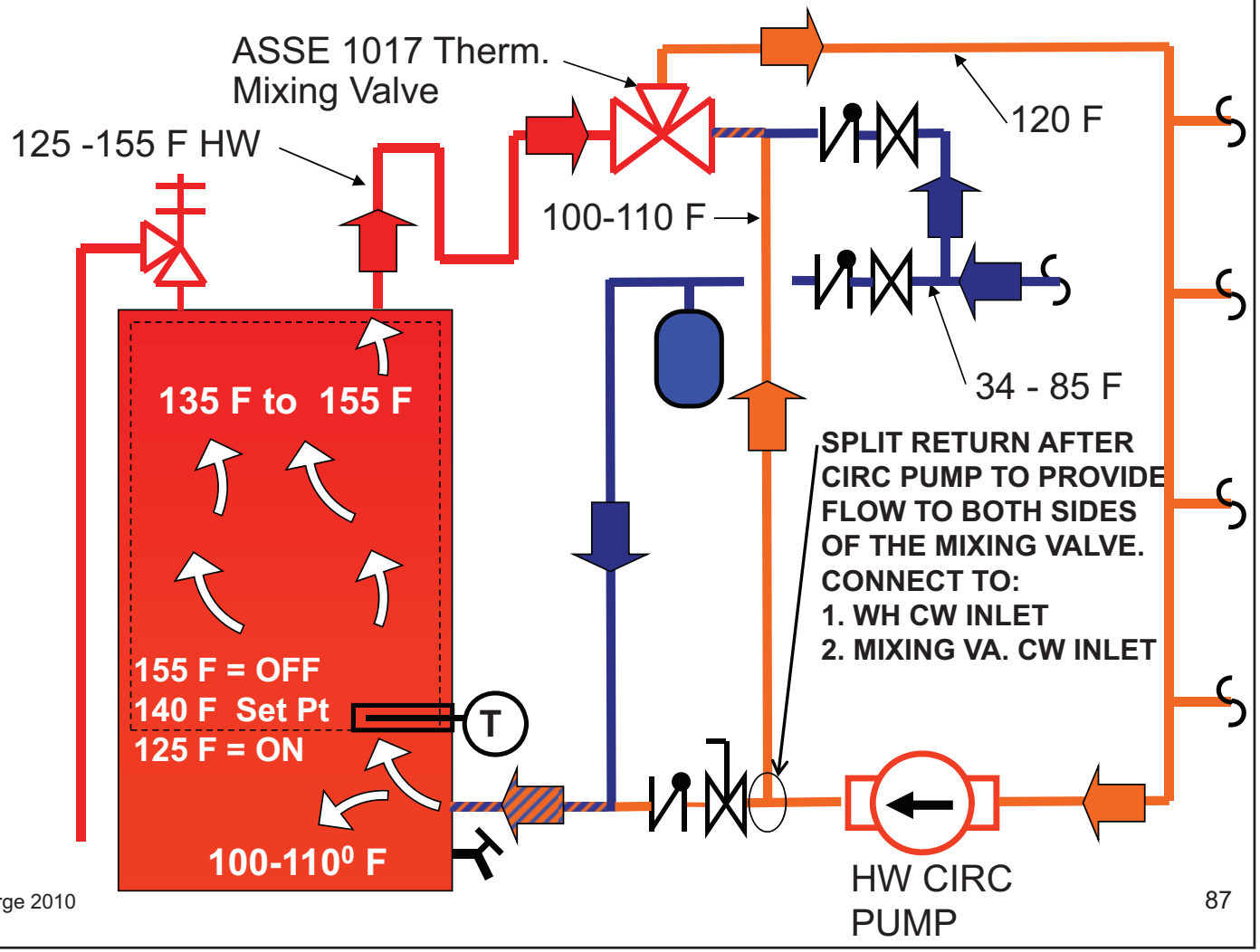
Problems with Recirc piping and mixing valves

Use ASSE 1017 Thermostatic Mixing Valves at the Water Heater!

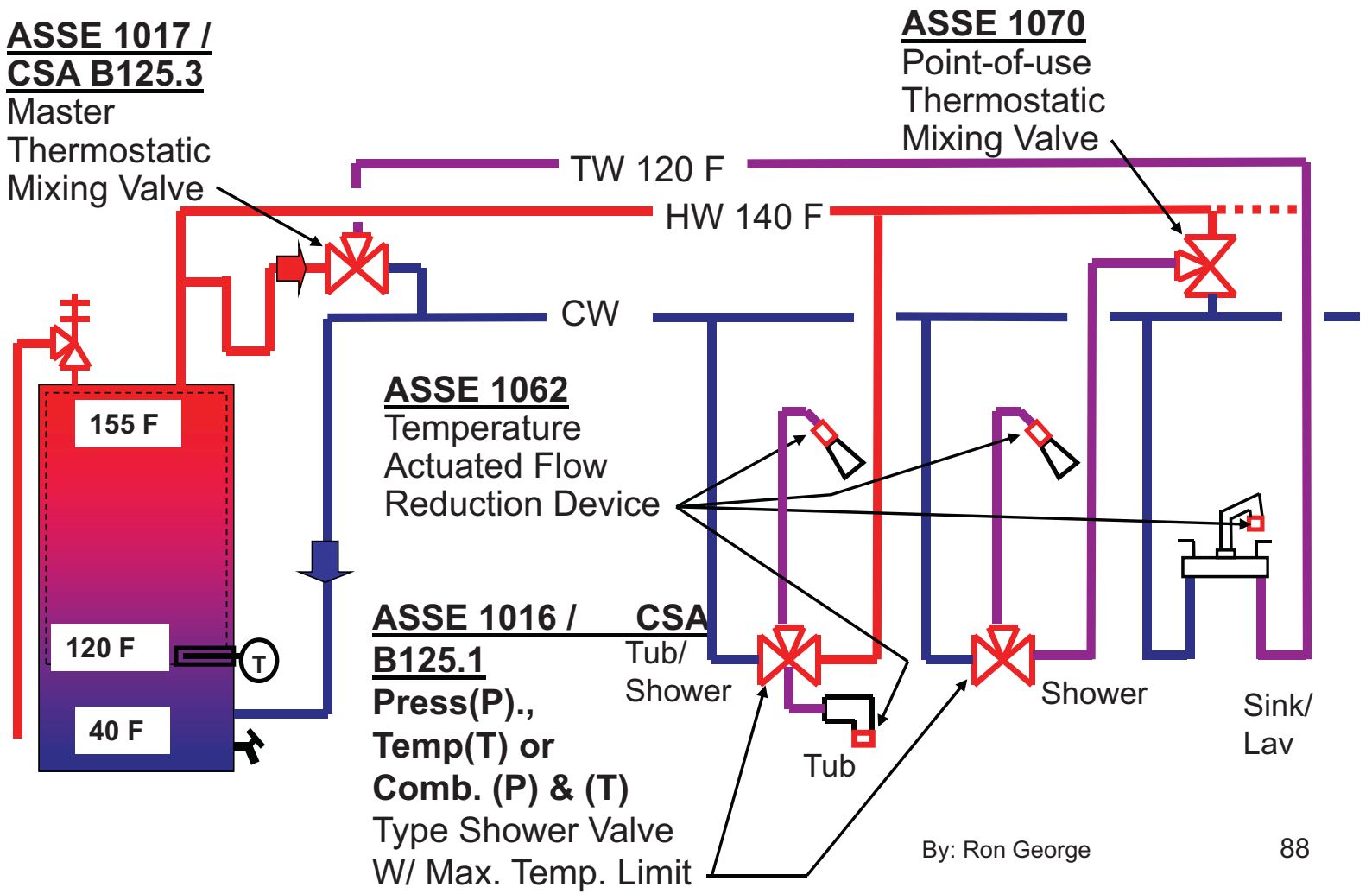


Proper Recirc Pump Piping with a Mixing Valve

Use ASSE 1017 Thermostatic Mixing Valves at the Water Heater!



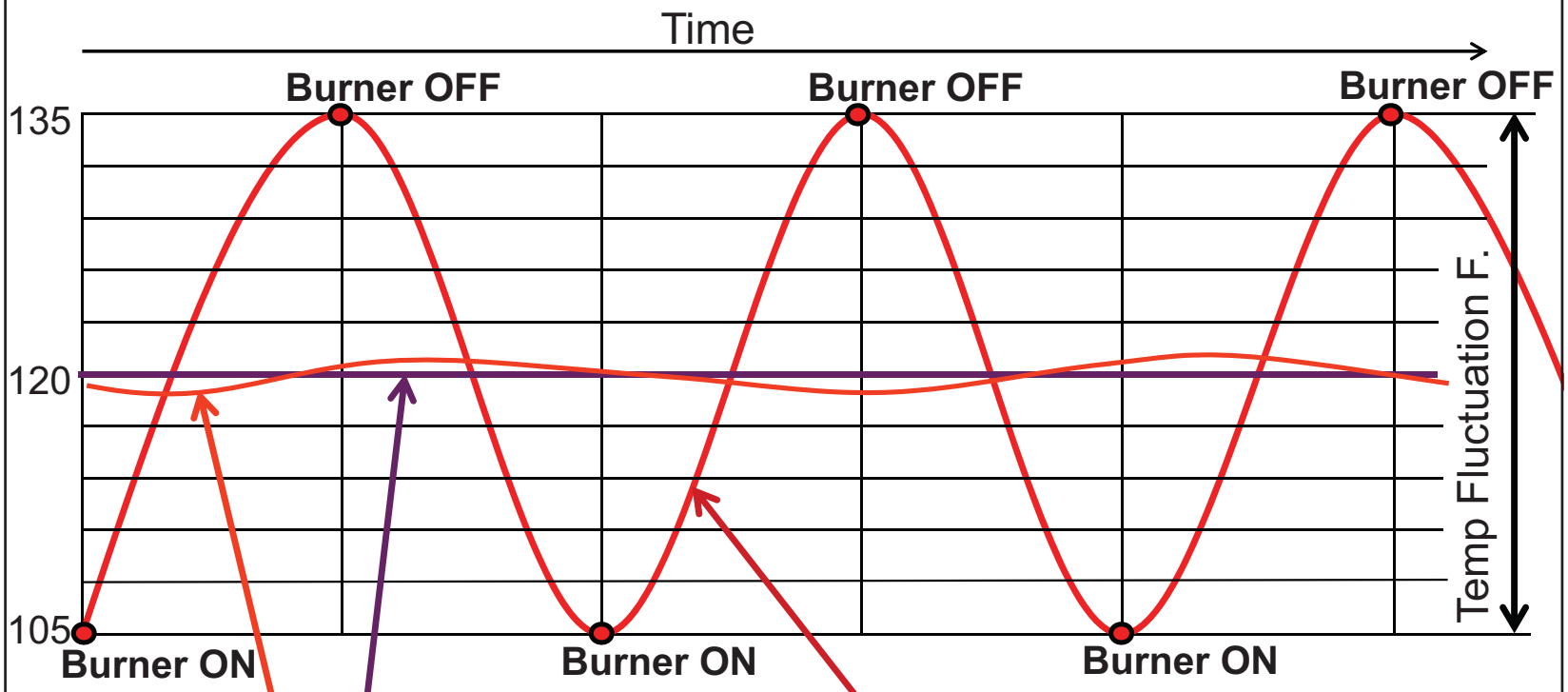
How To Control the HW Temperatures?



Why use Thermostatic Mixing Valves?

1. To accurately and safely deliver hot water to points of use.
2. Because water heaters cannot deliver a consistently safe HW supply temperature.
3. Because hot water must be storage above 135 to 140 F to prevent Legionella bacteria growth.
4. To prevent flue gases from condensing in low temperature, gas fired water heaters

Water Heater Burner Control



The Real World – Old Hot Water Systems

- Over 50% have no Master Mixing Valve (ASSE 1017)
- Over 50% have no Temperature or Pressure Compensating Shower Valve (ASSE 1016)
- Over 50% have no means to limit the maximum hot water temperature with temperature limit stops.
- Many have no ability for old water heaters to maintain HW capacity when they get scaled up with lime/calcium deposits.
- Many systems have the thermostat adjusted to a hotter storage temperature to compensate for a slow recovery rate in hard water areas.

The Real World – Old Hot Water Systems

- Many systems have no ability to address Legionellae bacteria when the water heater temperatures are turned down to address scalding concerns.
- Most systems have no ability to satisfy the peak hot water demand when the water heater thermostat is turned down to address scalding concerns.
- Most systems have no ability to address pressure imbalances in the water distribution system when there is a non-compensating shower control valve installed.

92

Thermal Shock & Scalding Concerns

- Over 50% of existing installations, Those with the greatest potential for scalding and thermal shock are not being tested with low flow shower heads!

Thermal Shock & Scalding Awareness

- **WARNINGS ARE NEEDED ON LOW FLOW SHOWER HEADS**

  because

  the RISK of scalding increases exponentially with the reduction in flow at the shower head!

94

Thermal Shock & Scalding Awareness

- **A major water conservation program has decided not to require warnings on the shower heads, the packaging or the literature for low flow shower heads for fear that warnings would detract from marketing efforts.**

- **We must warn the unsuspecting public of the scald hazards!**

95

Thermal Shock & Scalding Awareness

- ASSE Press Releases?
- ASSE HW Scald Awareness Committee prepared a White Paper/Report. Publicize the issue.
- Work with ASME and ASSE Shower Head and shower valve standards committees to match the flows in the standards and develop a way to match products.

96

Thermal Shock & Scalding Awareness

- Work to get ASSE and ASME to publish flow rates on the products to be able to match the flows. Is there is another way to accomplish this.
- Does ASSE adjust the 1016 standard to Mandate the shower head flow rate matches the shower valve flow rate?
- We need “Warnings” on the products about the dangers of non-compensating control valves.

Matched Flows are Needed for Shower Head and Shower Valve Product Standards

- **The ASME A112 Standard for Shower Heads Requires Shower Heads to Be Flow Tested at 80 PSI**

  (A pressure which the shower head will never be exposed to because 80 psi is the maximum pressure allowed in the plumbing system. During flow the residual pressure is likely to be 60 PSI or less. The ASME shower head flowing test pressure does not take into account the friction loss in the piping system.

98

Matched Flows are Needed for Shower Head and Shower Valve Product Standards

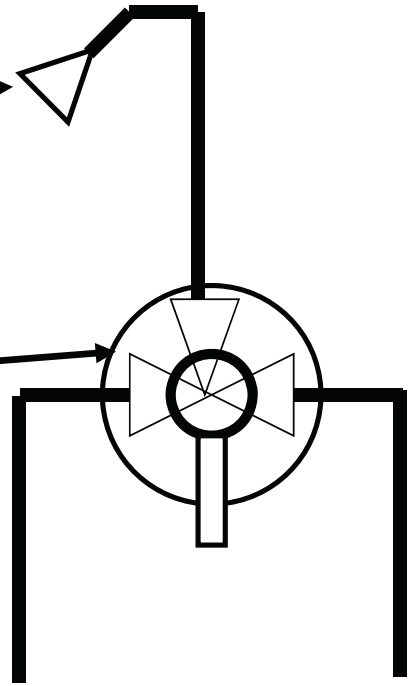
- The ASSE 1016 Standard tests the shower valves at 45 PSI.

99

Test Pressures and Flows

Tested at 80 PSI to not exceed 2.5 GPM Many Products have flows at or below 1 GPM

Tested at 45 PSI and 2.5 GPM only.



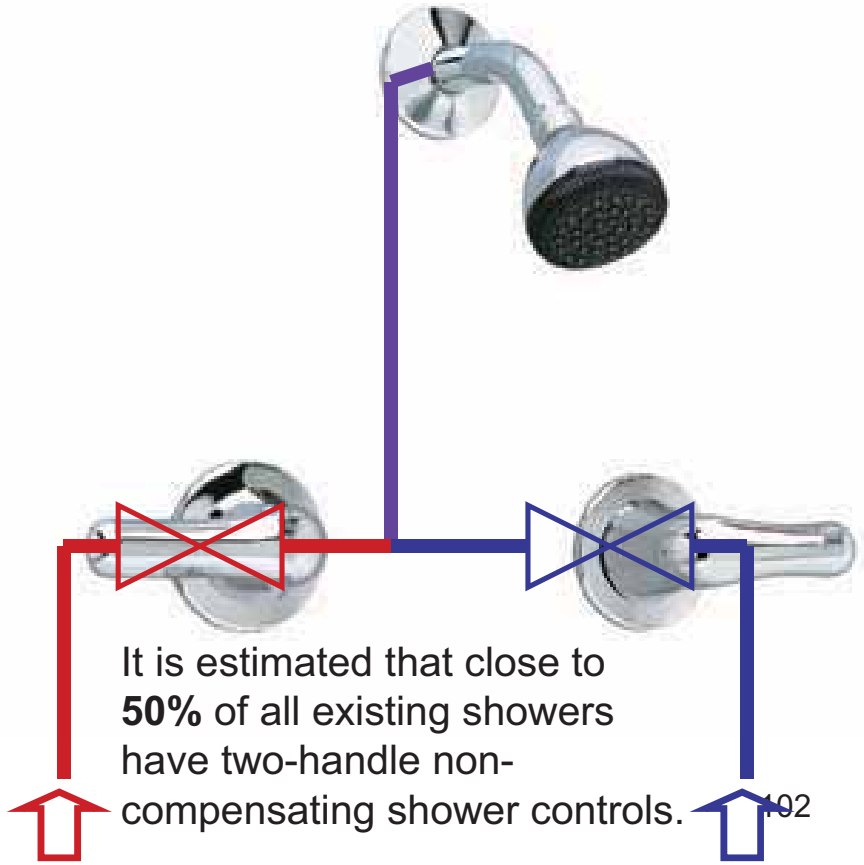
100

Definition:

- **Non-Compensating Shower Control Valve – A shower valve that does not compensate for changes in pressure or temperature. This would include: Two-handled shower valves and older style Single-handle shower valves without a pressure balancing/compensating component or a thermostatic compensating component. It is estimated that over 50 percent of all existing homes have non-compensating shower valves.**

101

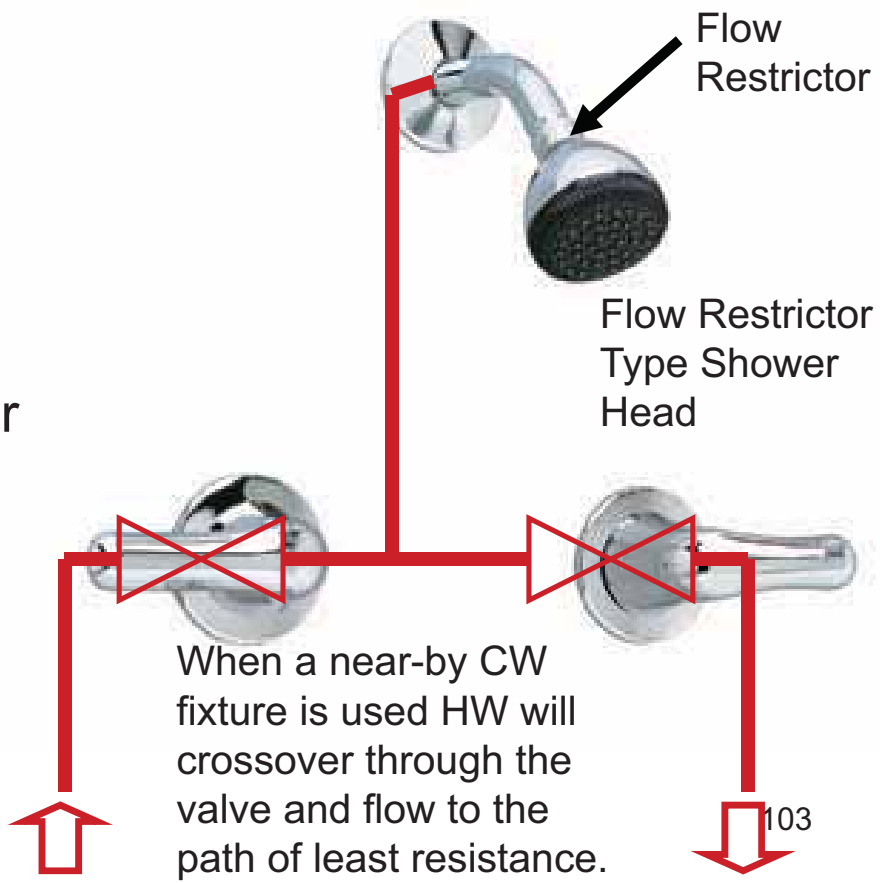
Two-Handled Shower Valves do not prevent: *Thermal Shock* or *Scalding*



It is estimated that close to **50%** of all existing showers have two-handle non-compensating shower controls.

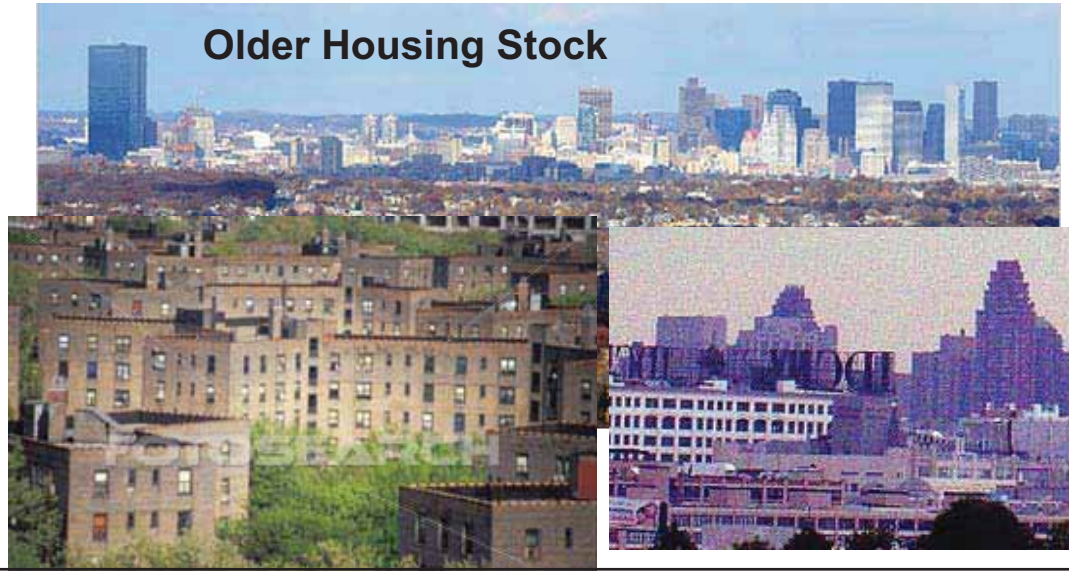
Two-Handled Shower Valves do not prevent: *Thermal Shock* or *Scalding*

When an existing shower head is replaced with a low flow shower head, the low flow shower head creates a flow restriction in the shower head riser. Pressure disturbances in the system become the path of least resistance when another nearby fixture is opened.

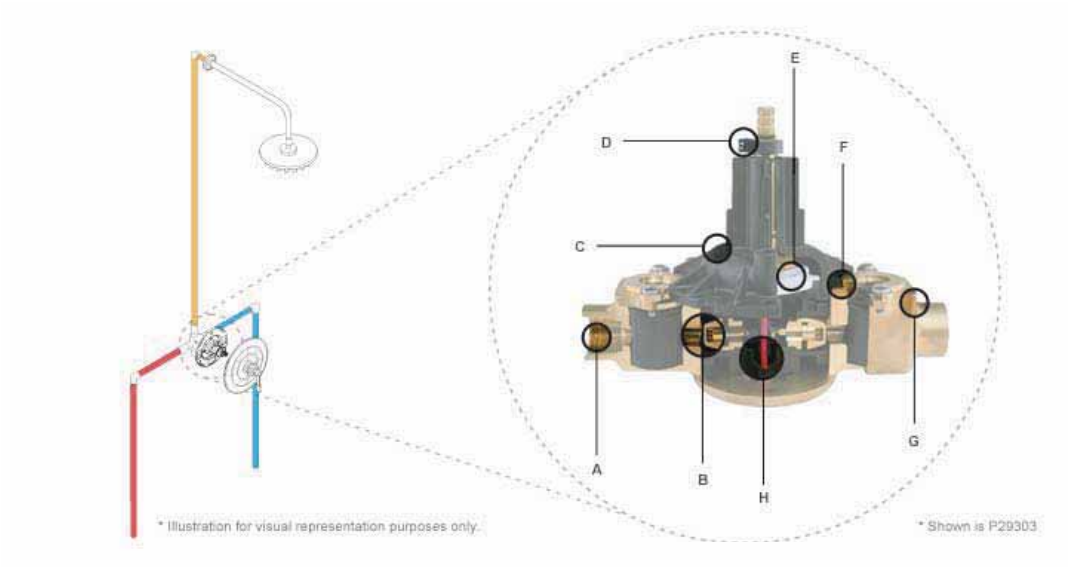


Existing Non-Compensating Installations

- The non-compensating style of shower control is probably the most common shower valve installed in older homes in the US. **(About 50% or more)**
- ***Two-handled shower valves do not compensate for changes in incoming pressure or temperature as required by the model plumbing codes.***
- **These types of valves were generally installed prior to 1978 when codes required anti-scald valves for new construction.**
- **What testing is there for existing Installations?**

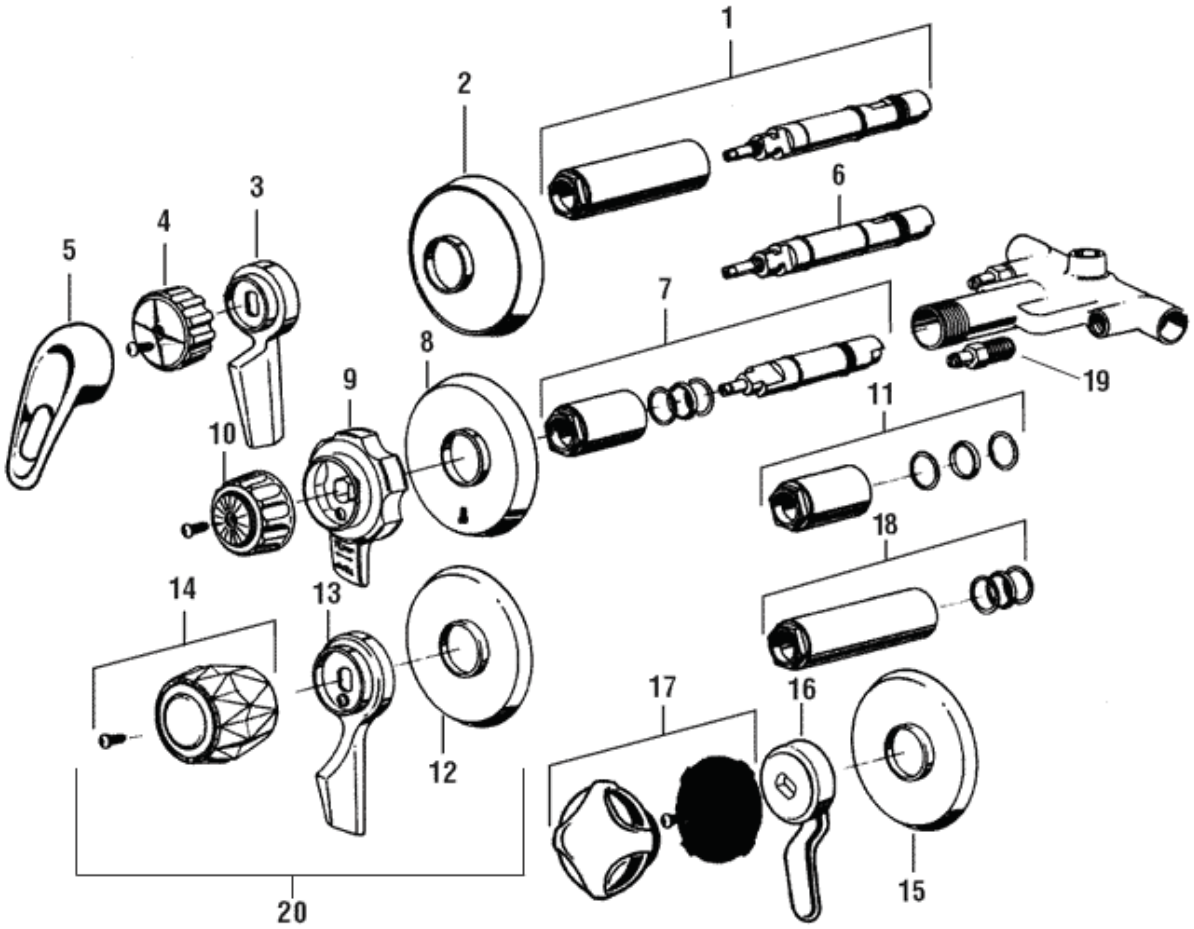


Pressure Balancing Shower Valves



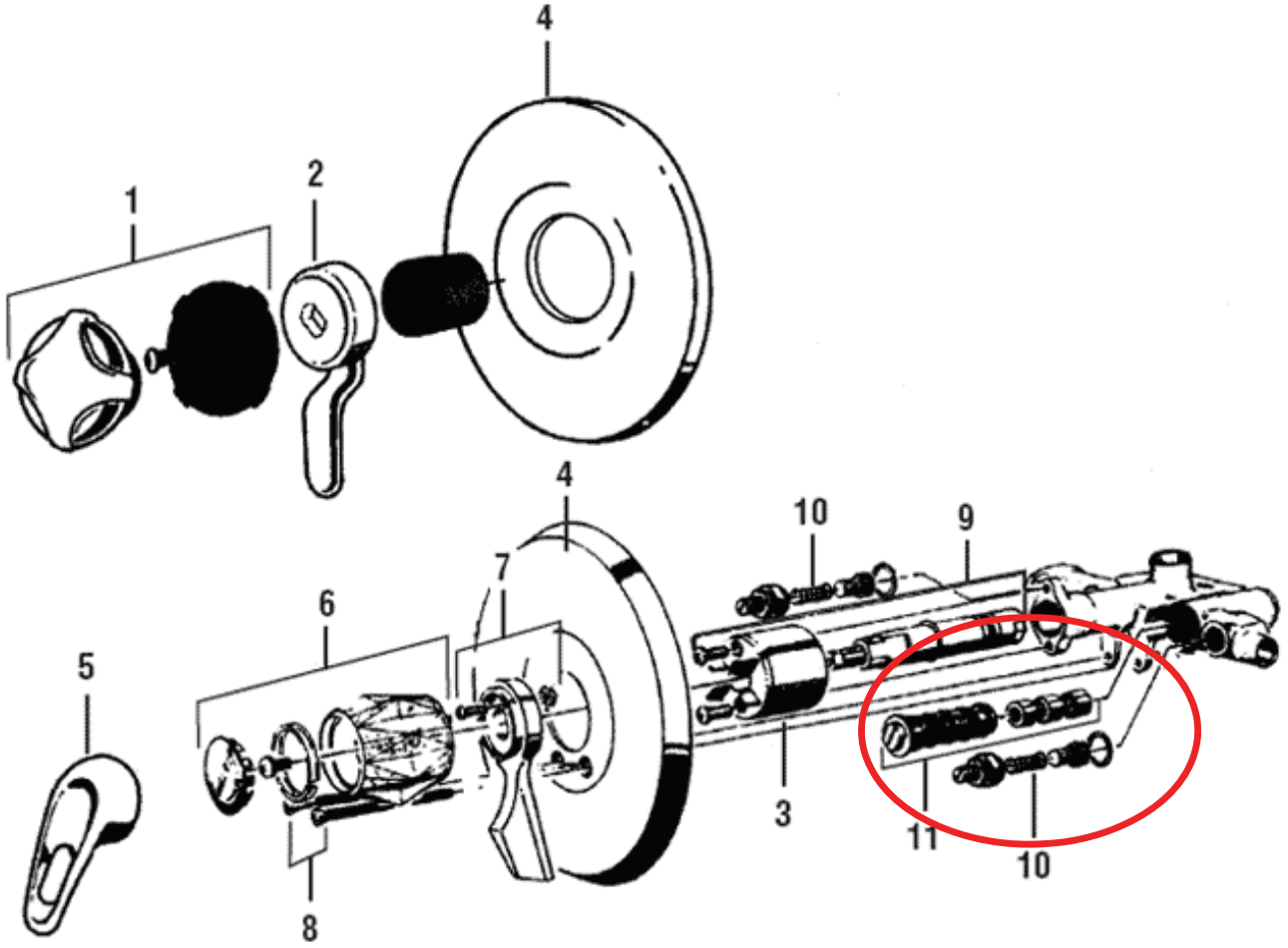
105

Non-Pressure Balancing Shower Valve



106

Pressure Balancing Shower



Pressure Balancing Spool

107

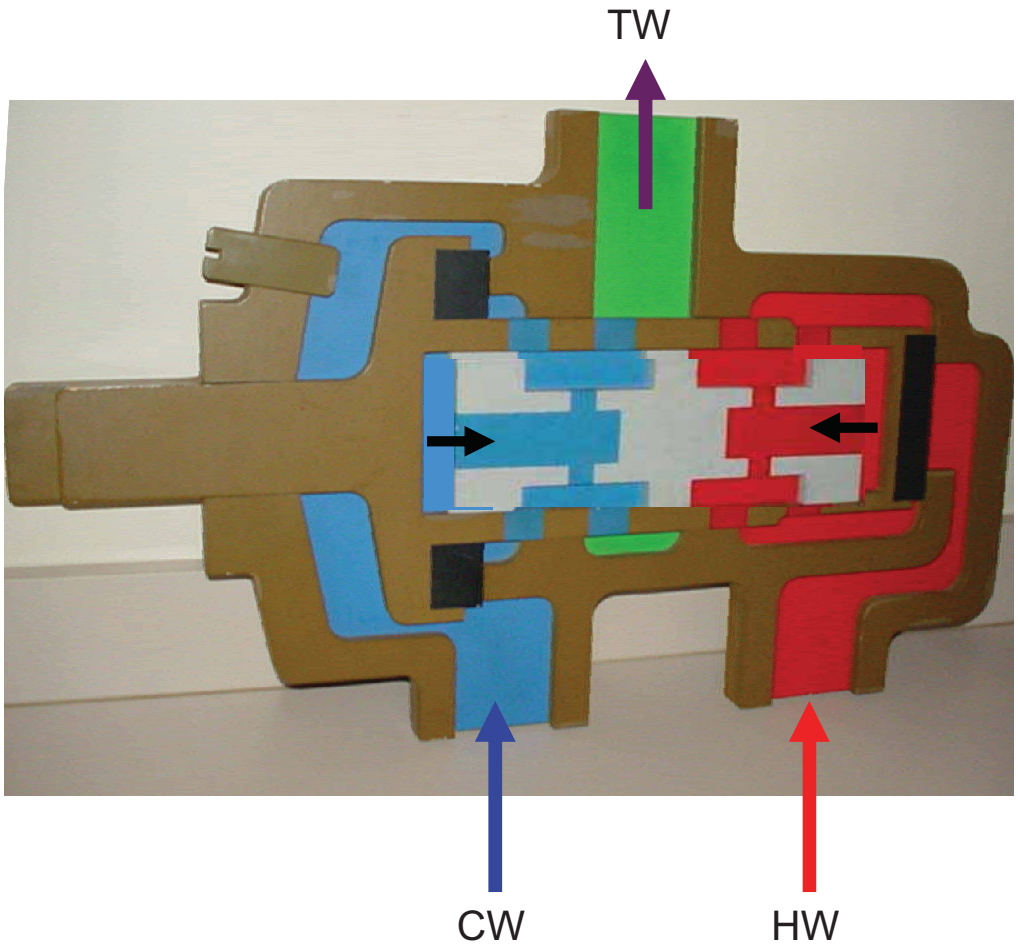
Thermostatic shower valves

What type of valves are these?

You don’t always know until you look behind the cover plate

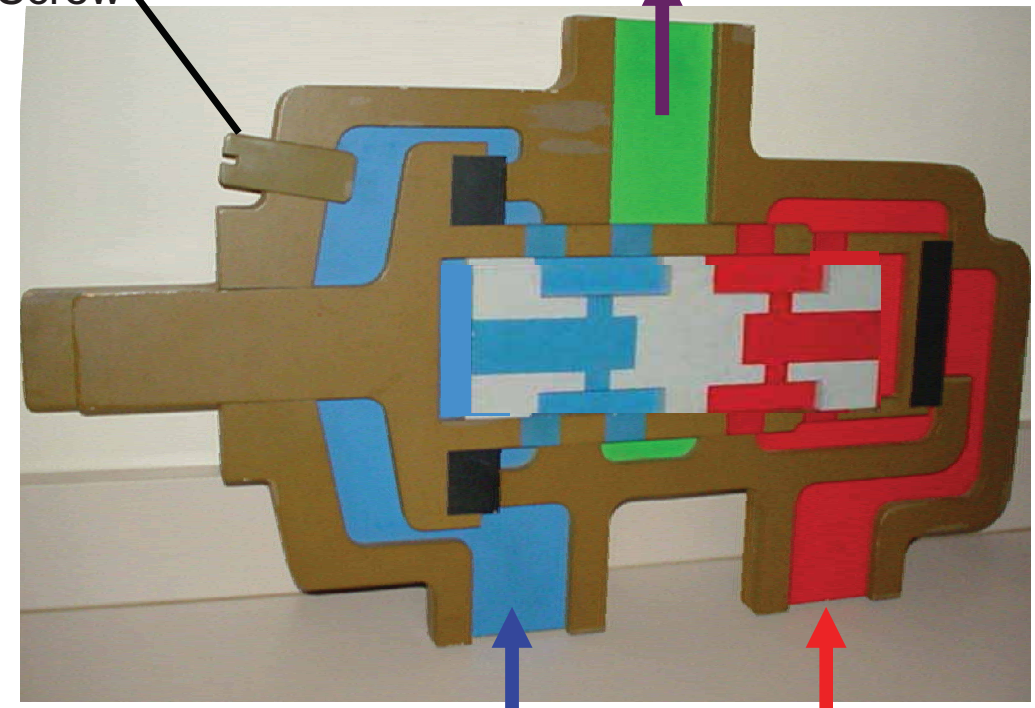
109

Pressure Balancing Valve



110

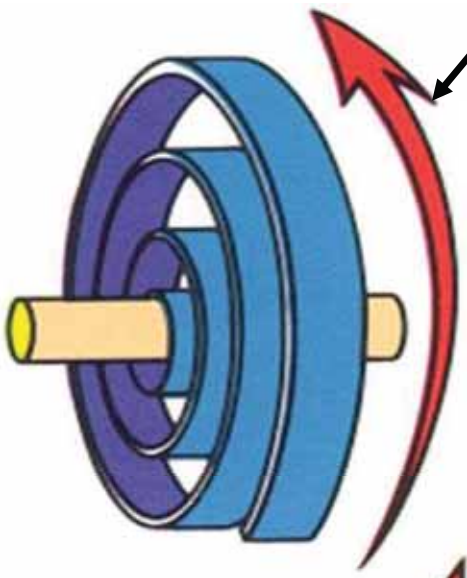
Pressure Balancing Valve



If the incoming water temperature changes this type of valve does not have the ability to sense temperature and compensate for incoming water temperature changes

111

The Thermostatic Shower Valves
Two kinds of actuators

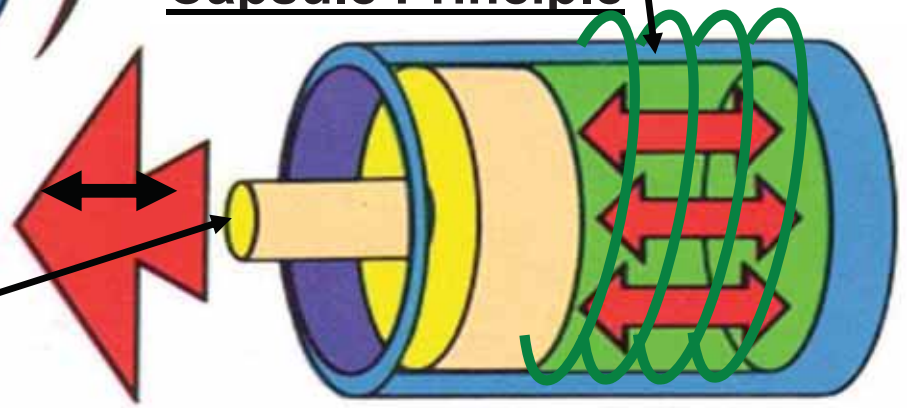


Only a few pounds of force to move a mixing valve shuttle.

1. Bi-Metal Principle

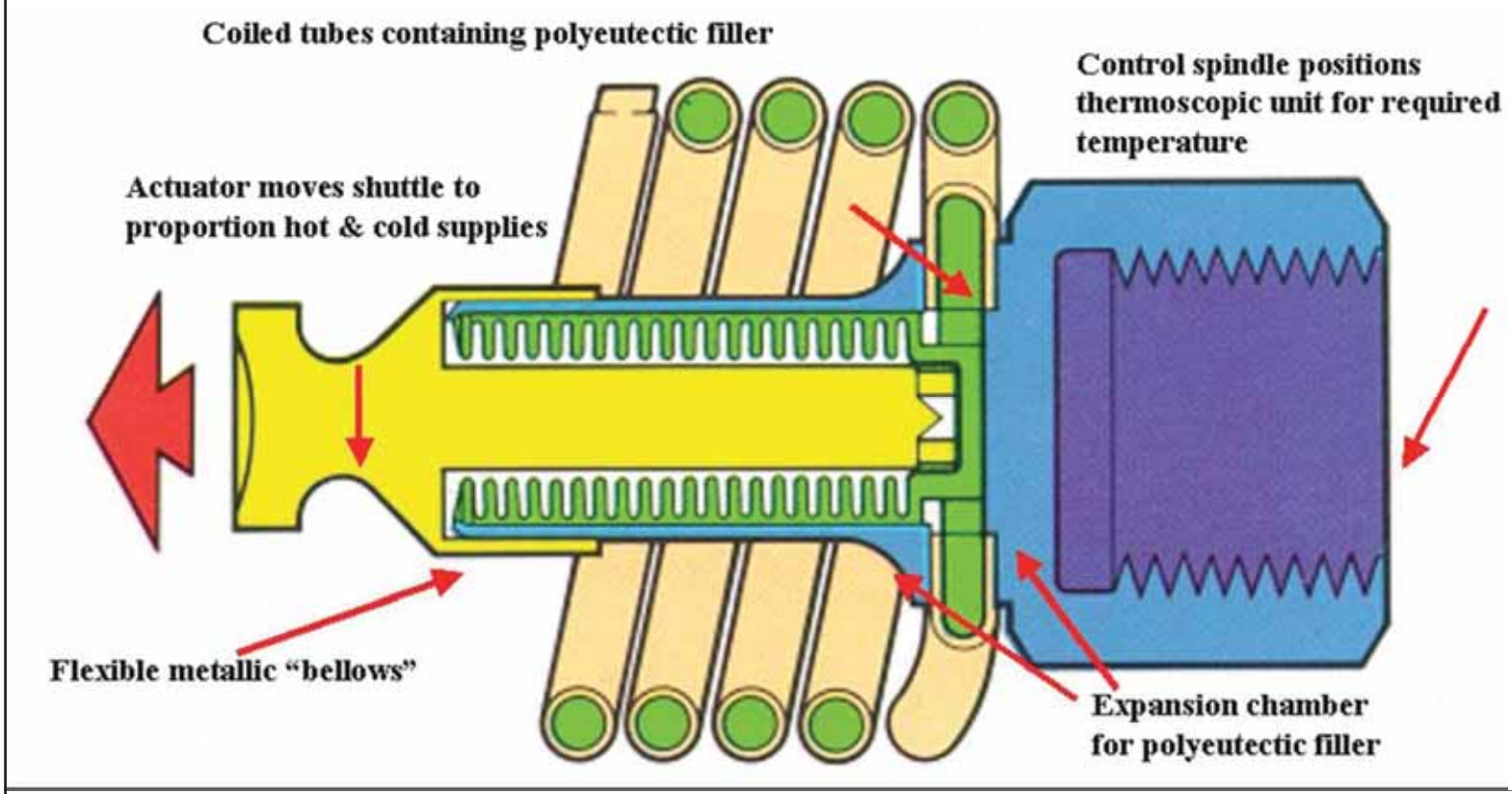
This Design is like a clock spring. It has poor torque & it is susceptible to sticking because of scale & sediment build-up on the coil and shuttle. Low torque requires greater manuf'g tolerances.

2. Liquid Parafin Wax Filled Capsule Principle



Hundreds of pounds of force to move a mixing valve shuttle.

Thermostatic Valves with Parafin Wax offer swift reaction and a powerful stroke

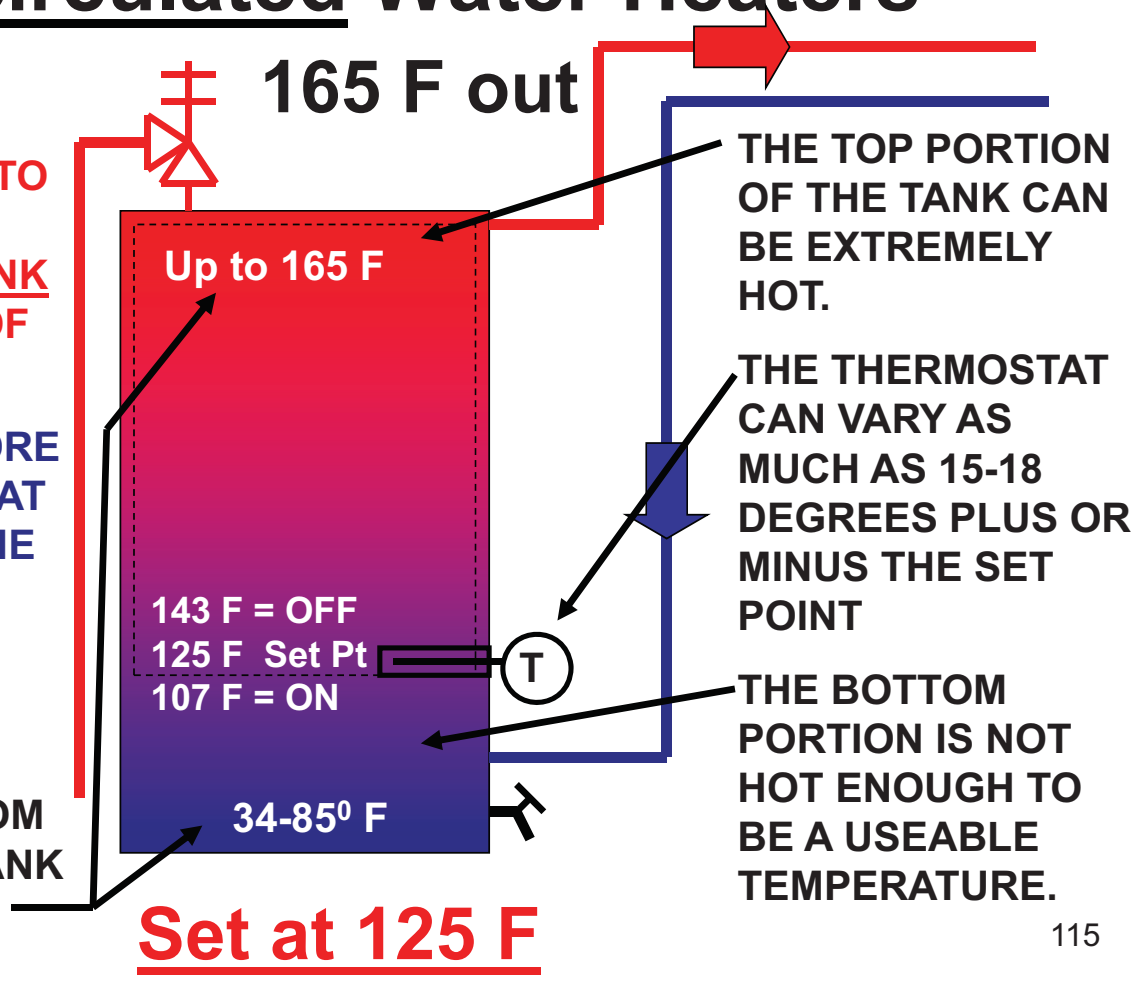


Scald Burns

- **Scald Burns are extremely painful and life altering injuries that can be deadly!**
- We must take every precaution to prevent the increased risk of thermal shock and scalding. If there is any possibility of an increased risk we must make corrections to the plumbing system or warn consumers and the building owner of the potential increased risk of scalding.
- Warnings should be included on products, packaging and in installation and maintenance literature with low flow showerheads (Below 2.5 GPM)
- Ignoring the problem and Increasing the risk of thermal shock and scalding should not be allowed.

114

The "Stacking Effect" in Un-circulated Water Heaters



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115

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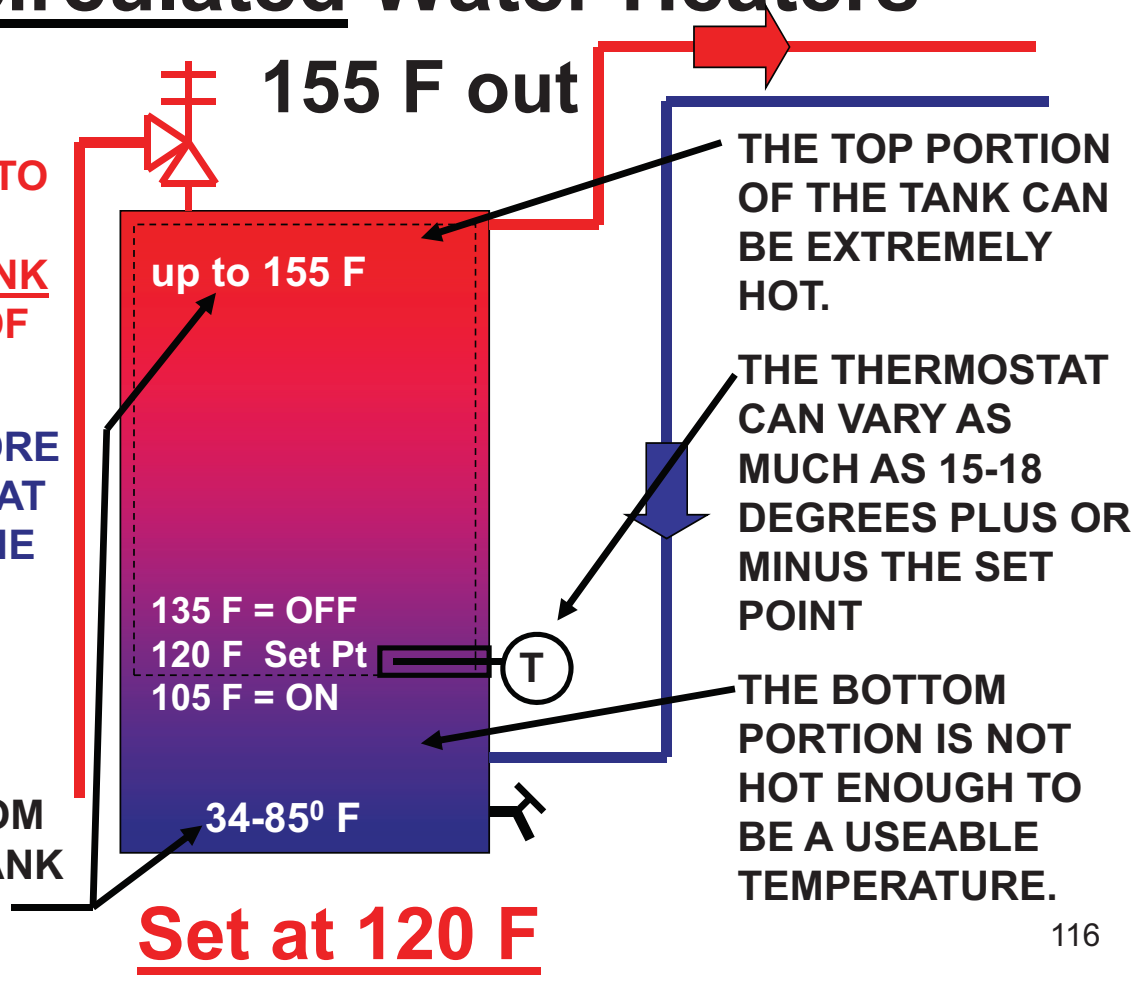

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116

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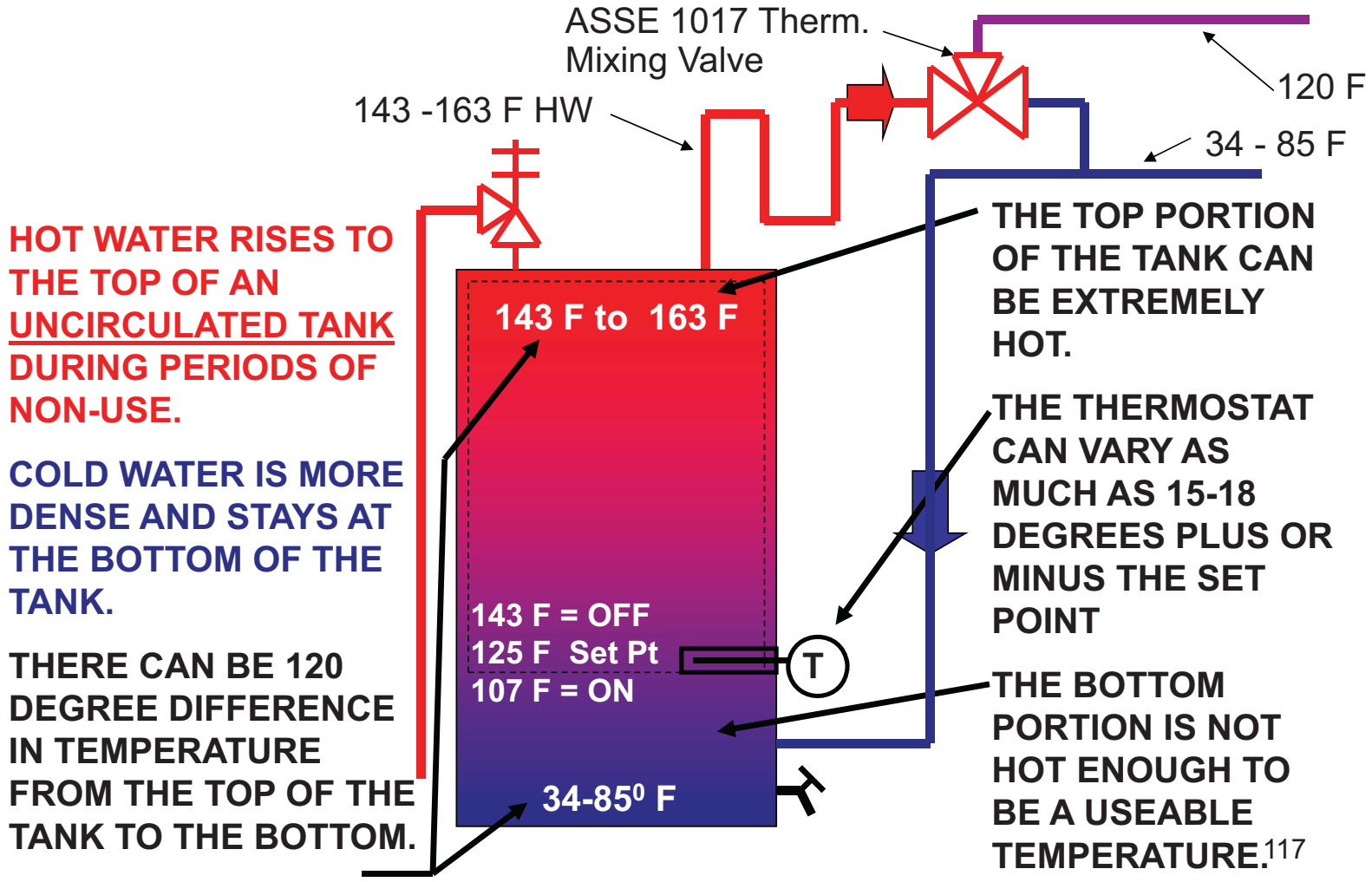

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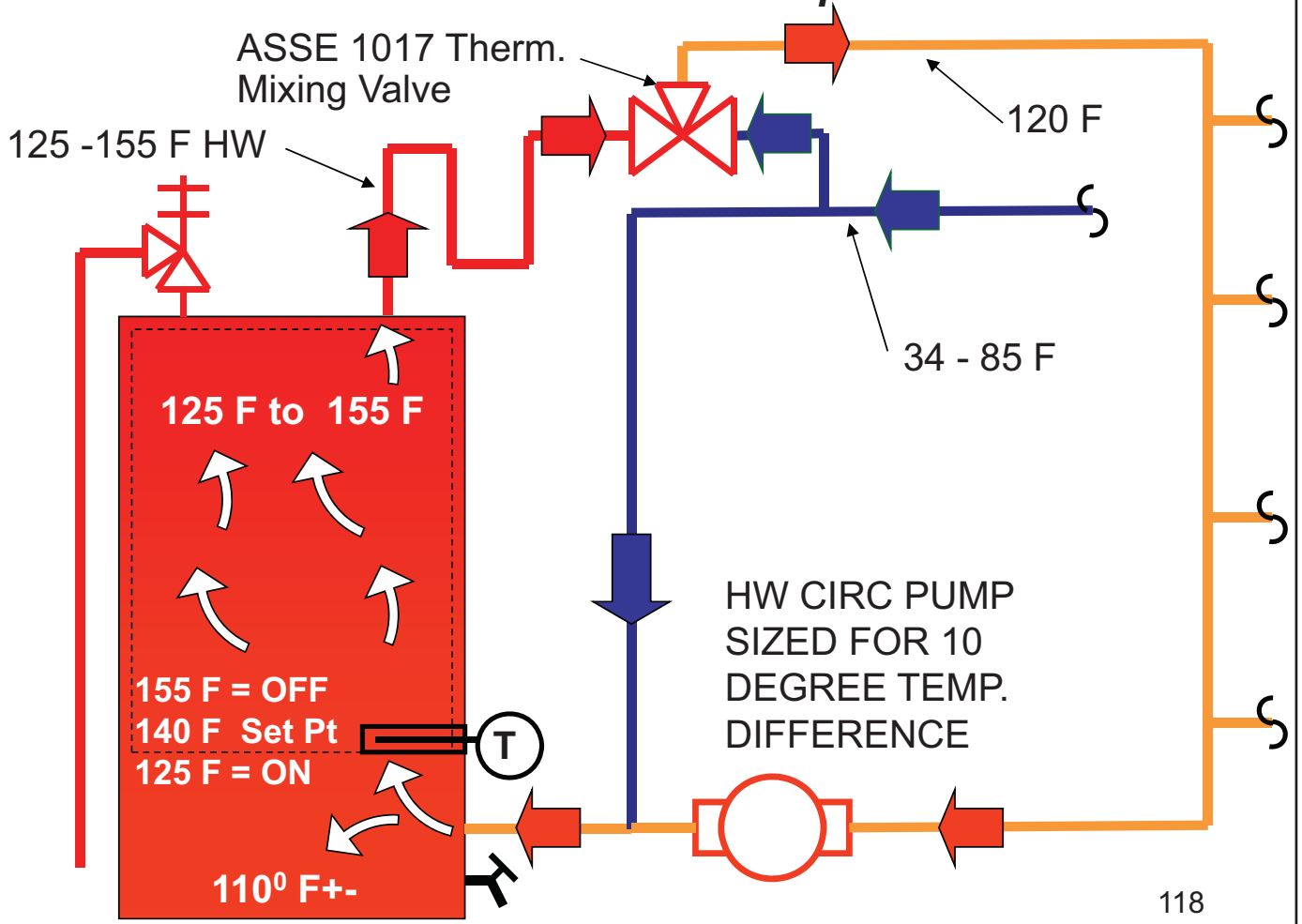
How Do We Control the Temperature Swings?

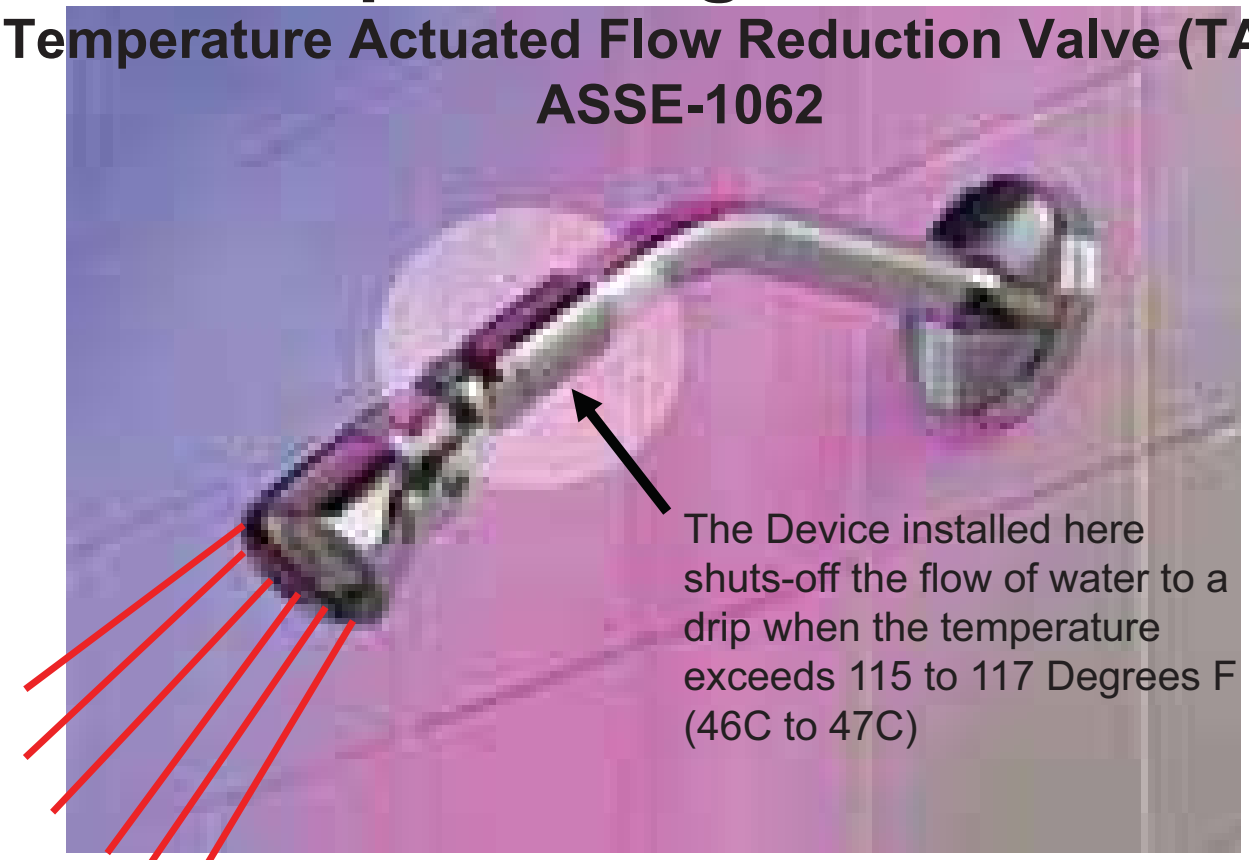
Circulating hot water return through the heater mixes up the hot water in the tank and stabilizes the hot water temperature!



118

A cheap solution for non-compensating shower valves.

Temperature Actuated Flow Reduction Valve (TAFR) ASSE-1062



Available at:
http://www.cashacme.com/prod_thermostatics_HG_TAFR.php
or www.pppinc.net

119

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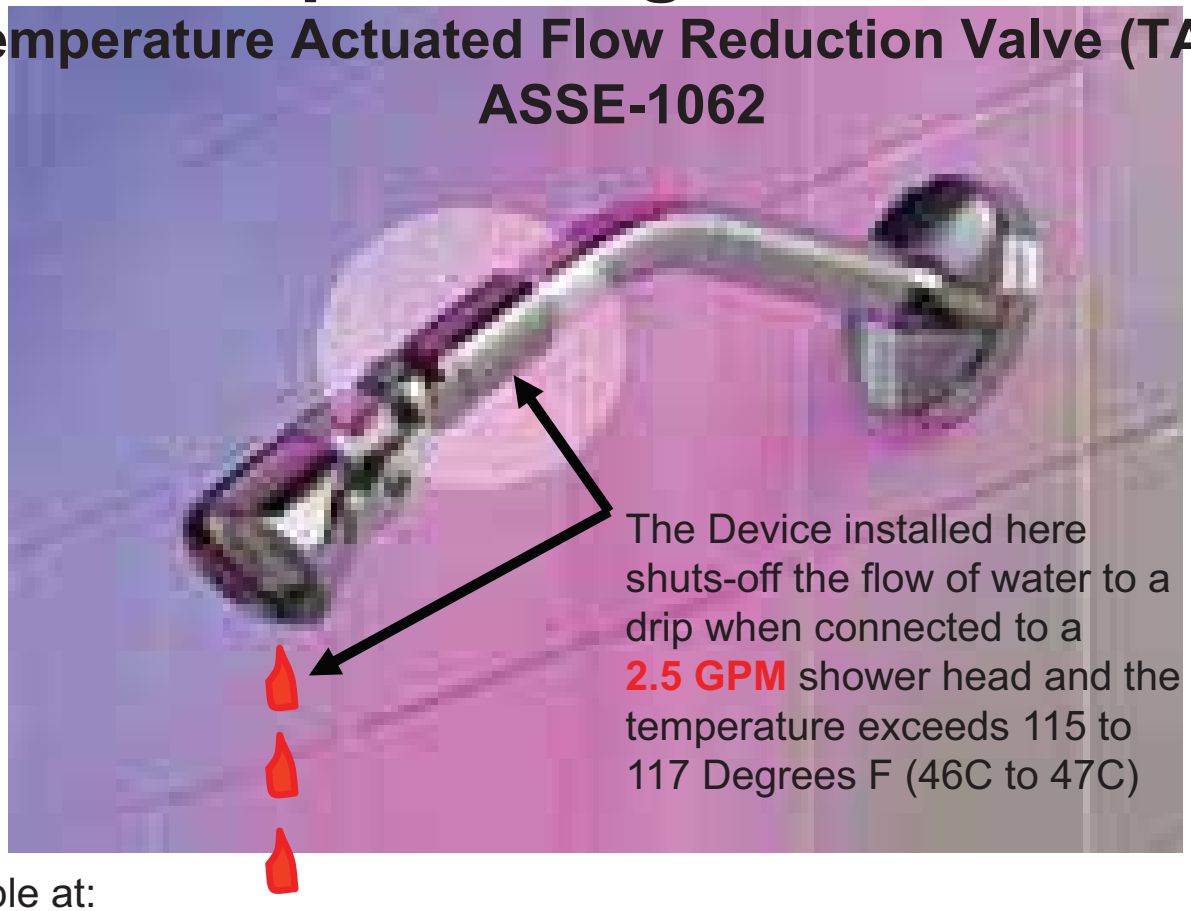

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120

A cheap solution for non-compensating shower valves.

Temperature Actuated Flow Reduction Valve (TAFR) ASSE-1062

Many Low Flow shower heads **1.5 GPM & below** still have a full spray pattern when the ASSE 1062 Device reduces the flow to approx 0.5 GPM.

Available at:
http://www.cashacme.com/prod_thermostatics_HG_TAFR.php
or www.pppinc.net

Why use Thermostatic Mixing Valves?

- Safety: Accurately and Safely deliver water to points of use when the water storage temperatures have been increased to:

A) Eliminate legionella incubation

B) Deliver water at a safe temperature for bathing.

C) Prevent flue gases from condensing in gas fired water heaters

Quotes

"Protection of the Public's Health and Safety is Non-negotiable!"

Source:

Undersecretary, Department of Environment and Natural Resources, (DENR)

Brigadier General, Francisco Bravo (Philippines)

123

College of Engineering
Department of Professional Development

Plumbing System Design Including Water Conservation and Reclaim

April 16–20, 2012 Madison, Wisconsin

Hot Water System Design Considerations in High Rise Buildings

"Sustainable vs Unsustainable" Designs

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High Rise Hot Water Systems

1. Why do we need to treat high rise Hot Water systems any different than a one story building?

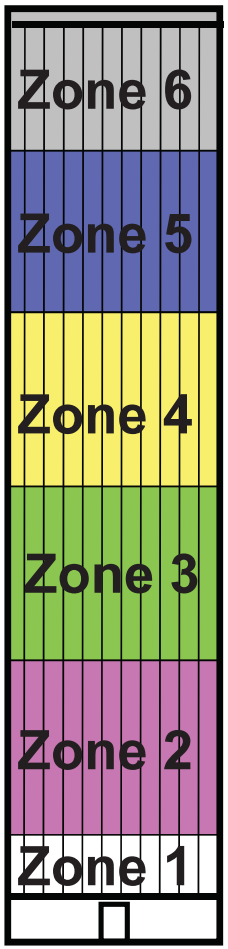
- We don't really need to treat them different, but we need to think about how to install the systems properly.

2. What can happen if there is a problem in a hot water system?

- Injuries, Property Damage, and Wasted energy.

High Rise Bldg. Hot Water System Design

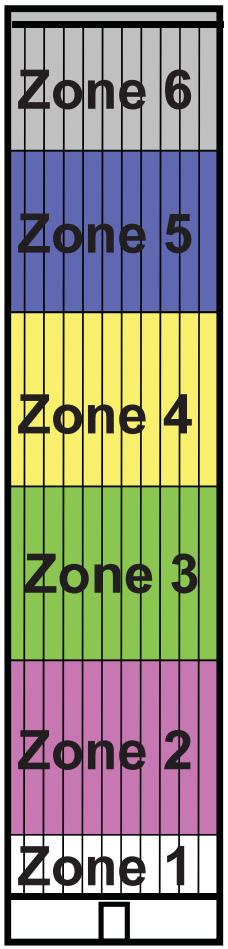
What are the unique challenges for high rise building plumbing systems?



1. **Water Pressure**
2. **Pressure Zones**
3. **Venting** *(Gas Appliance Flue/Vent Routing)*
4. **Floor Space** *(Water Heaters)*
5. **Ceiling Space**
6. **Pipe, Valve & Equip Pressure ratings**
7. **Balanced Press HW-CW**
   - **Scalding/Thermal Shock**
   - **Crossover of HW to CW or CW to HW**
8. **Water Heater Type/Location**
9. **Pipe Expansion & Contraction**

High Rise Bldg. Hot Water System Design

What are the unique challenges for high rise building plumbing systems?



10. Water Hardness
11. Softening
12. Corrosion
13. Peak Demand Loads
14. Hot Water Circulation
    - Sizing HW Circ. Piping
    - System Piping configuration
    - Circ Pump Location
    - Air Vents
15. Excess Pressure relief
16. Temperature control
17. Combined Systems *(HVAC-PLBG)*

There are many High Rise System HW Design Configurations.

1. Some are sustainable and many are not sustainable.

2. We covered Pressure Zones in the High Rise Building for CW Systems.

3. Many of the pressure zone issues apply here also.

4. The key is to keep the HW system within one pressure zone. You will see why.

Hot Water Pressure Zones Piping Configurations

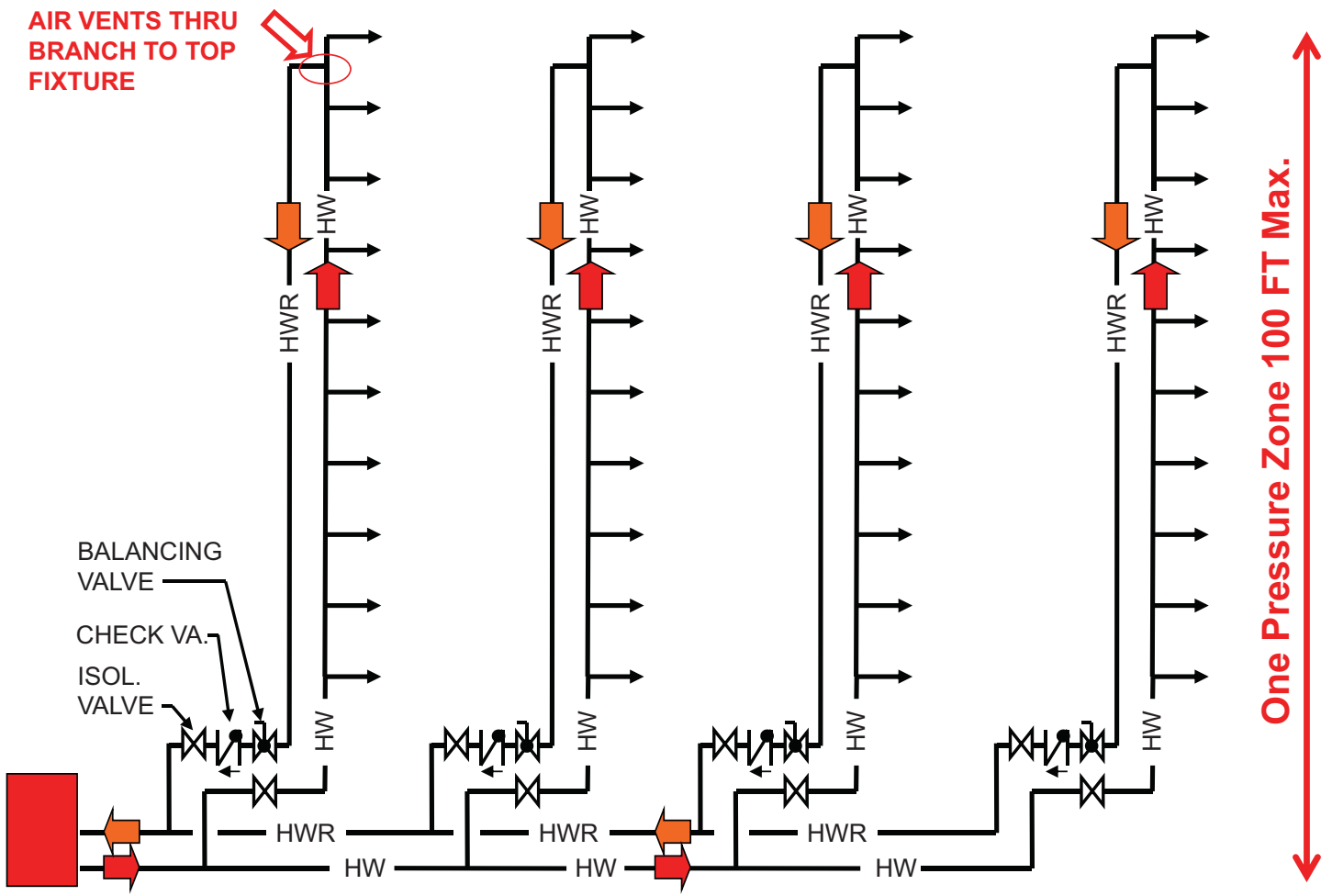


Fig. 1 - HW UPFEED SYSTEM

(WH LOCATED OT THE BOTTOM)

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Hot Water Pressure Zones Piping Configurations

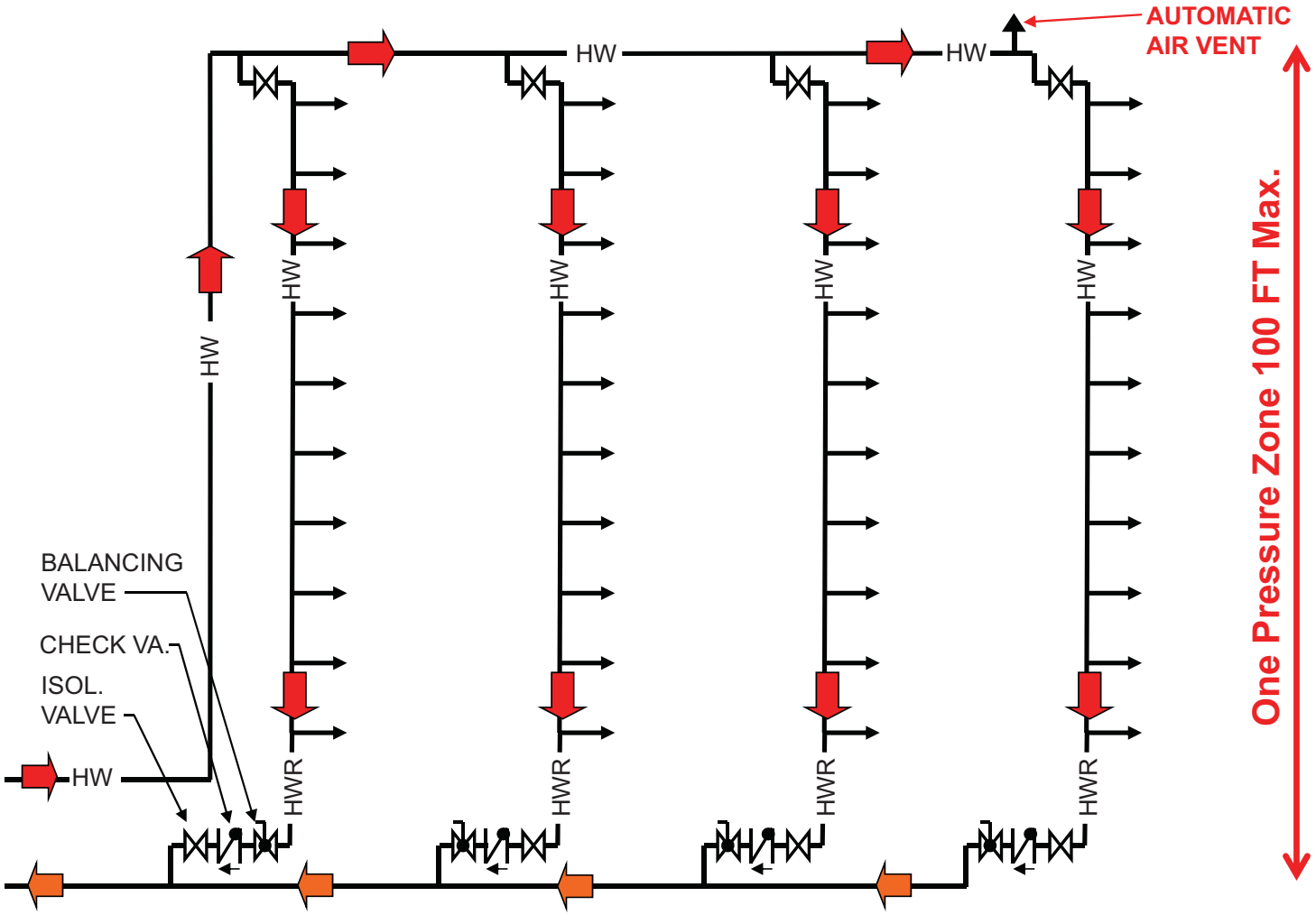

Fig. 2 - HW DOWNFEED SYSTEM

(WH LOCATED OT THE BOTTOM)

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Hot Water Pressure Zones Piping Configurations

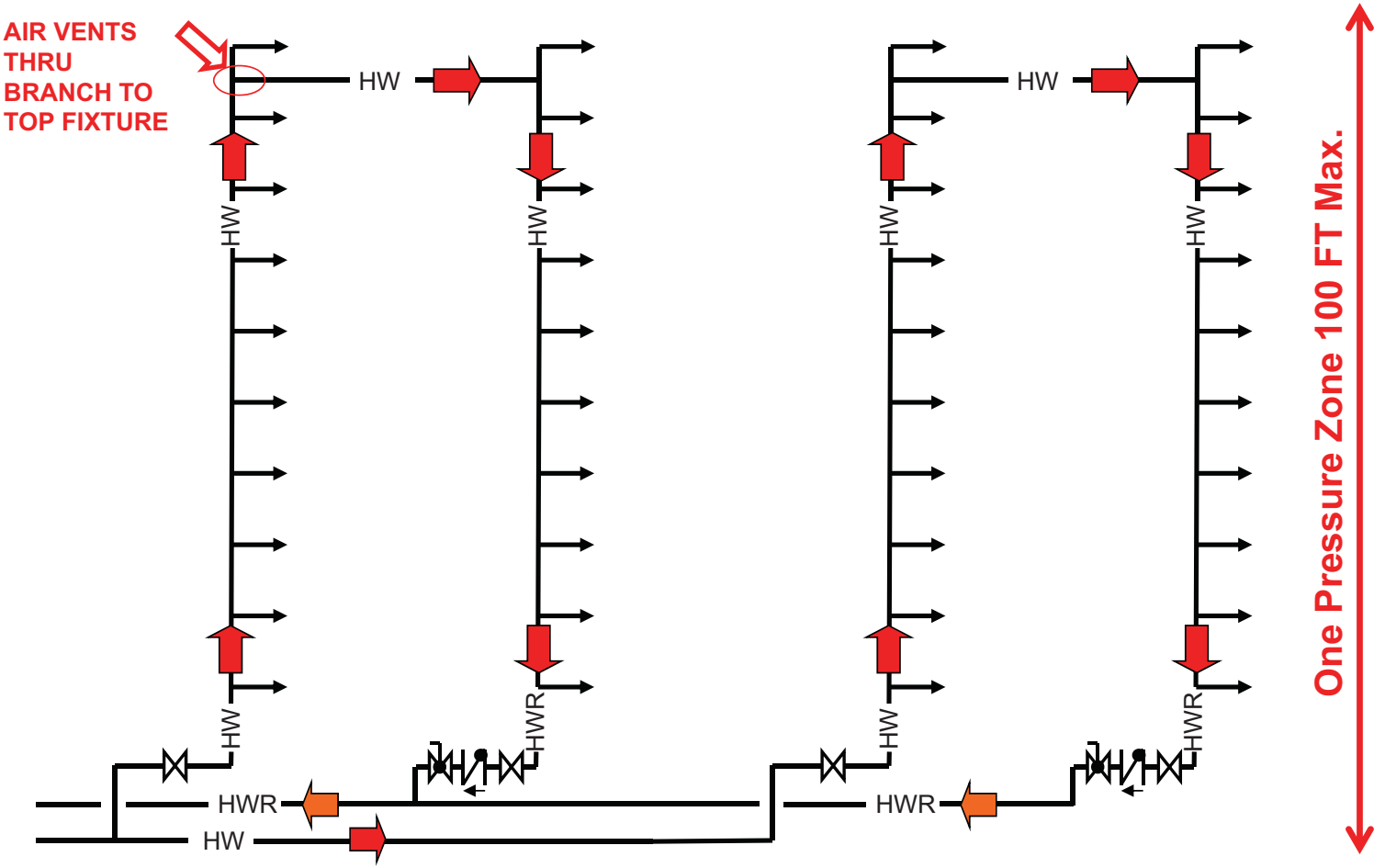

Fig. 3 – UPFEED AND DOWNFEED SYSTEM

(WH LOCATED OT THE BOTTOM)

Hot Water Pressure Zones Piping Configurations

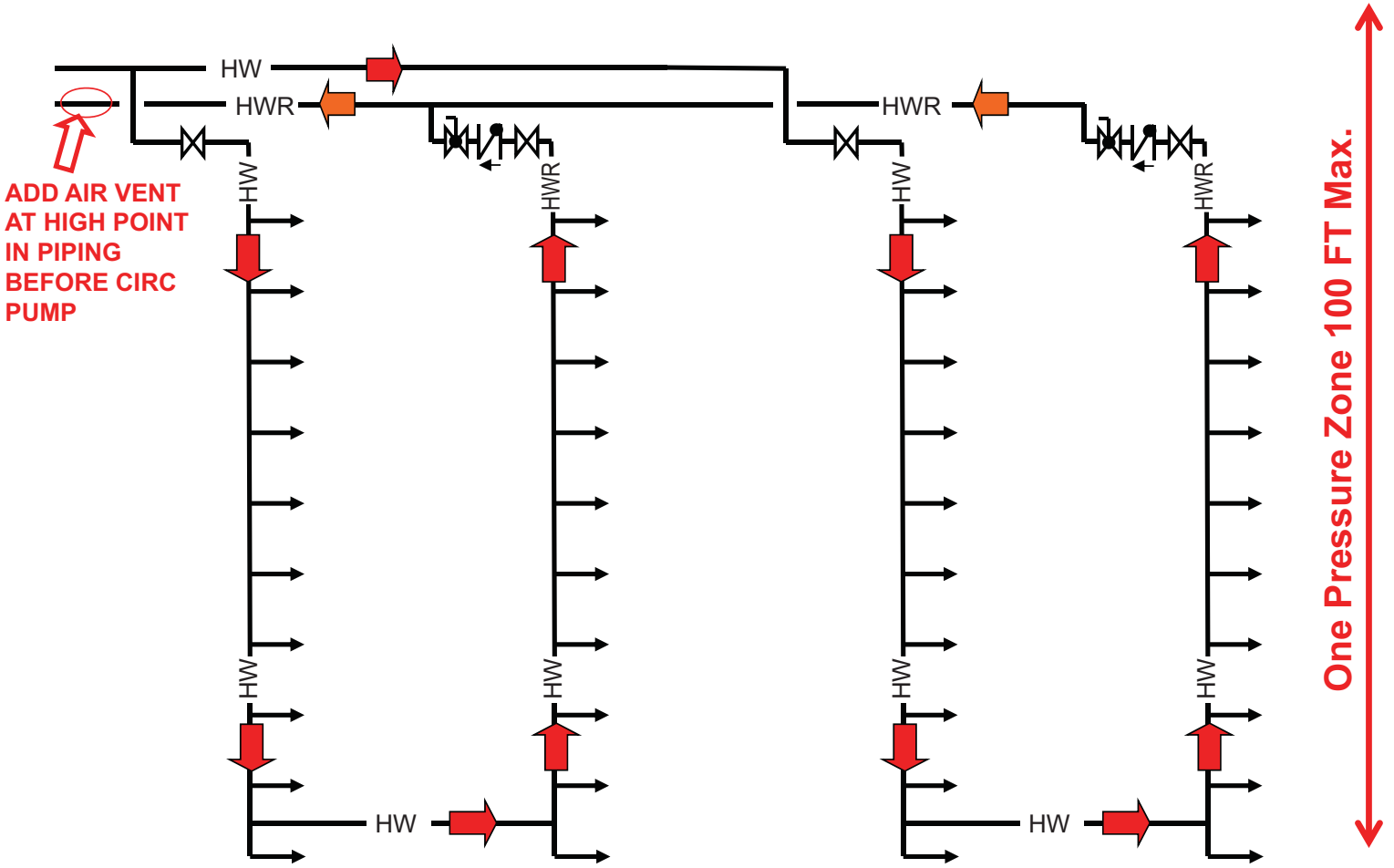

Fig. 4 – UPFEED AND DOWNFEED SYSTEM

(WH LOCATED OT THE BOTTOM)

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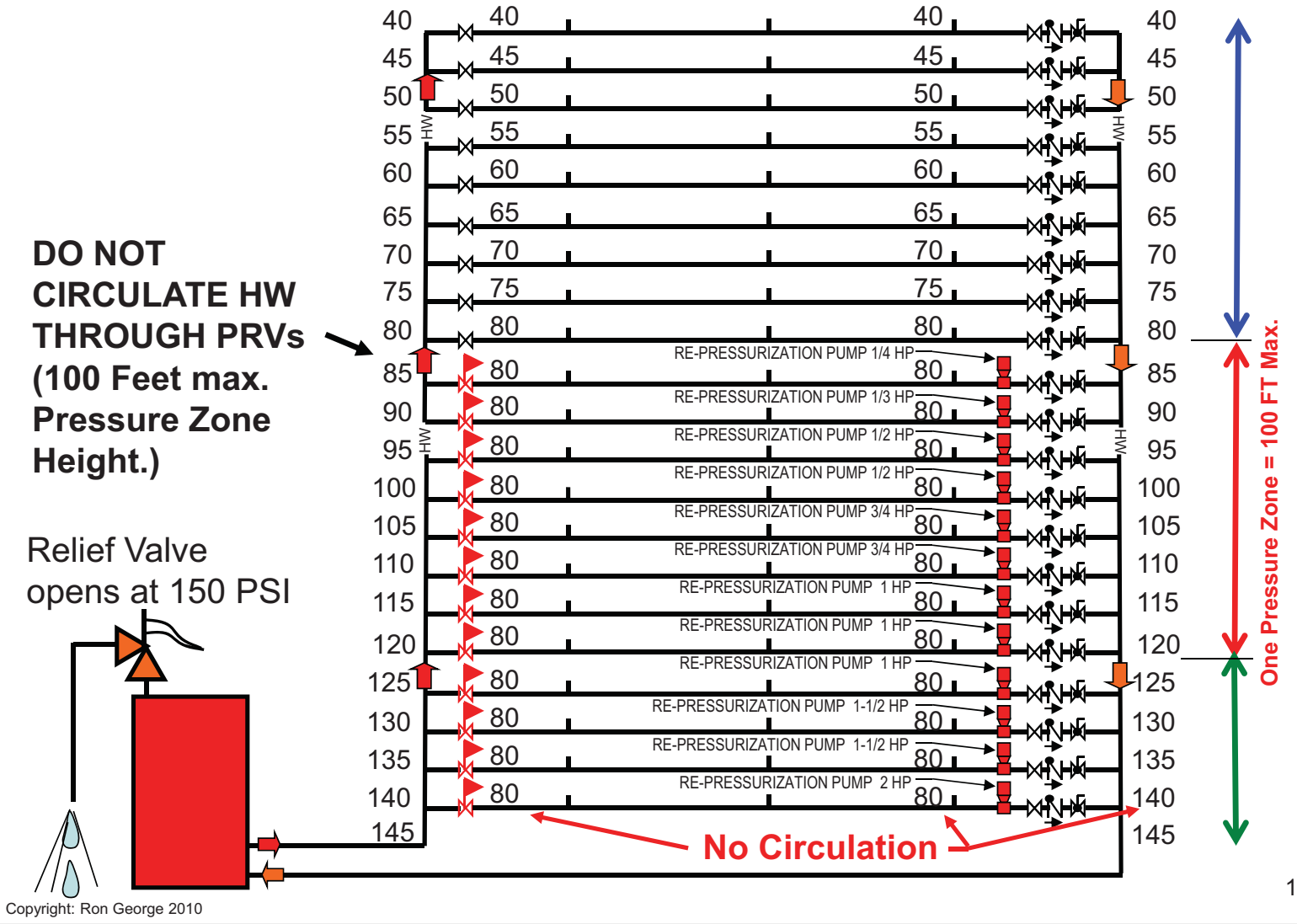
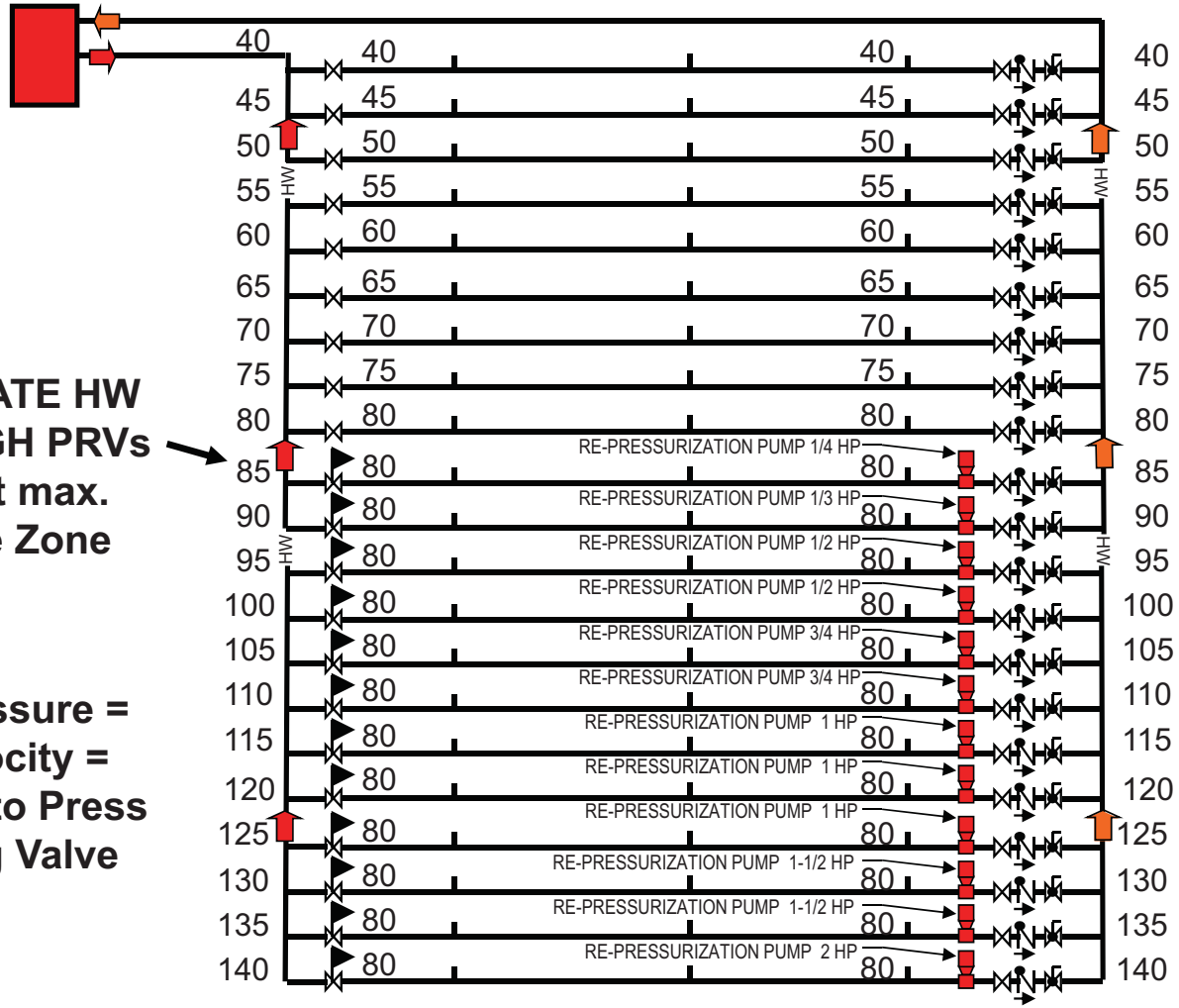
Hot Water Pressure Zones - Piping Mistakes



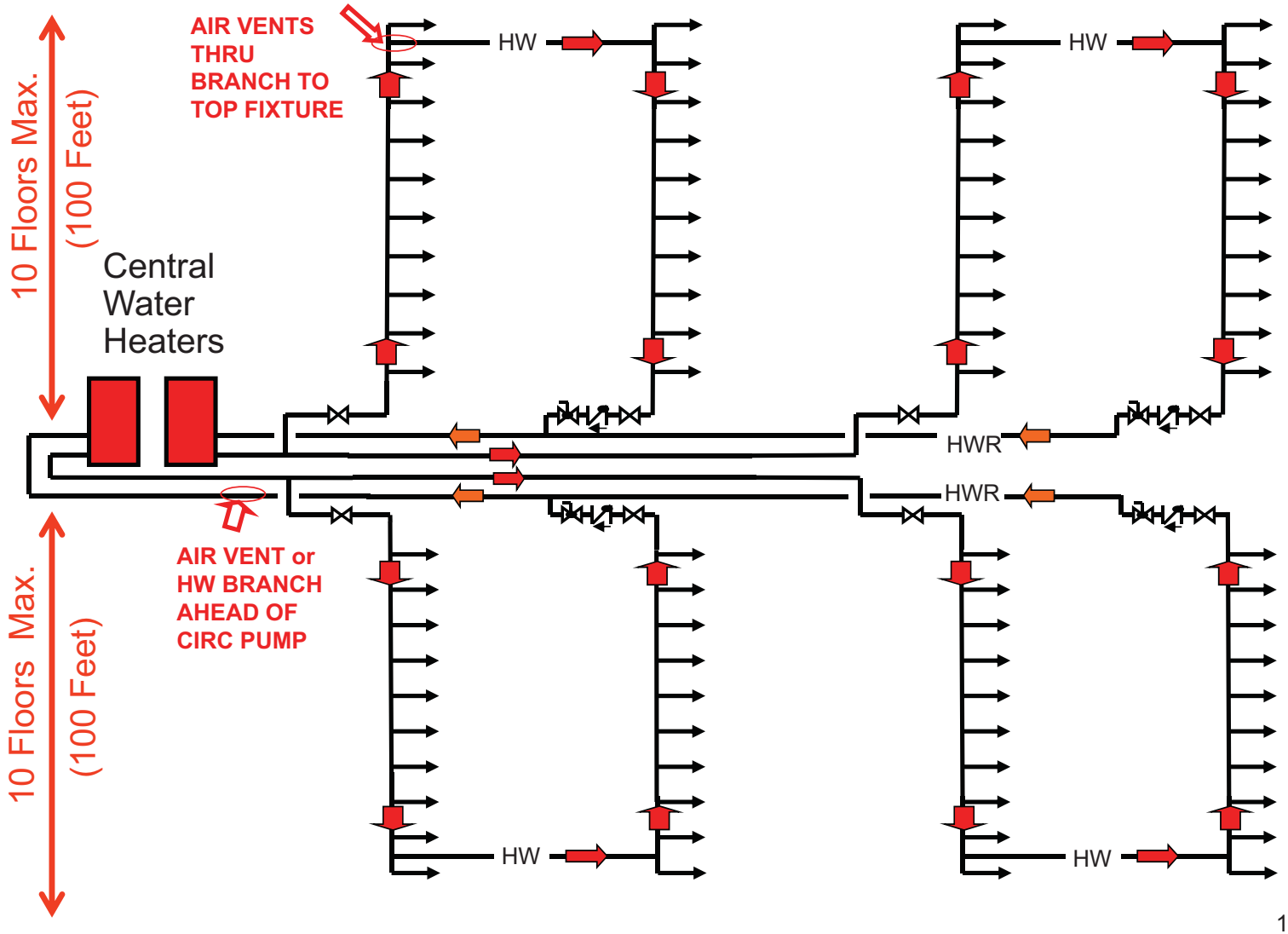
Hot Water Pressure Zone Piping Mistakes

DO NOT CIRCULATE HW THROUGH PRVs (100 Feet max. Pressure Zone Height.)

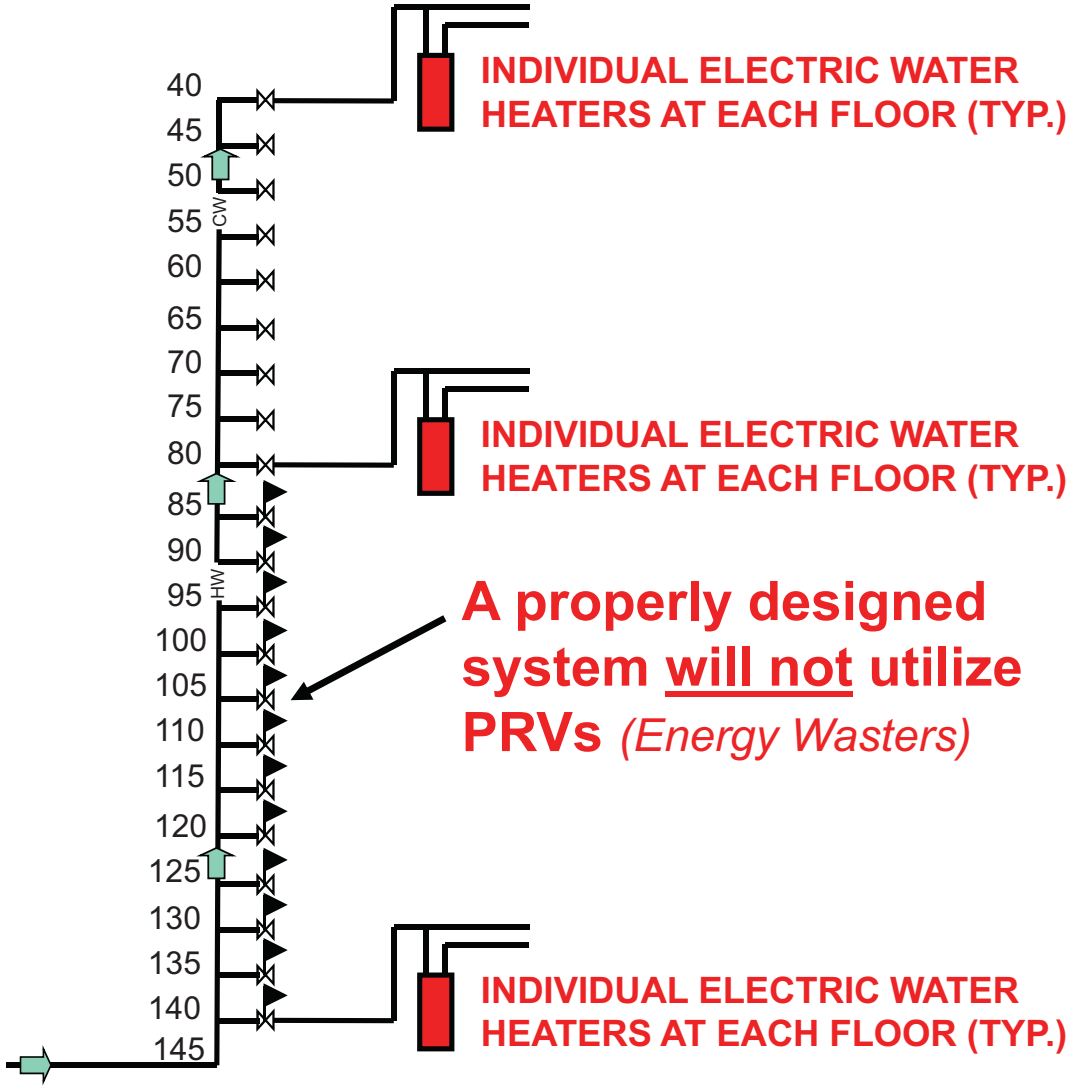
High Pressure = High Velocity = Damage to Press Reducing Valve Seats.



Correct Piping for Hot Water Pressure Zones



Hot Water Pressure Zone Piping Mistakes



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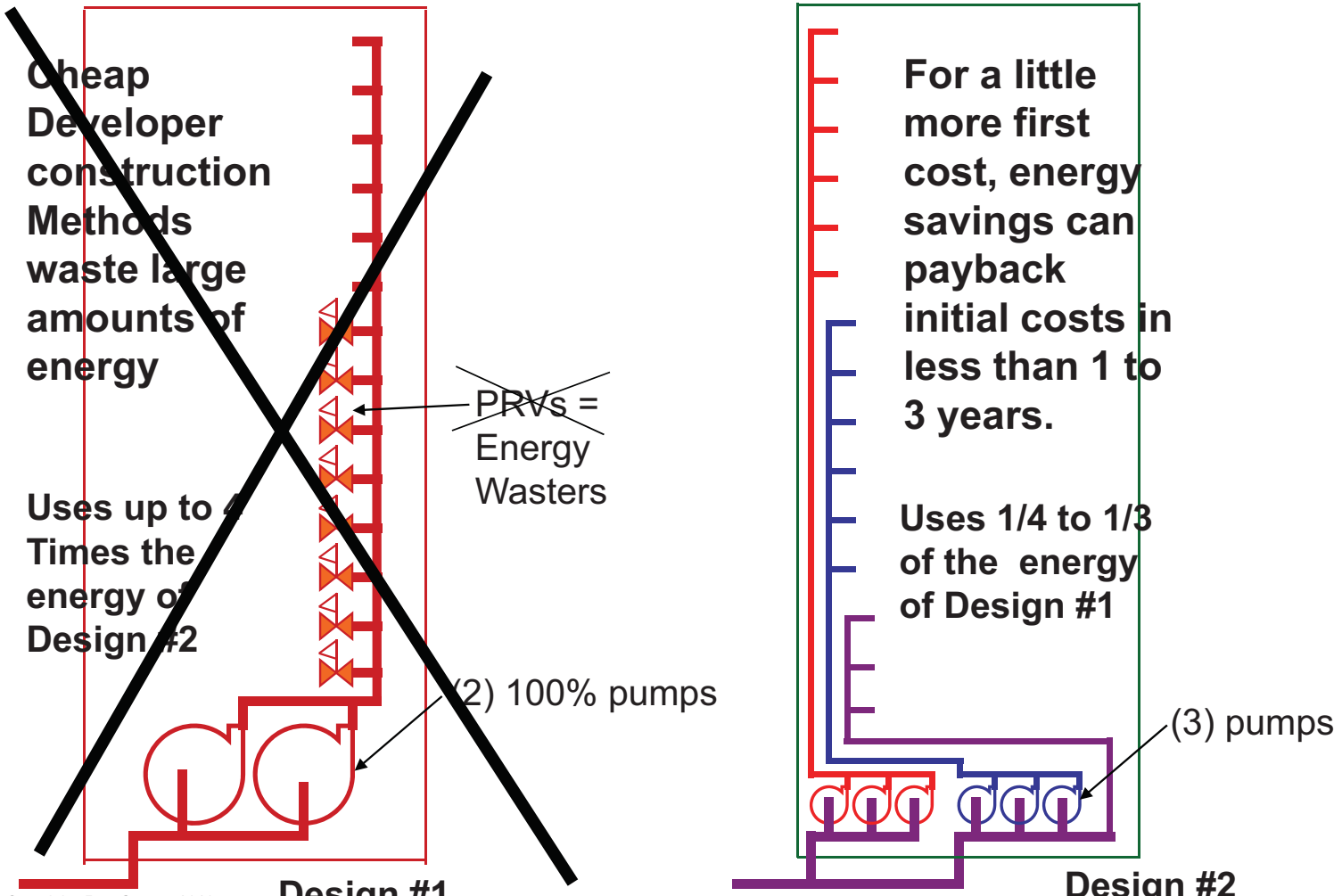
Domestic Water Booster Pump

Green High Rise Plumbing Designs



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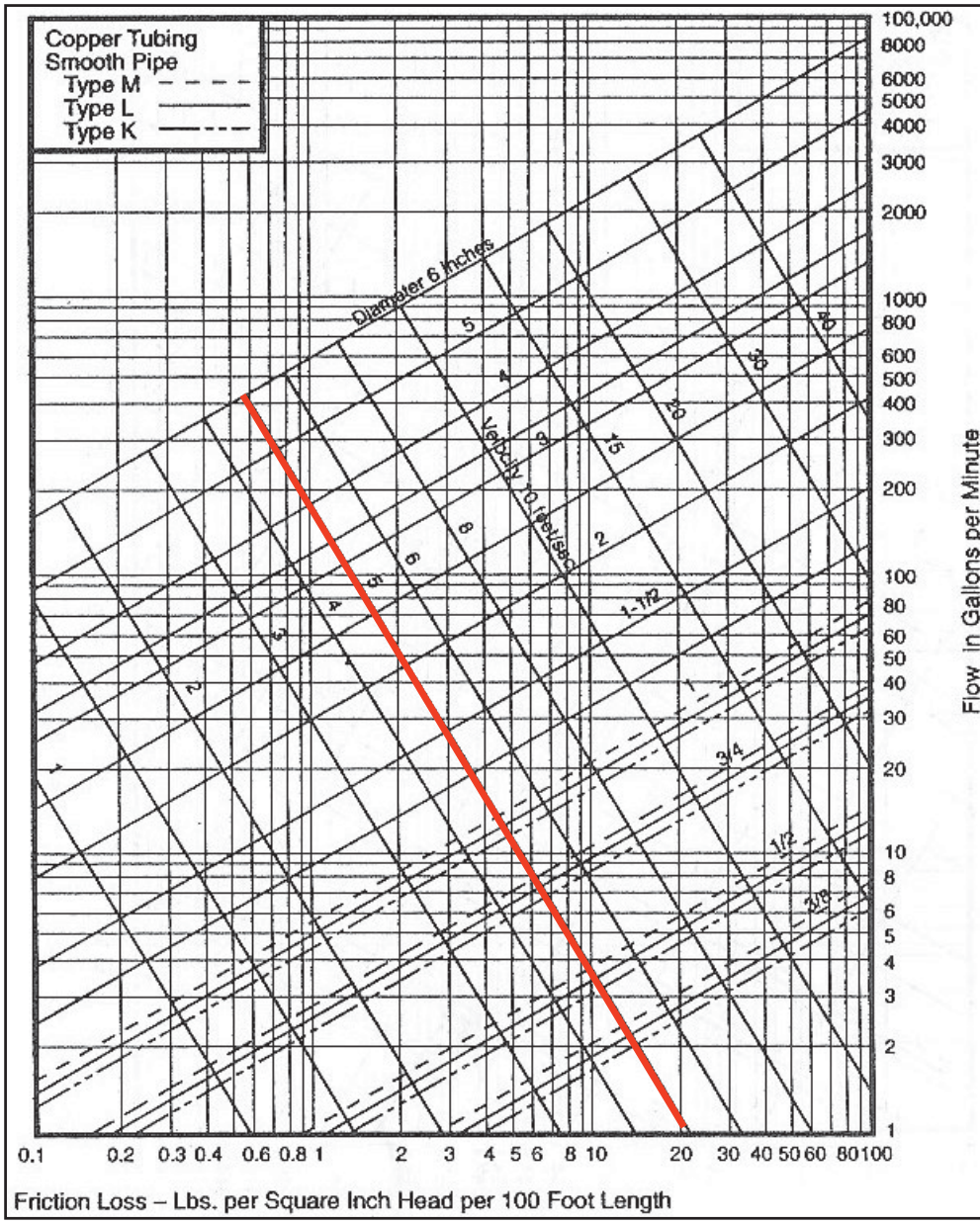
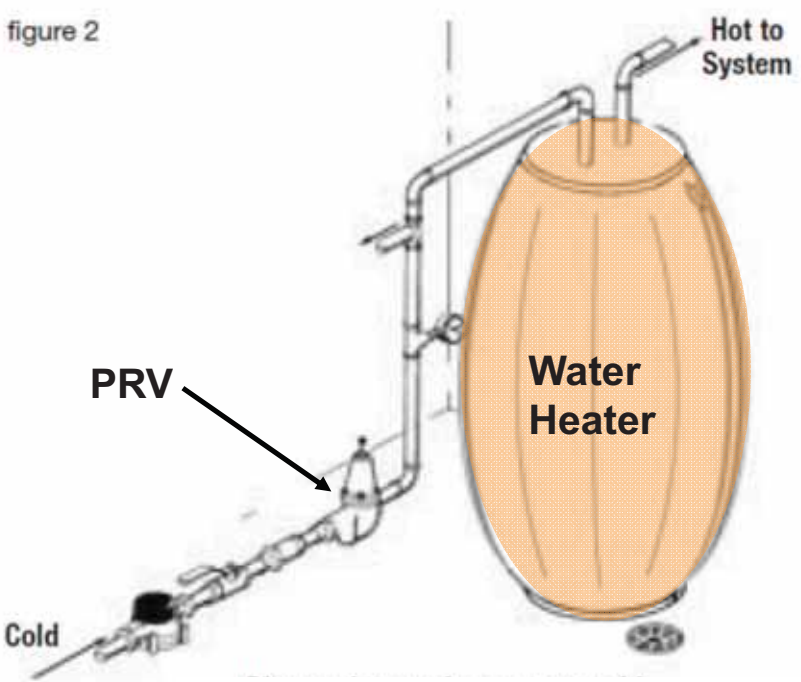


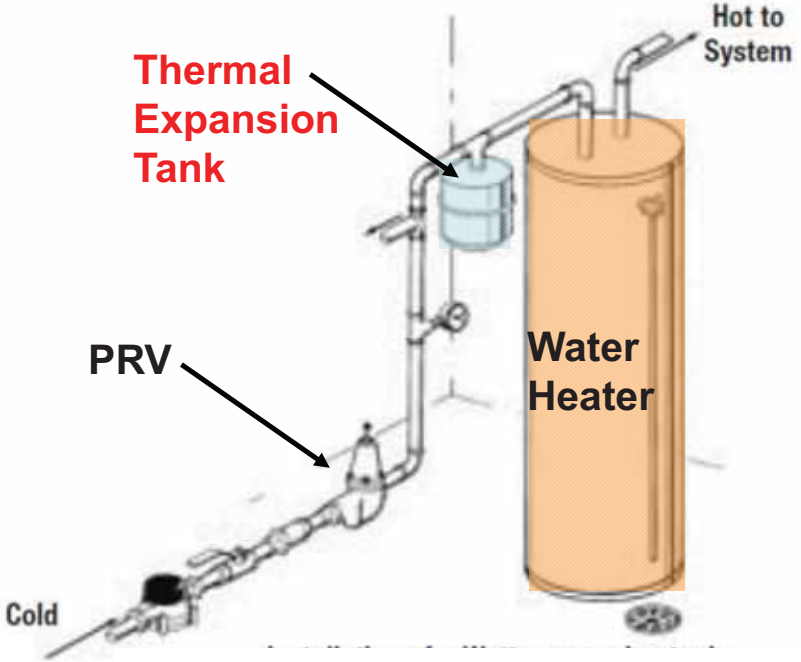
Maximum Recommended Velocity of HW in copper tubing is 5 Feet Per Second

(Source: Copper Development Association)

Thermal Expansion Tanks

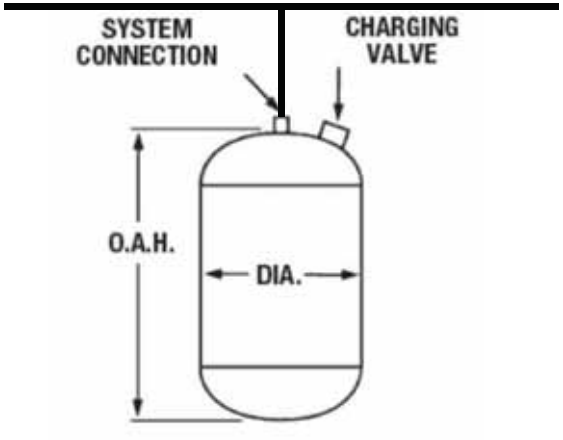


Distorted Water Heater from Excess pressure over 100 PSI will crack a glass lining and void the Manufacturer's warranty.

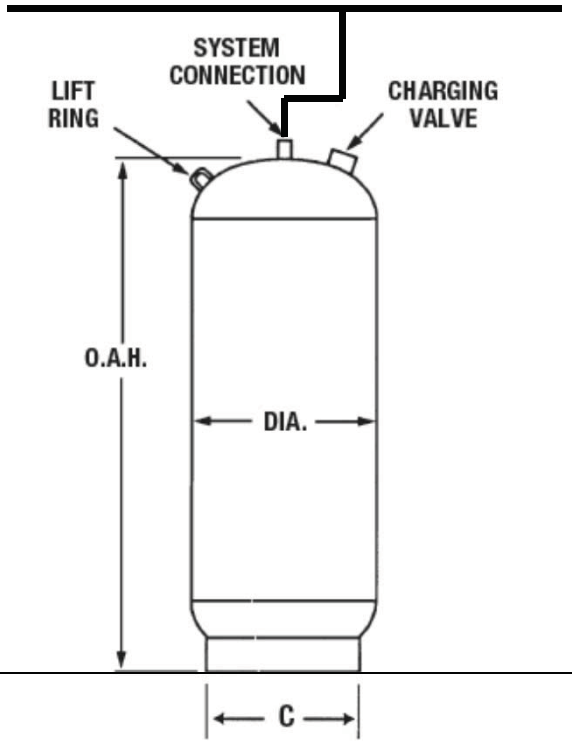


Installation of a thermal expansion tank will protect the water heater and all associated components in the HW System from excessive pressure.

Thermal Expansion Tanks



Pipe Mounted Expansion Tank



Floor Mounted Expansion Tank

Thermal Expansion Tanks

How they work.

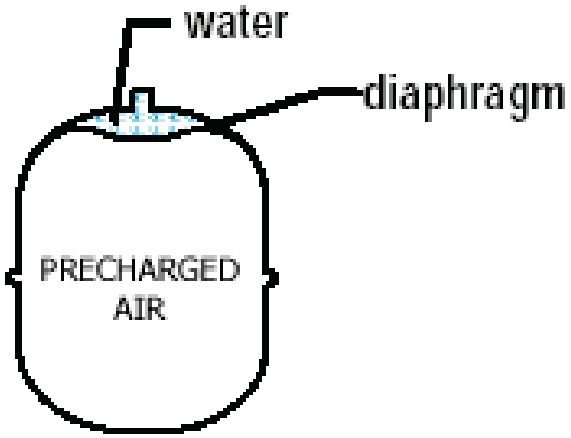


Figure 1. As the water temperature increases, the expanded water is received by the tank.

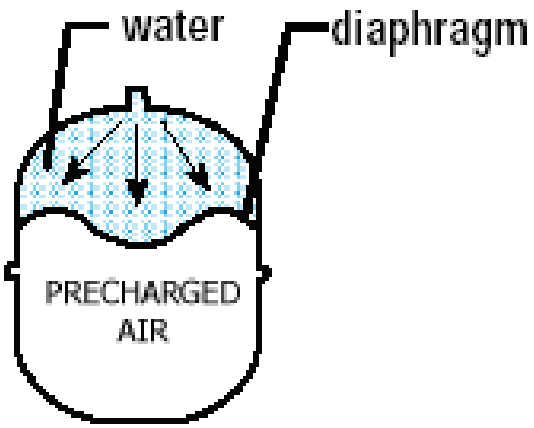
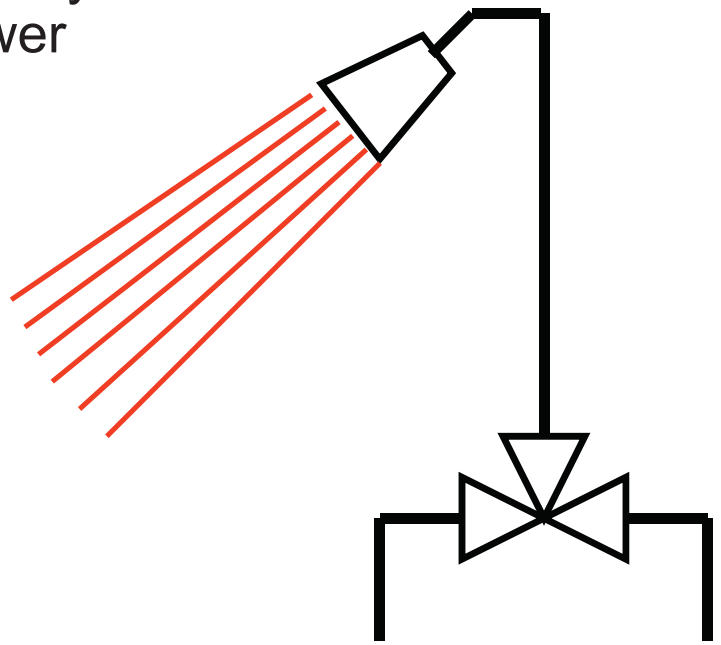


Figure 2. As the water and pressure reaches its maximum, the diaphragm flexes against the air cushion (air is compressible) to allow for increased water expansion.

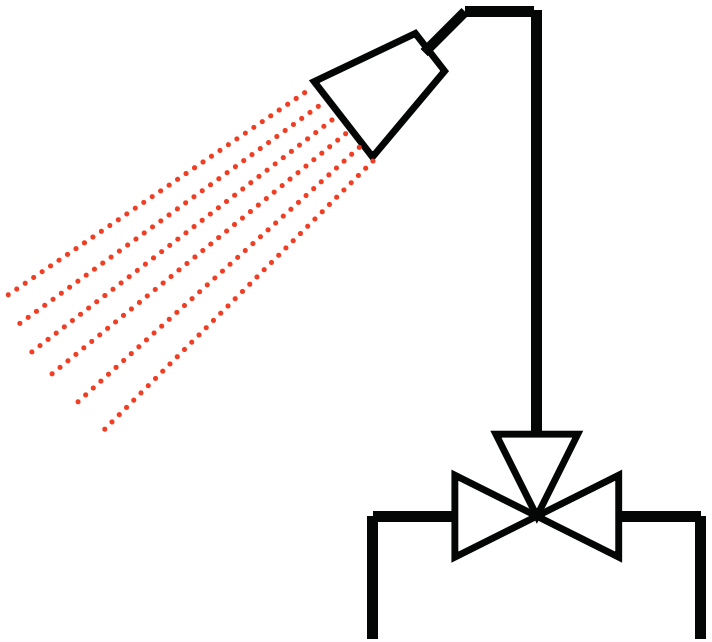
ASSE 1016/CSA B125 Valves

- During a cold water failure test.
- Some shower heads are designed to have a full spray pattern at very low flows.
- TAFR valves by-bass enough water to allow a full spray pattern on some shower heads. (0.5 GPM)



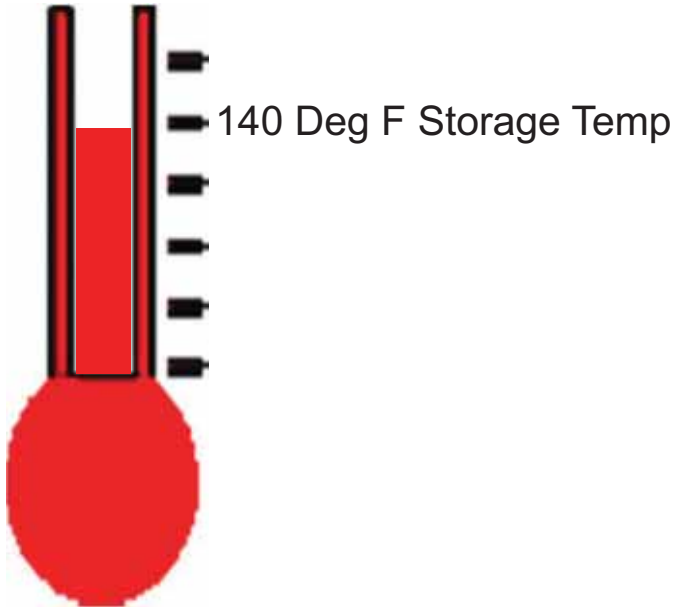
Water Droplet Size

- If water droplets are small enough, they can be inhaled increasing the risk of Legionnellae.



Plumbing Engineers recommend storage temperatures of 135 ºF - 140ºF and delivery temperatures of 120ºF maximum.

- 140ºF Water Storage Temperatures Kill Bacteria and Pathogens in the hot water such as Legionellae.



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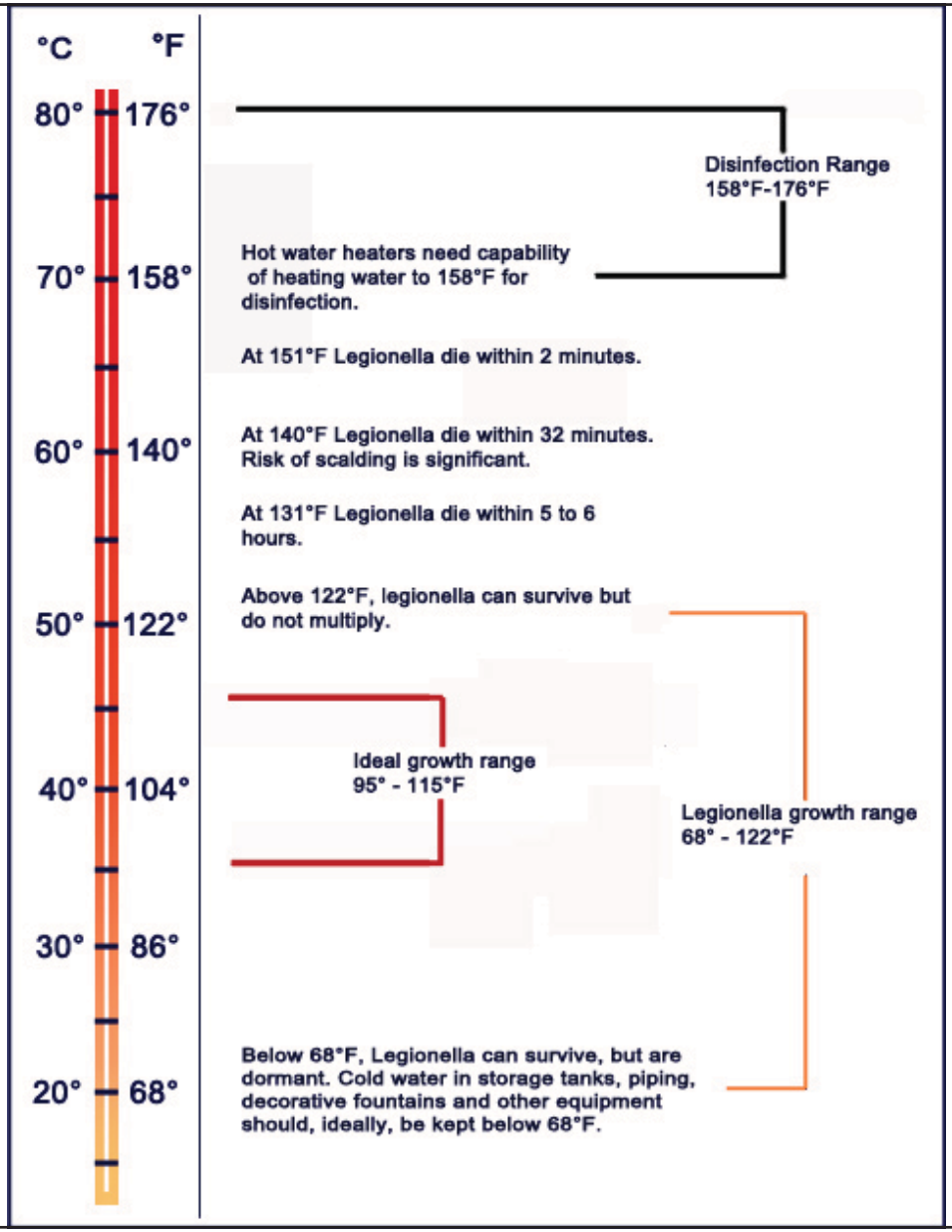
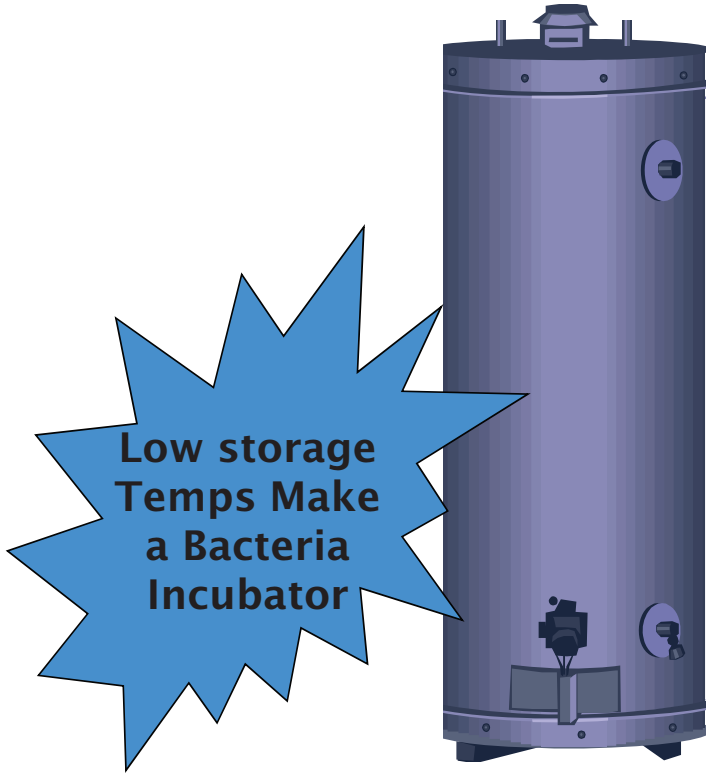
The Effect of Temperature on Legionellae Bacteria

- Below 68°F legionellae can survive but are dormant
- Legionellae growth range **(68°F - 122°F)**
- Ideal growth range **(95°F - 115°F)**
- Above **122°F** legionellae can survive but do not multiply
- At **131°F** legionellae die within **5 to 6 hours**
- At **140°F** legionellae die within **32 minutes**
- At **150°F** legionellae die within **2 minutes**
- Disinfection range **(158°F - 176°F)**

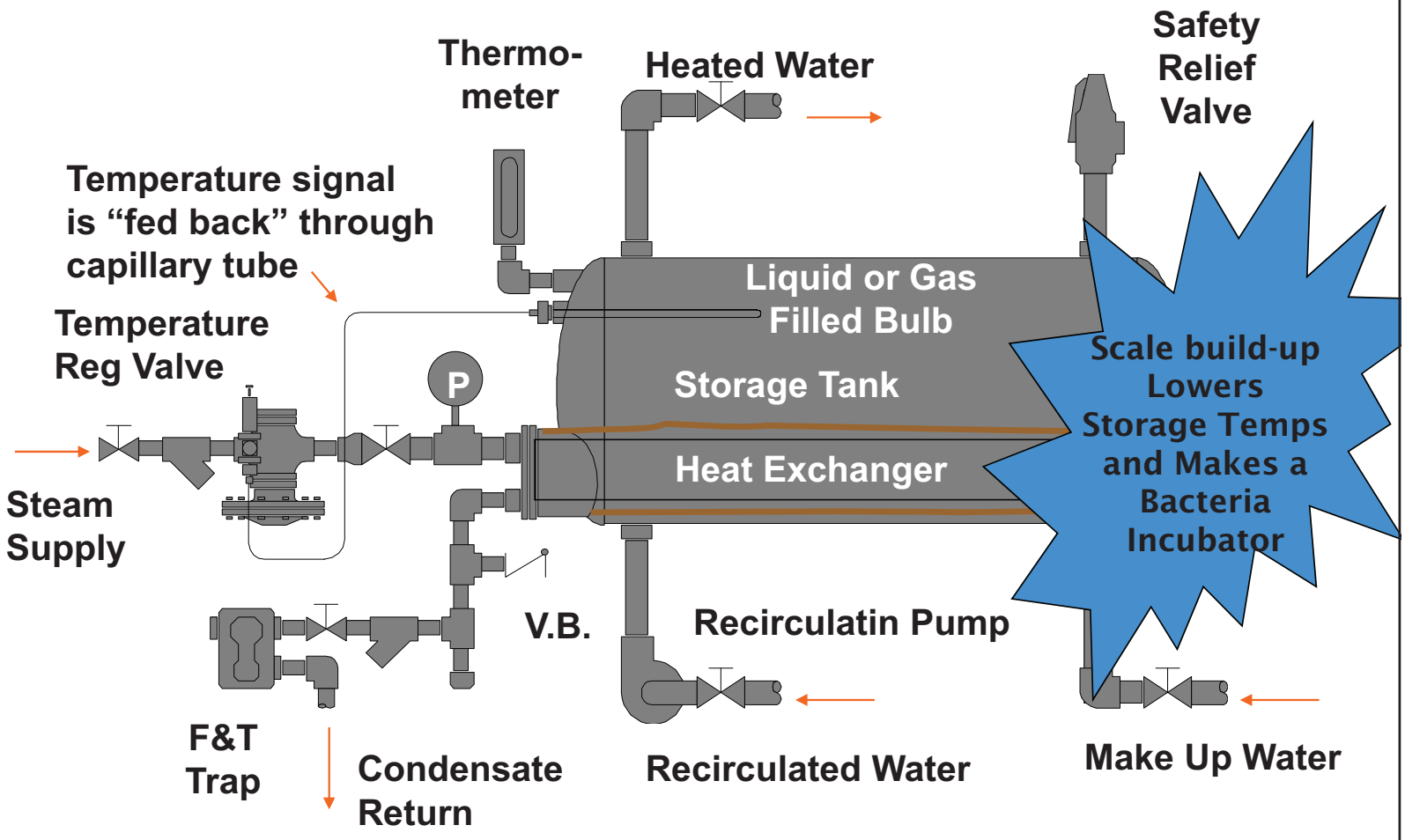
Ideal Legionella Bacteria Growth Temperature Range



Gas Fired Storage Tank Design



Horizontal Steam supplied Hot water Generator



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Media for Biofilm growth in HW tank (Cement Tank Lining)

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Why use Thermostatic Mixing Valves?

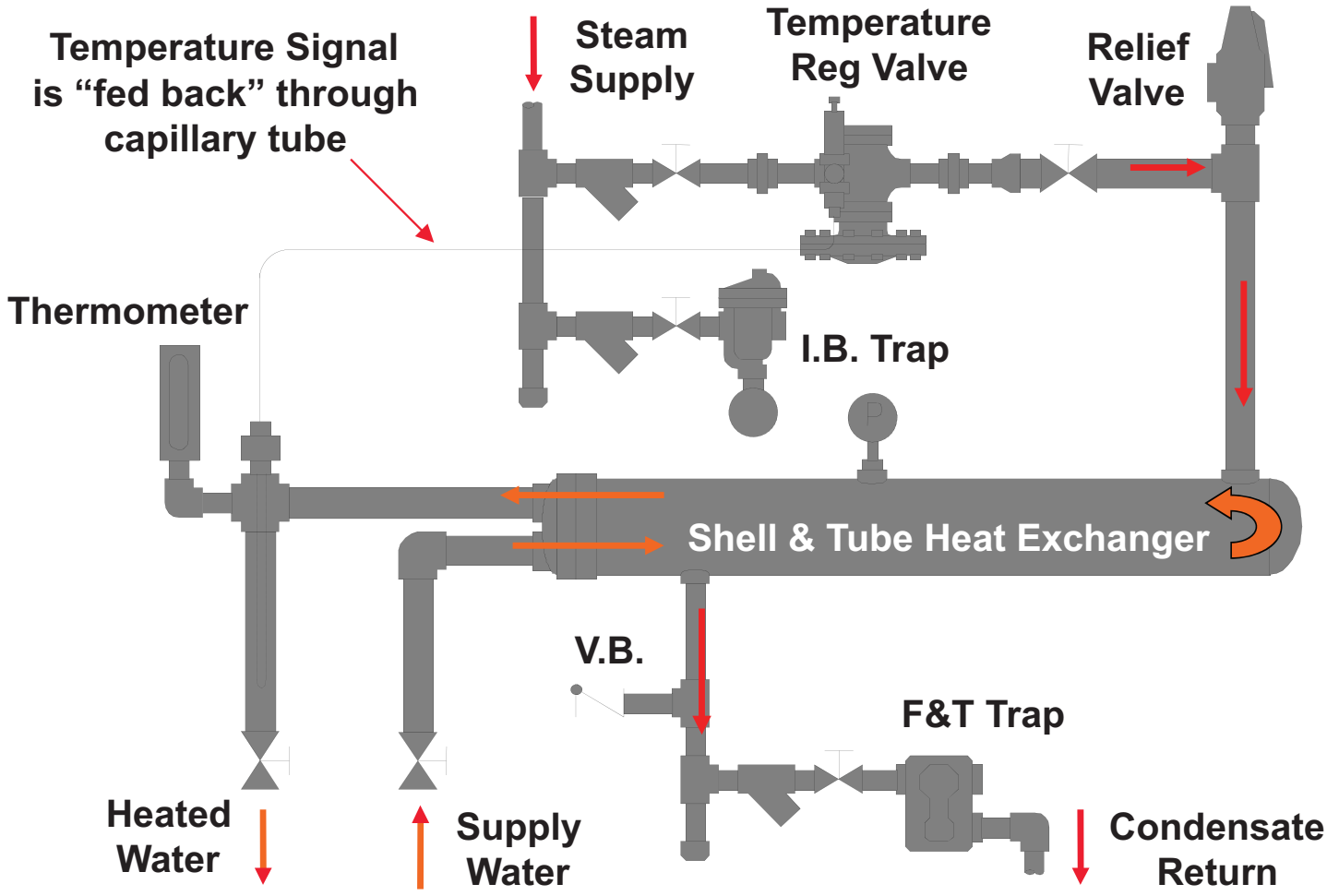
- **Safety:** Accurately and Safely deliver water to points of use when the water storage temperatures have been increased to:

A) Eliminate legionella incubation

B) Deliver water at a safe temperature for bathing.

C) Prevent flue gases from condensing in gas fired water heaters

Tankless Instantaneous Feedback System

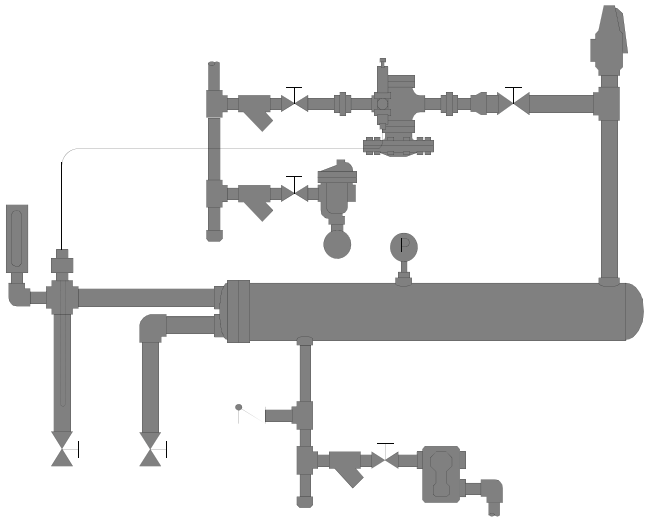


Tankless Instantaneous Feedback System

Steam "Feed-Back" designs often have:

A lag time from message to action which can cause Significant temperature fluctuations.

A difficulty managing diverse (low) flows which can cause temperature inconsistencies.



Instantaneous Water Heaters

Electric, Gas or Steam Models Often have:

1. Fluctuations in Temperature as usage varies.
2. Newer instantaneous gas water heaters use a control valve to modulate flow to help address temperature fluctuations. This causes fluctuations in system pressure.
3. They have difficulty managing diverse (low) flows which can cause temperature inconsistencies.
4. Many operate with a flow switch and do not activate at low flows.
5. There are often exaggerated performance claims.
6. They are suitable where there is a remote location and temperatures are not critical.

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Instantaneous Gas Heater Exaggerated Claims

1. Up to 97% thermal efficiency
2. Capacity to supply continuous hot water simultaneously to multiple plumbing demands
   More sanitary hot water (Be careful of temp rise)
3. Long-lasting design and reduced risk of flooding
   Extreme heat stress and condensing in heat exchangers often leads to failures and flooding. New code changes allow tankless water heaters to not have a drain pan under them, yet their failure rate is equal to or higher than tank type heaters.
4. Cost

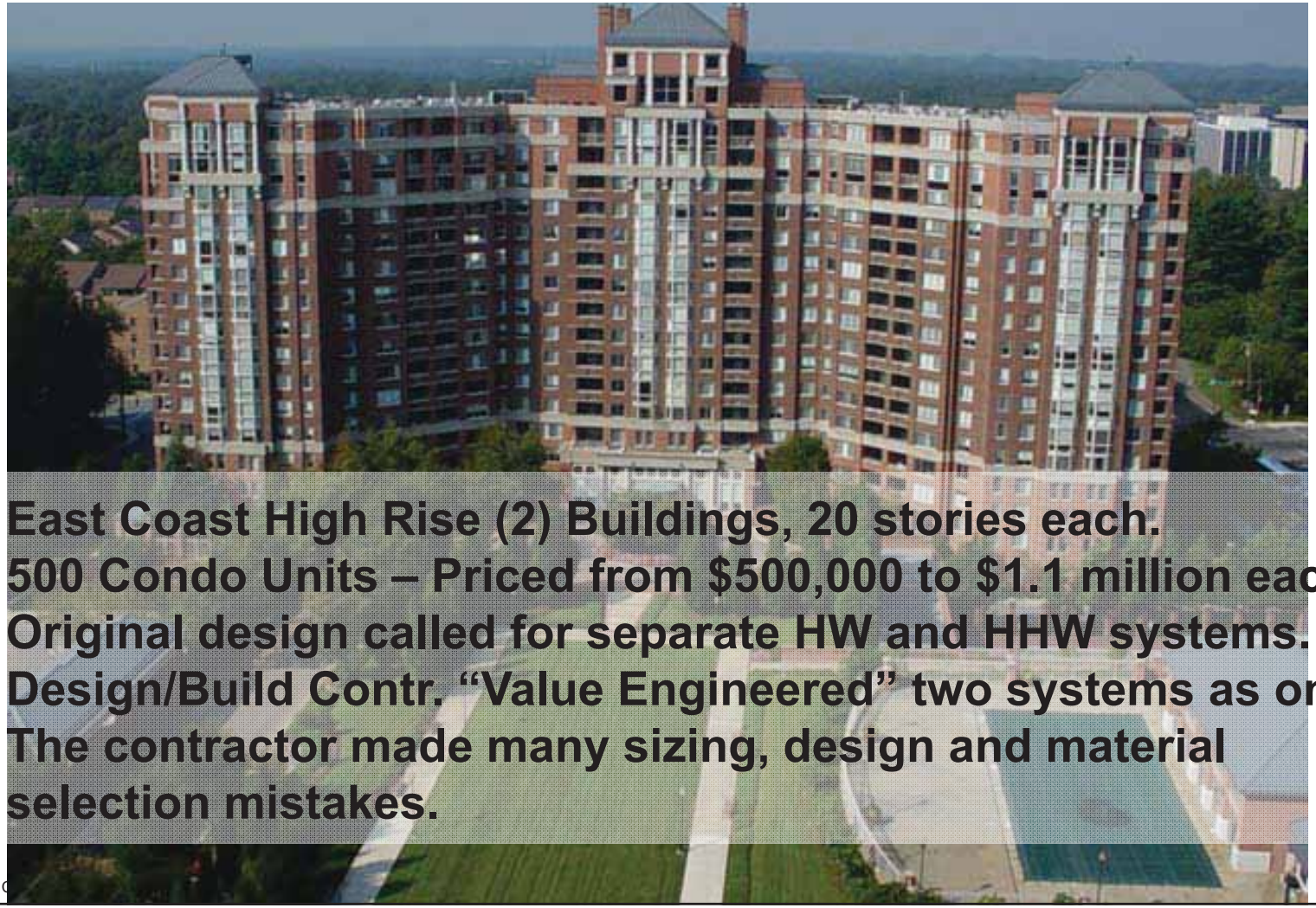
$800 - $3500

$250 - $400

Combining Heating Hot Water Systems and Domestic Hot Water Systems do NOT work.

DOMESTIC HOT WATER

2 Year Old Building North Bethesda, Md.



East Coast High Rise (2) Buildings, 20 stories each.
500 Condo Units – Priced from $500,000 to $1.1 million each
Original design called for separate HW and HHW systems.
Design/Build Contr. "Value Engineered" two systems as one.
The contractor made many sizing, design and material selection mistakes.

DOMESTIC HOT WATER

Over one Million Dollars for some of the 500 Condos in this Building.

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Galvanized HW Pipes!

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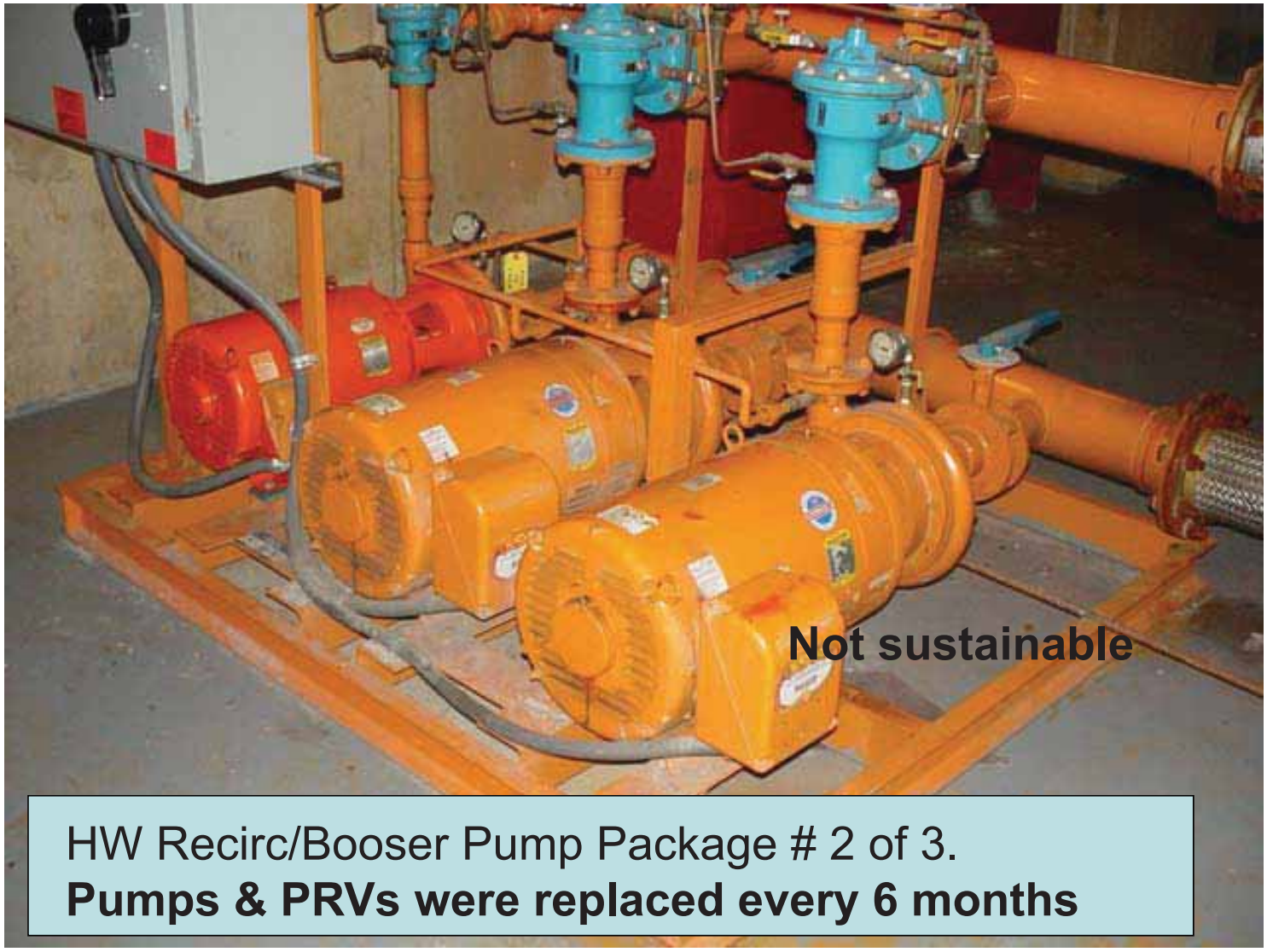
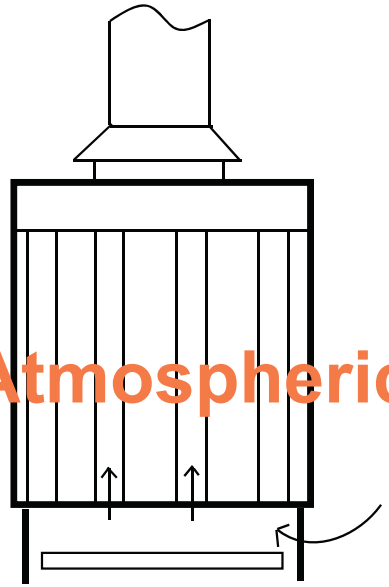
DOMESTIC HOT WATER



HW Recirc/Booser Pump Package # 2 of 3.
Pumps & PRVs were replaced every 6 months

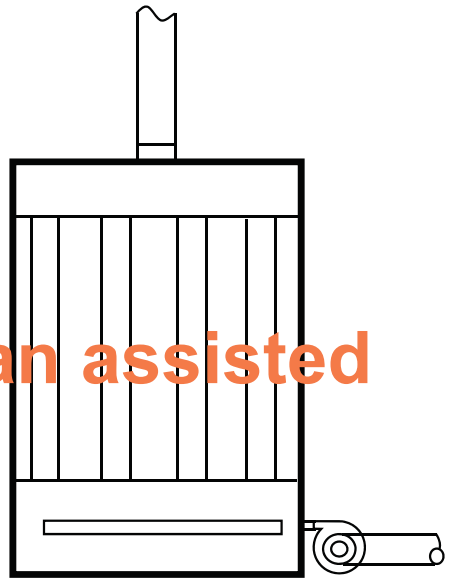
Atmospheric -vs- Fan Assisted Combustion Technology



Burner on: Heats well

Burner off: Draft Cools water

75% + - Efficient



Burner on: Heats well

Burner off: No draft heat loss

80-93% + - Efficient

More Common HW System Problems

- Scalding can occur when the temperatures exceed 120 degrees F.
- Thermal Shock can occur if the fixtures are too far from water heater with no temperature maintenance system. (Closer Apts/Recent use)
- Thermal Shock can occur if there is a sudden change in pressure between hot & cold water supplies to a fixture & there is no Safety Type Shower Valve installed.
- Only a Combination Press Balance/Thermostatic valve protects against both temperature and pressure fluctuations.
- Thermal shock often leads to slip & fall injuries.
- HW Recirculation Pump failure

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DOMESTIC HOT WATER
A Home made Mixing Valve