Commercial Domestic Water Heating

Definitions, Sizing, System design, Water quality, System efficiency

Denver Chapter Luncheon

Presenter: Chris Bollas – Watts Water Technologies

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DOE defines Commercial Water Heating

U.S. Classifications for Water Heaters: Residential vs. Commercial

- As specified by DOE for applying test procedure (note: different breakpoints for applying minimum efficiency standards)
- A Commercial Water Heater meets *any* of the following criteria:
  - Electric: does not use single phase power
  - Designed to provide outlet hot water at T > 180 °F (82 °C)

	Storage Volume Greater Than…	Input Rate Greater Than…
Storage: Gas	120 gallons (454 L)	105 kBtu/h (30.8 kW)
Storage: Electric	120 gallons (454 L)	12 kW
Storage: Oil	120 gallons (454 L)	140 kBtu/h (41 kW)
Instantaneous: Gas	2 gallons (7.6 L)	200 kBtu/h (58.6 kW)
Instantaneous: Electric	2 gallons (7.6 L)	200 kBtu/h (58.6 kW)
Instantaneous: Oil	2 gallons (7.6 L)	210 kBtu/h (61.5 kW)

All other water heaters are considered "Residential" or "Consumer."

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DO NOT CONFUSE WITH ASME REQUIREMENTS

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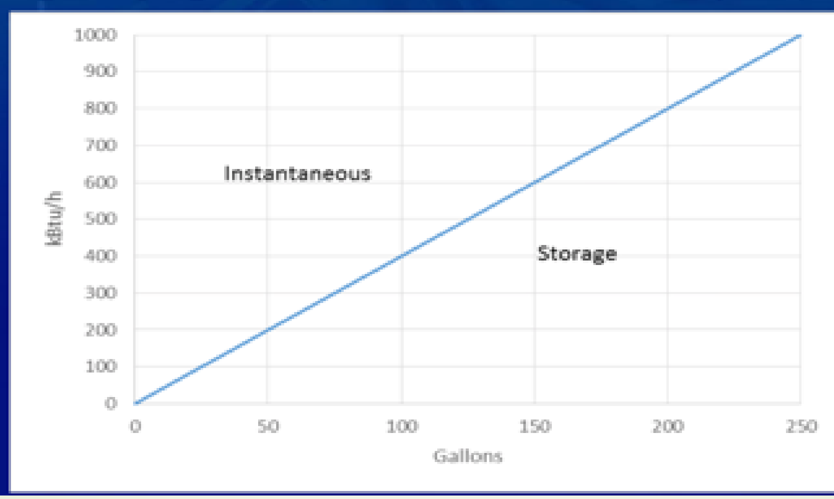
ASME INPUT >199,000 Btuh

Instantaneous vs. Storage Water Heaters

U.S. Classifications for Water Heaters: Storage vs. Instantaneous

- As specified by the Department of Energy (DOE)
- A function of storage volume and heating input rate
  - Instantaneous < [1 gallon per 4000 Btu/h of input (1 L / 310 W)]
  - Storage ≥ [1 gallon per 4000 Btu/h of input (1 L / 310 W)]



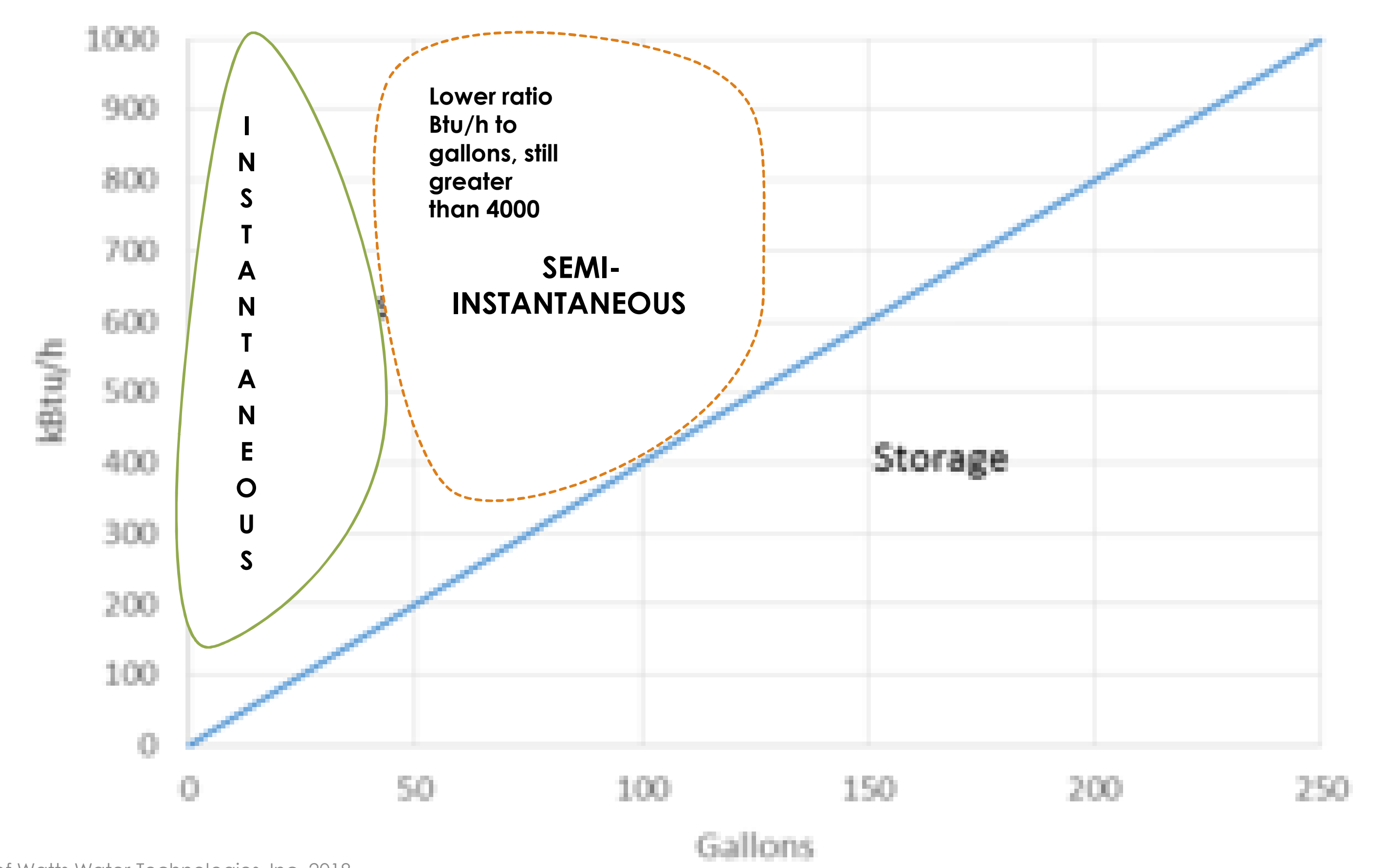
I - >4000 btu/h per gallon

S -<4000 btu/h per gallon

Different styles of water heaters – defined beyond DOE classification

- Instantaneous
- Semi-Instantaneous – 70 years of market history ignored
- Storage

Instantaneous – Semi-Instantaneous and Storage Water Heaters



Instantaneous Water Heaters

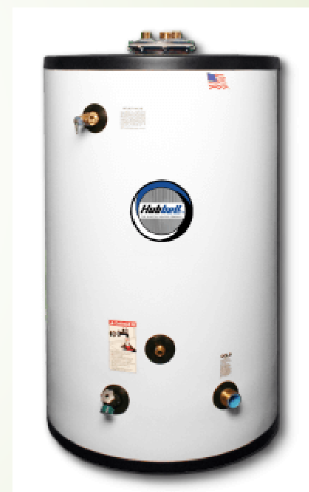
- Control Premise: Design temp = output temp
  - started as blending systems with steam
- High btu/h to water volume content
- Smallest footprint
- Wall hung capability
- On-demand heating, no storage
- Hi speed control response - electronic, mechanical or physics
- Highest pressure drop – pipe dia. dependent
- Fixed gpm/temp relationship – no flywheel
- Recirculation return water temperature impacts system efficiency

Semi-instantaneous Water Heaters

- **Control premise: Design temp = output temp**
- **Medium btu/h to water volume content**
- **Larger than Inst., smaller than Storage**
- **Floor mount the norm**
- **Quick recovery**
- **Hi speed control response**
- **Lower pressure drop than Instantaneous**
- **gpm/temp relationship – control and flywheel**
- **Recirculation may affect system efficiency**

Storage type Water Heaters

- **Control premise: Vessel is part of control system – response to the tank aquastat**
- **Expect volume at stored temperature to fluctuate – deposits and withdrawals**
- **Lowest btu/h to water volume content**
- **Stored water footprint – floor mounted**
- **No pressure drop through the vessel**
- **Tank capacity allows overdrive of heat exchanger gpm - decouples gpm/temp relationship**
- **Tank turnover changes with dump load demand – different per building type**
- **Can support highest system efficiency**



At the end of the day…..

The right product is defined by the requirements of the facility, its users, the need for uninterrupted supply, cost (operating or first or both), space, energy source, plumbing system complexity, design forgiveness, maintenance…

Equipment selection and sizing starts with understanding project variables

Every job has its own nature – Customers expect maximized design

Change in flow rates, water quality, efficiency, building designs

Things to consider

Variables all over the board

- Fixture counts
- Modified Hunters Curves
- Diversity
- Redundancy
- Dump, Blend, Constant loads
- Cold water temperature
- Output water temperature
- Efficiency
- Elevation

Applications all over the board

- K-12 schools
- Universities
- Assisted Living
- Public housing
- Multi-family housing
- Stadiums
- Correctional
- Convention hotel
- Select stay hotel/motel
- Paper plate restaurant
- Hard plate restaurant
- Laundries
- Labs
- Emergency showers
- Hospitals
- Clinics
- Office buildings
- Industrial

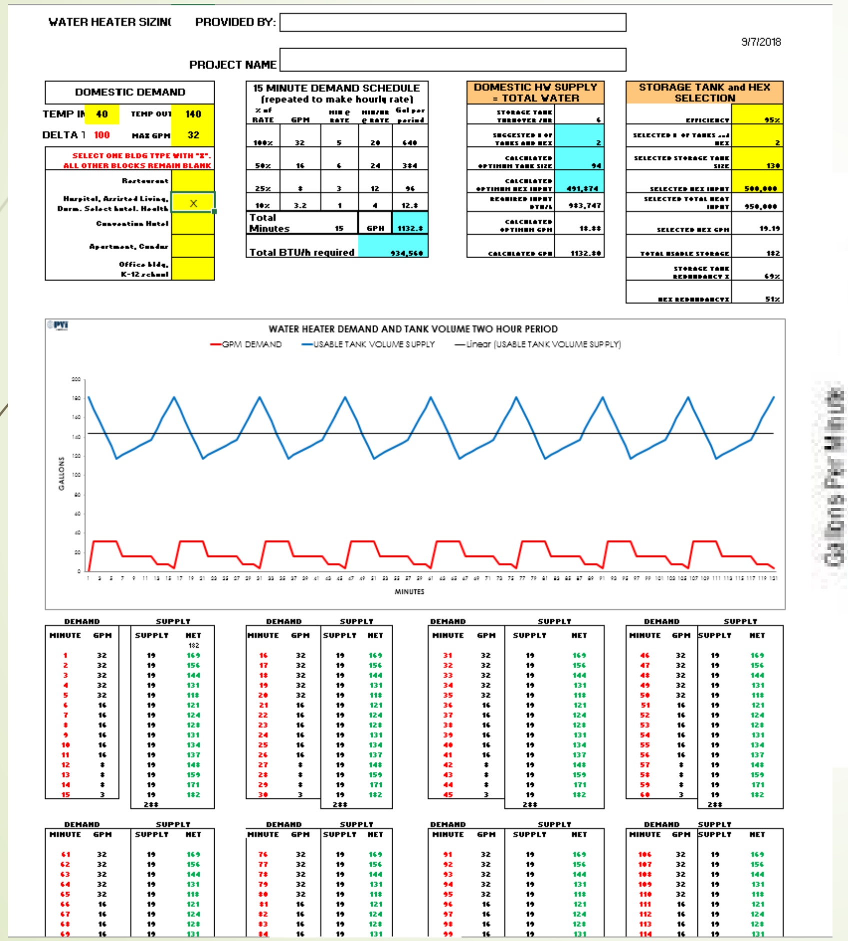
Break it down to its simplest elements

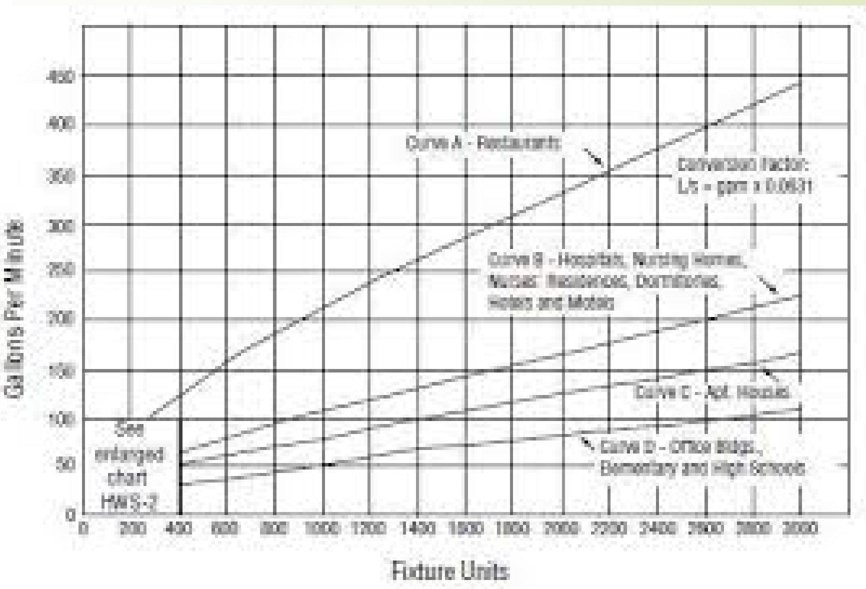
- Time – commercial loads are rarely constant
- Place - buildings types have different behavior patterns
- Energy - Know your lowest cost energy source available
- PVT - Pressure, volume and temperature – always!

Rules to live by

- Think in 15 minute increments, then repeat!
- Know your Water temps – cold and hot
- Max gpm in your total hot water fixture count is important
- Fixture count flow rate is different in building types – know your building type
- Redundancy important in commercial applications (owners revenue stream are affected)
- Find the tools to show your work – calculators, sizing guides, Rep relationships, books

Show your work – or make someone show theirs!





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System design
Centralized and Decentralized

Multi-family Housing

Centralized domestic hot water system

BENEFITS to PROMOTE

- Equipment redundancy
- Recirculation – whole bldg.
- Temperature consistency
- Residual chlorine at same level
- Lower First cost- meter, heaters, vent, gas

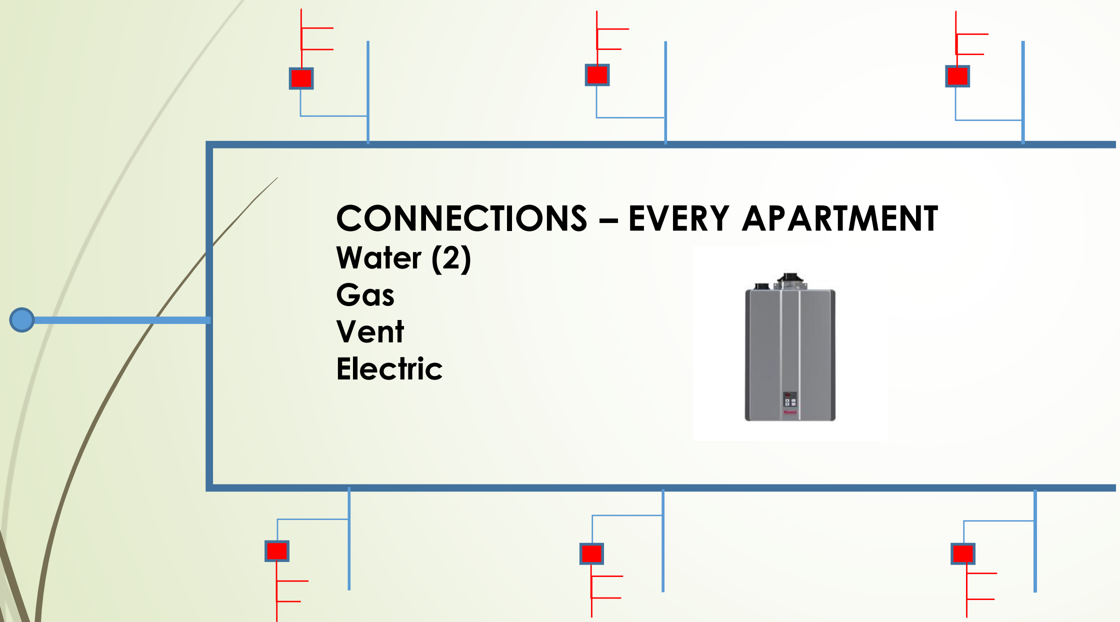
CONCERNS to ADDRESS

- More small diameter pipe – install
- Faucet mount Portable Washing machine crossover (no checks)

Advertised as All Bills Paid

Decentralized domestic hot water system

LAV, SHOWER/TUB, KITCHEN



BENEFITS to PROMOTE

- Individual metering for owner – utility bill responsibility for water, gas, electric
- Lower common fee (no central system)
- No crossover possibilities
- No recirculation pump

CONCERNS to ADDRESS

- Single point of failure – no redundancy
- First cost - meter, heater, vent, gas
- Larger diameter pipe – material, install
- Water heater location

Advertised as Lower rent + Utilities

Water Quality and Water Treatment

We need to understand what is in our water for three reasons that impact commercial applications

Equipment Protection

Scale and corrosion buildup

Cost of warranty/service repair to water heater

Equipment down time

Health and Safety

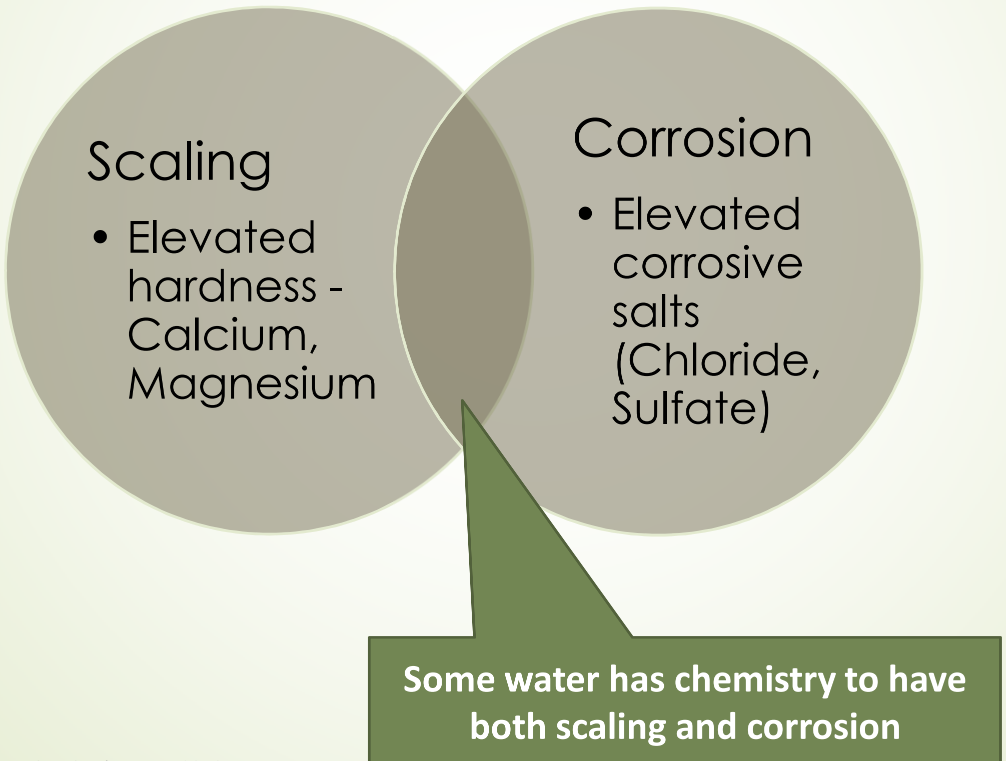
Bacteria, Cysts, Carcinogens, Heavy Metals

Product Quality

High quality products are susceptible to failure too – and so is your reputation

How does water impact equipment

- **Water quality has more of an impact on equipment performance than product quality**



Water constituents of concern

Total Hardness. Hardness levels above 35ppm/ 3gpg will lead to scaling. This is our principle concern.

Total Alkalinity and Sulfates. These combine with Hardness minerals to form scale. Levels over 150 ppm will need to be addressed.

Total Dissolved Solids. Levels above 100 ppm will lead to scale.

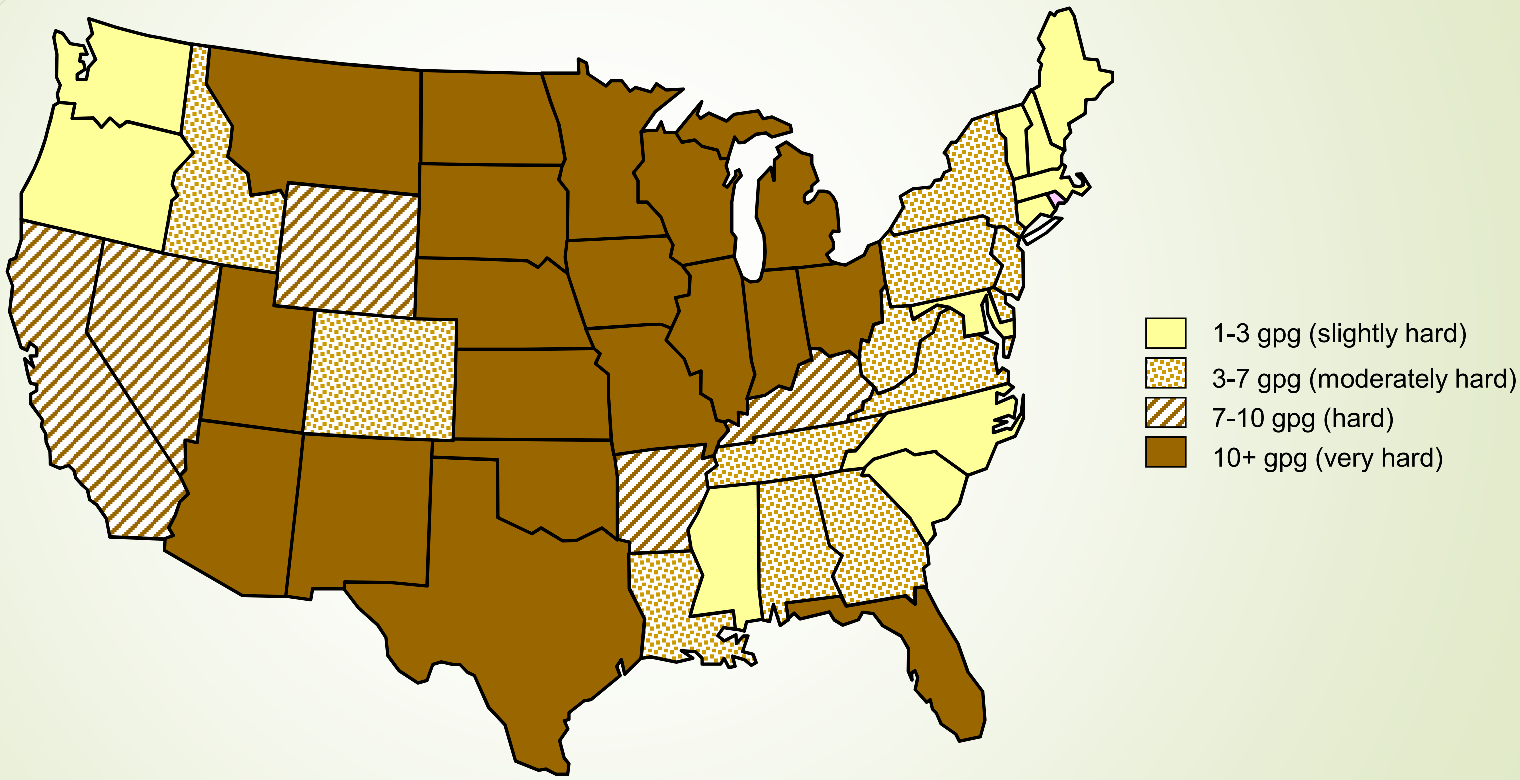
pH. Low pH, below 6.5 will be corrosive and above 7.8 could be caustic.

Chlorides. Chlorides become aggressive at high temperatures. Chlorides become concentrated in scale and forms on heat exchangers.

Sulfates. Scale forming and corrosion at temperature.

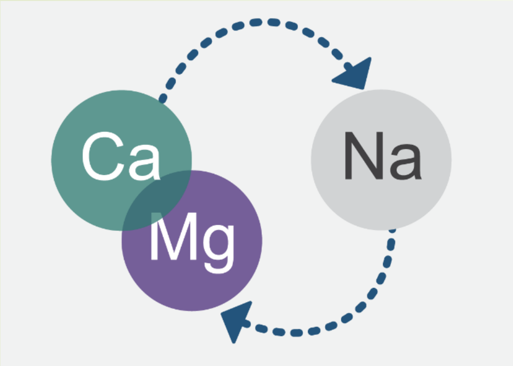
Any of these could lead to equipment damage if not properly addressed.

Average U.S. Water Hardness



So what? Hard water = equipment damage

Existing Scale Treatment

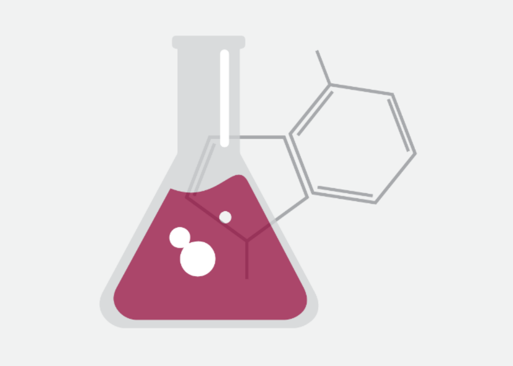


ION EXCHANGE

Reduce water hardness by REPLACING magnesium and calcium (Scale) with sodium or potassium.

PROS: Soaps and shampoos "suds" better, Spot-free rinsing, Scale formation prevented.

CONS: An unnatural amount of sodium finds its way into the environment and affect water reuse. Monthly replacement of salt is costly and time consuming.



CHEMICAL TREATMENT

ADDING chemicals like poly-phosphates, to sequester hardness ions and prevent them from forming scale.

PROS: Effectively prevents scale build up in most systems.

CONS: Require constant introduction of chemicals, resulting in ongoing monthly costs to end users, and downstream effects to the environment

MAGNETICS

Reduces water hardness by PASSING water through a magnetic field to prevent Scale from sticking to pipes and fixtures.

PROS: No consumables, no additives.

CONS: Limited effectiveness. Failed to pass any scale control standards designed by internationally recognized 3rd party testing agencies.

Contaminants and filter types

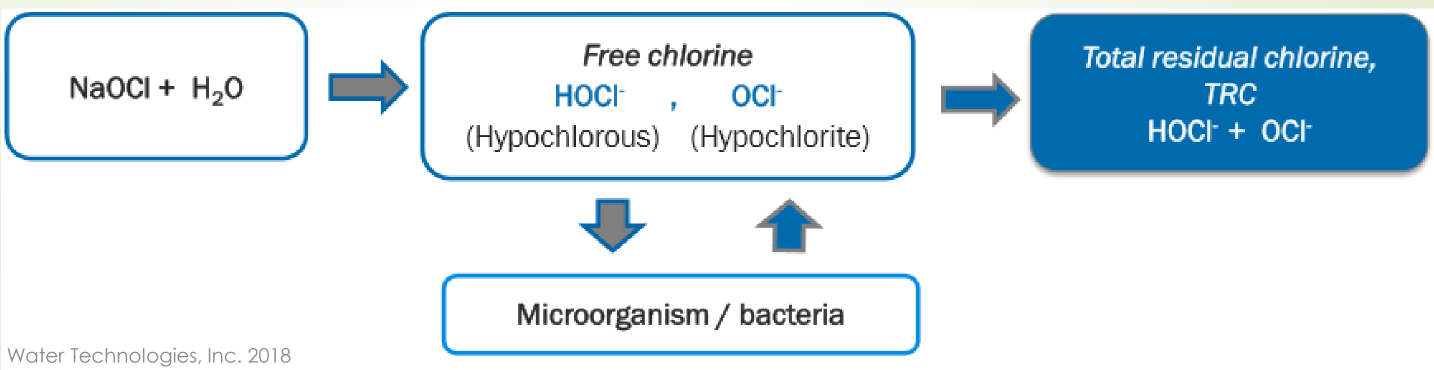
Will it reduce/filter/control?

Contaminant	Carbon Filter	Cation Softening	Reverse Osmosis	TAC
Hardness	NO	YES	YES	Application Specific
TDS	NO	YES	YES	Application Specific
Chlorine	YES (low flow long contact time)	NO	YES	NO
Chloride	YES (low flow long contact time)	NO	YES	NO
Chloramine	YES (low flow long contact time)	NO	YES	NO
Alkalinity	NO	YES	YES	NO
Silica	NO	NO	YES	NO

Chemical contaminants – intentionally introduced

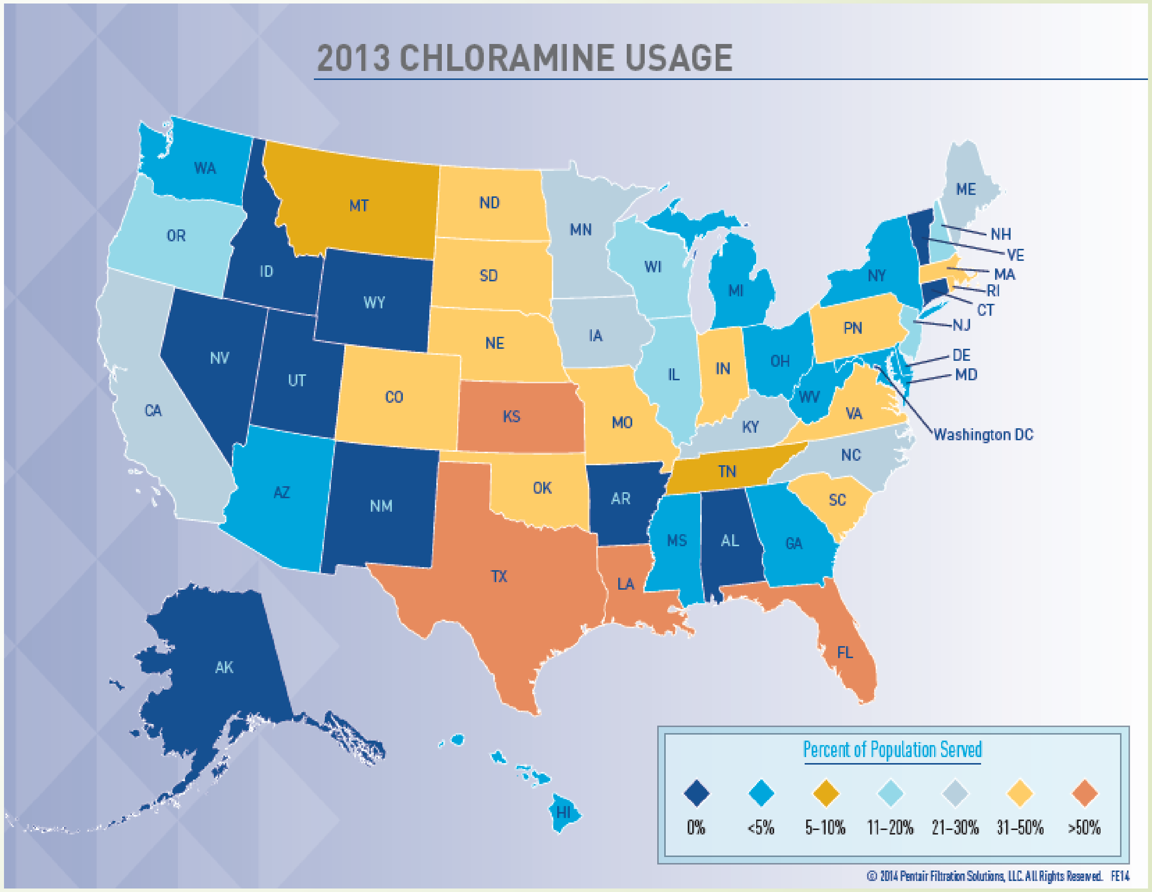
Chlorination is the process of adding the chlorine to water as a method of water purification.

- Sodium hypochlorite (NaOCl) is a chlorine-containing compound that can be used for disinfection and bacterial control
- Drinking water is treated to give a residual chlorine level of **0.2 to 0.5 mg/L to kill bacteria – higher levels are not any more beneficial**



Chemical contaminants – intentionally introduced

- Chloramines
  - Combination of Chlorine & Ammonia
  - Usage on the rise
- Why?
  - Doesn't dissipate as fast as chlorine
  - Its cost effective
  - Less disinfection byproducts than Chlorine



Identifying contaminant damage

- Swollen gaskets or O-rings

  from **Chloramines** (Can also appear brittle)

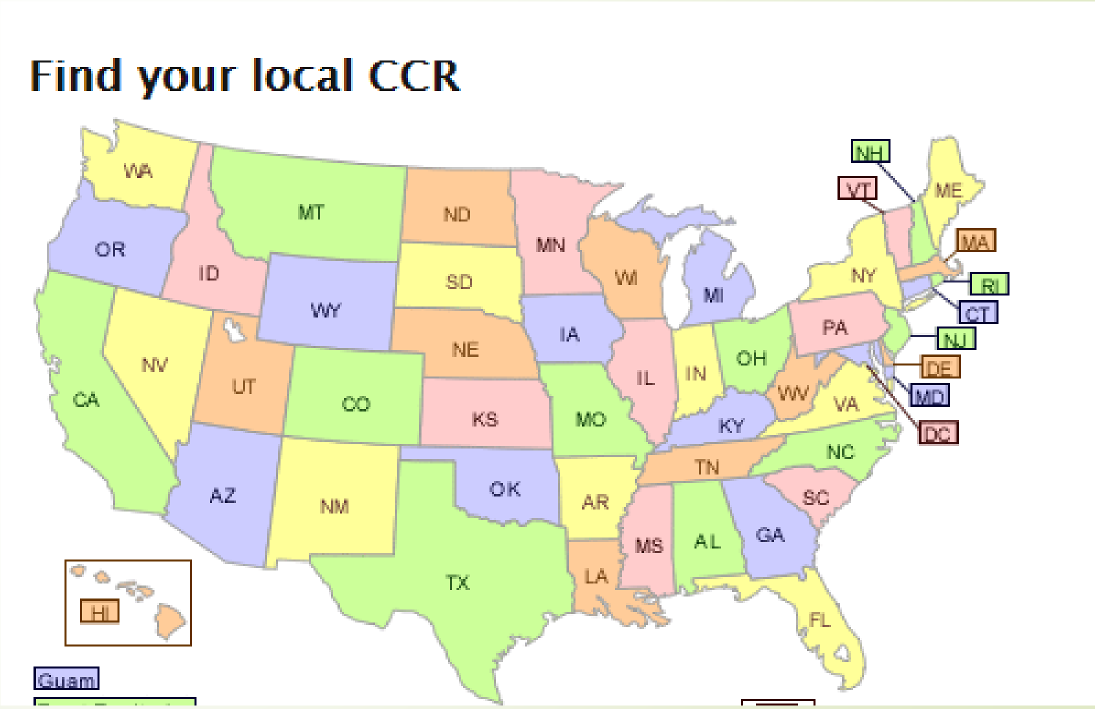
- Massive corrosion on metal **corrosive salts** in the water)

- Corrosion starting on a weld (**corrosive salts** in the water)

WATER RESOURCES

CONSUMER CONFIDENCE REPORT (CCR))

- **EPA Required Document on your local water quality**
  - http://www2.epa.gov/ccr
- **EPA Safe Water Drinking Act contaminants**



Water Heating System Efficiency

starts with thermal efficiency but doesn't end there

Thermal Efficiency Certification - ANSI Z21.10.3

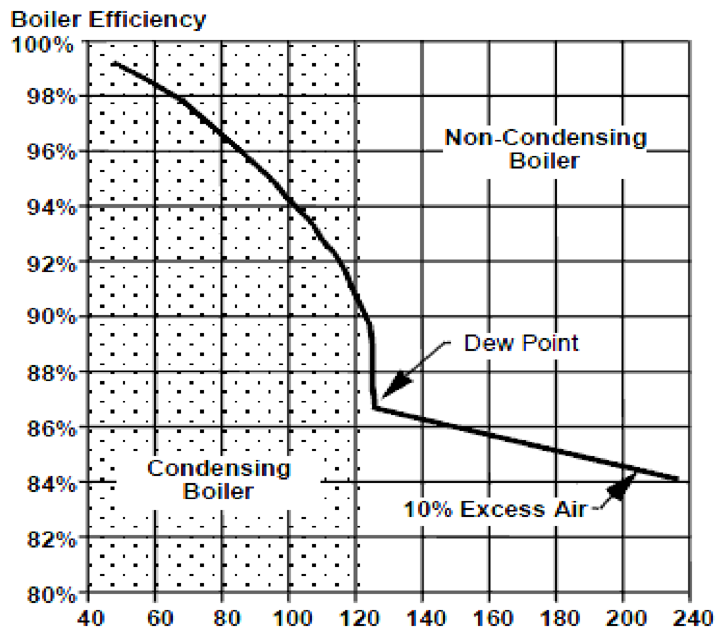
70° entering water temperature and 140° leaving water temperature
Thermal Efficiency E_t, shall be computed by use of the following formula:

$$E_t = \frac{KW(0_2 - 0_1)}{(C_f \times Q \times H) + E_c} \times 100$$

K	=	1.004 Btu per pound mass degree F, nominal specific heat of water at 105°F
W	=	total weight of water heated, lbs.
0_1	=	average temperature of supply water, °F
0_2	=	average temperature of outlet water, °F
Q	=	total gas consumed as metered, cu. Ft. (m^3)
C_f	=	correction applied to the heating value H
H	=	total heating value of gas, Btu per cu. Ft. (Mj/m_3)
E_c	=	electrical consumption of the water heater and any required test circulating pump

Return Water Affect On Efficiency

Exhibit 3-3: Impact of Return Water Temperature on Efficiency[1]

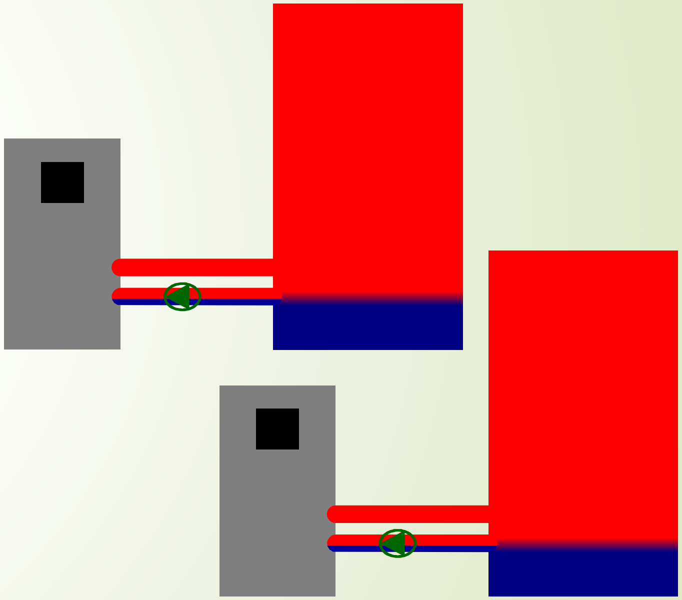


As shown in this figure, very high efficiencies are attained as the return water temperature drops below 130°F. We see that the same boiler operates as a conventional boiler with efficiencies below 88 percent when the return water temperature is above 130°F. It is important for the condensing boiler specifier to perform a comprehensive analysis of the building load and to select terminal heating equipment that is designed to operate at the low water temperatures needed for optimum performance of the boiler selected. Radiant floor heating systems and water-source heat pump systems are two examples of space heating systems that require operating water temperatures in the 80°F to 100°F range for optimal

Source: 2000 ASHRAE Handbook, HVAC Systems and Equipment

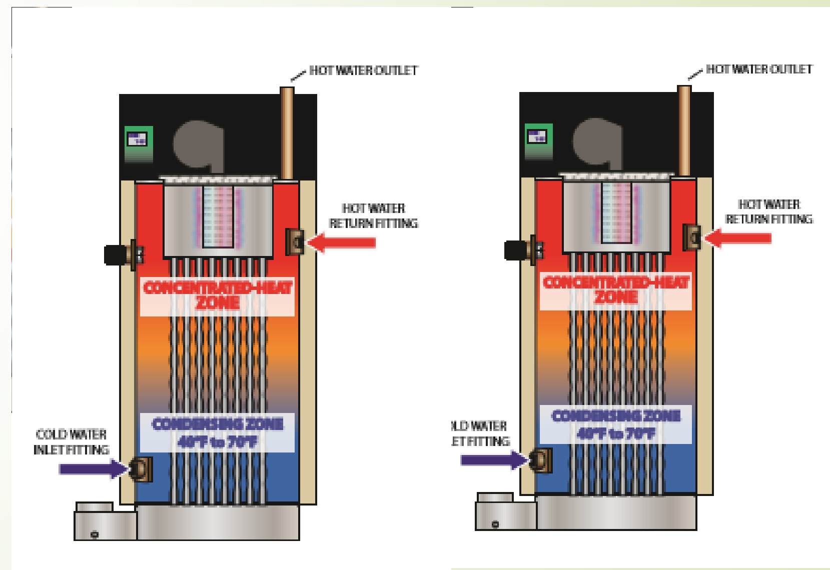
Boiler/Tank Combination thermal efficiency

- **Fixed delta T across heat exchanger requires higher water temperatures to reach use temperature**
- **Boiler/tank combinations not tested as a system, boiler only component to be certified.**
- **ANSI Z21.10.3 is not a modulating test**
- **Pump operation, Interconnecting piping is not calculated in water heater efficiency certification**
- **Standby loss of storage tank is not calculated**



Storage Water Heater Thermal Efficiency

- **All electrical energy is included**
- **Standby heat loss is accounted for**
- **Return water temperature can have no impact on efficiency**
- **Total $$ spend is accounted for**



Instantaneous Water Heater thermal efficiency

- **Fixed heat exchange to gpm dependent**
- **Change in flow impacts efficiency or output**
- **Return water temperature affects inlet water temperature if applied**

No matter what equipment you choose, count all the pieces to derive <u>system efficiency</u>

You have choices

- You have responsibilities and decisions to make
- Be informed, Ask questions
- ASPE is foundational to doing it right the first time
- Protect the health of the nation!

ASPE American Society of Plumbing Engineers™

Thank you, hope to see you in Atlanta, booth #1150!