Domestic Hot Water Systems

Presented to the
American Society of Plumbing Engineers
Technical Symposium

September 20, 2013

A Brief History

- There have been several innovations in water heating technology over the years, but while some things have changed, some have not.
- Let’s review a little history…

Hot Water in 1894

HEATING BY HOT WATER

(SECOND EDITION),

WITH

INFORMATION & SUGGESTIONS ON THE BEST METHODS

OF

HEATING

PUBLIC, PRIVATE, AND HORTICULTURAL BUILDINGS.

Treating on the HIGH and LOW Pressure Systems,

BATH APPARATUS,

HOT WATER SUPPLY for Public Institutions,

DUPLICATE BOILERS, RADIATORS,

Laundry Drying Stoves, Swimming Baths, Turkish Baths,

CAUSES of, and hints to PREVENT FAILURE;

BY

WALTER JONES.

96 ILLUSTRATIONS.

LONDON:

CROSBY, LOCKWOOD, AND SON,

7, STATIONERS' HALL COURT, LUDGATE HILL.

1894.

CHAPTER VI.

VELOCITY OF FLOW OF WATER.

The Velocity of Circulation depends upon the motive power mentioned in Chapter 4, and also upon the size of the mains and the circulating pipes. In order that some idea of this velocity may be ascertained, it may be well to explain here the **theory** of **circulation,** or in other words, the **law** of **gravitation,** viz.: That all falling bodies gravitate with the same velocity, and descend through a definite space in a given time, hence the velocity of flow depends upon the difference in weight of the *up* and *down* columns of water, and the colder the water in the return pipe, the more rapid will be the circulation, the gravitating force being inversely proportioned to the temperature, *i.e.*, it is slower as the respective temperatures approach each other.

The motive power is the difference between the specific gravity of the water contained in the *up* and *down* pipes, and the velocity may be calculated (theoretically) by this difference. I don't like theories, they are not always confirmed by facts; and I believe in the old maxim that "an ounce of practice is worth a pound of theory." Nevertheless, the latter may be useful in shewing what results ought to be obtained under perfect conditions.

The following formula gives the method for ascertaining the velocity of a body or substance falling by gravitation.

$$V = 8\sqrt{H} \quad \text{or} \quad V = \sqrt{H} \times 8.$$

i.e., The Square Root of the height (in feet) × 8 = velocity (in feet) per second.

Now the *height* referred to here is not the height of the flow or up pipe, nor the height of the supply cistern, but the difference in weight of the water in the up pipe, and that in the down pipe.

Hot Water in 1894

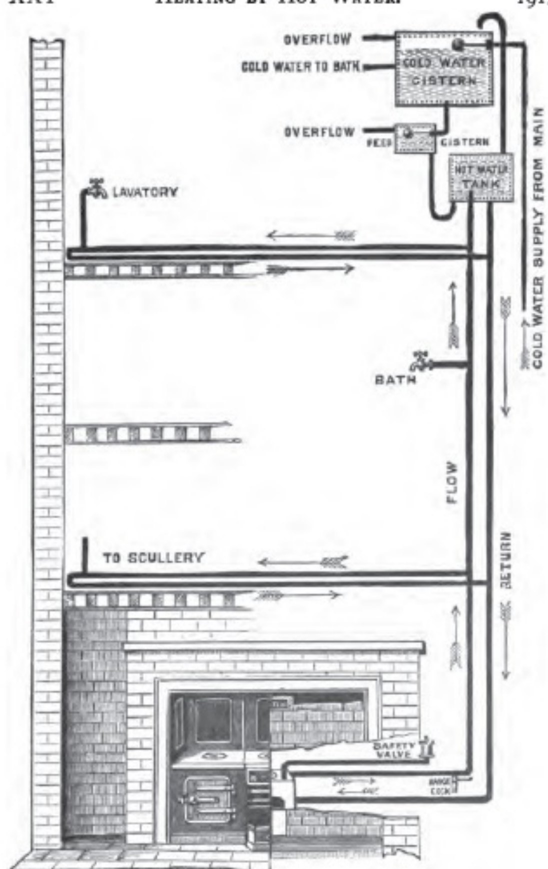


Fig. 90.
BATH APPARATUS—TANK SYSTEM.

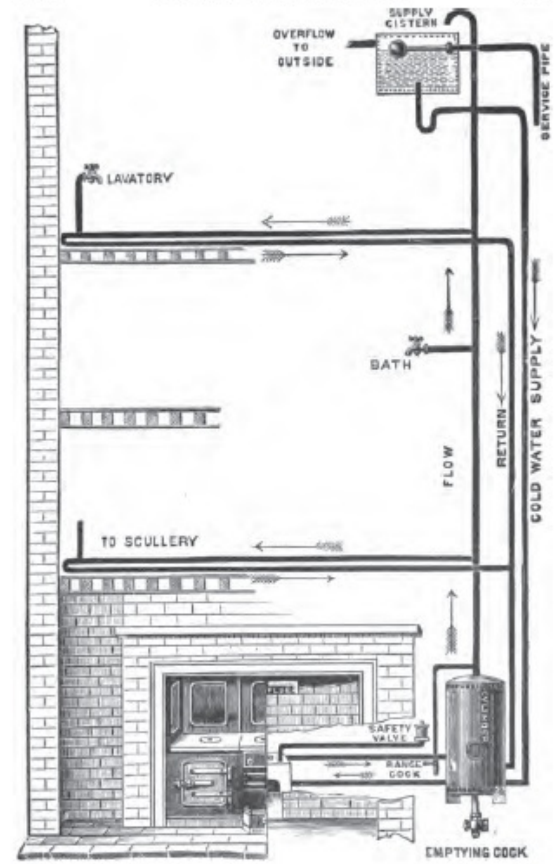


Fig. 94.
BATH APPARATUS—CYLINDER SYSTEM.

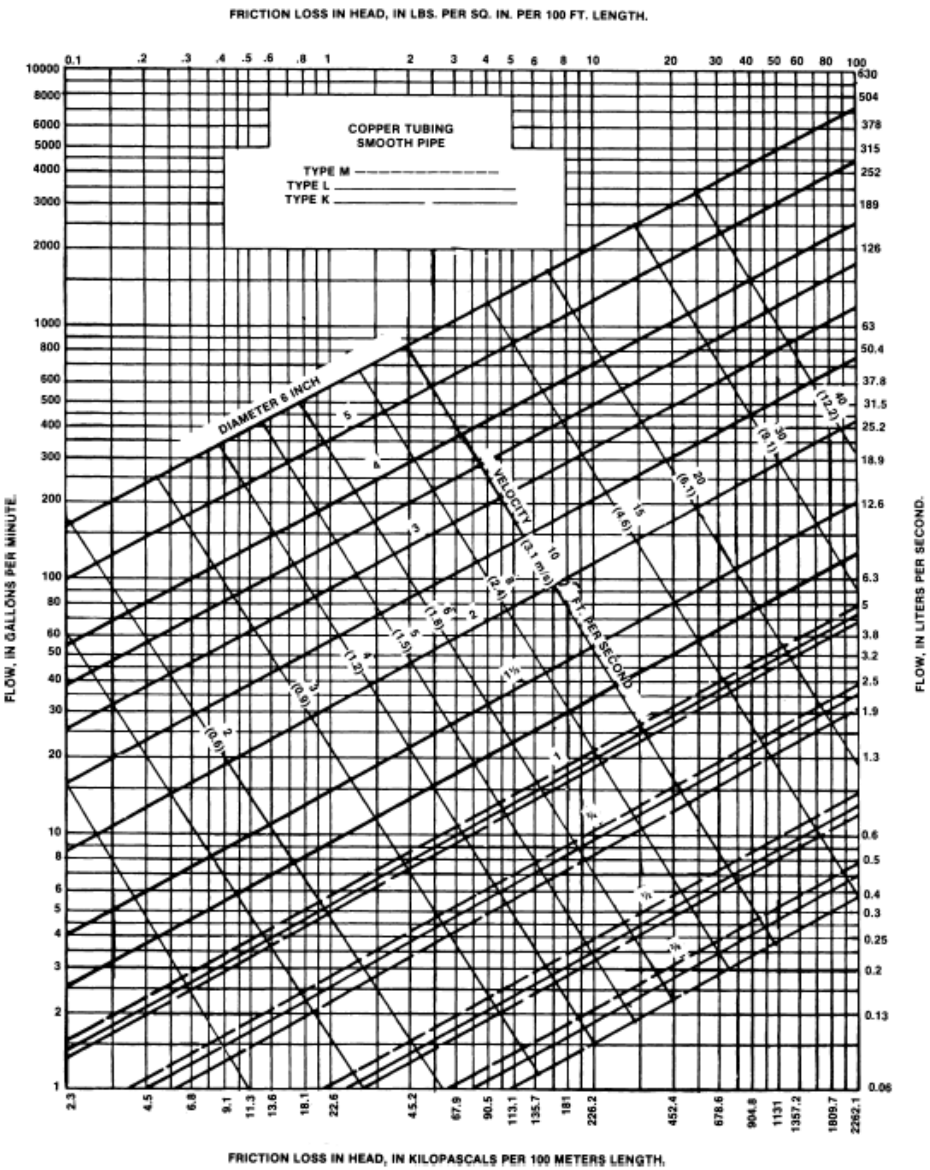


Figure 5-7 Pipe Sizing Data, Smooth Pipe

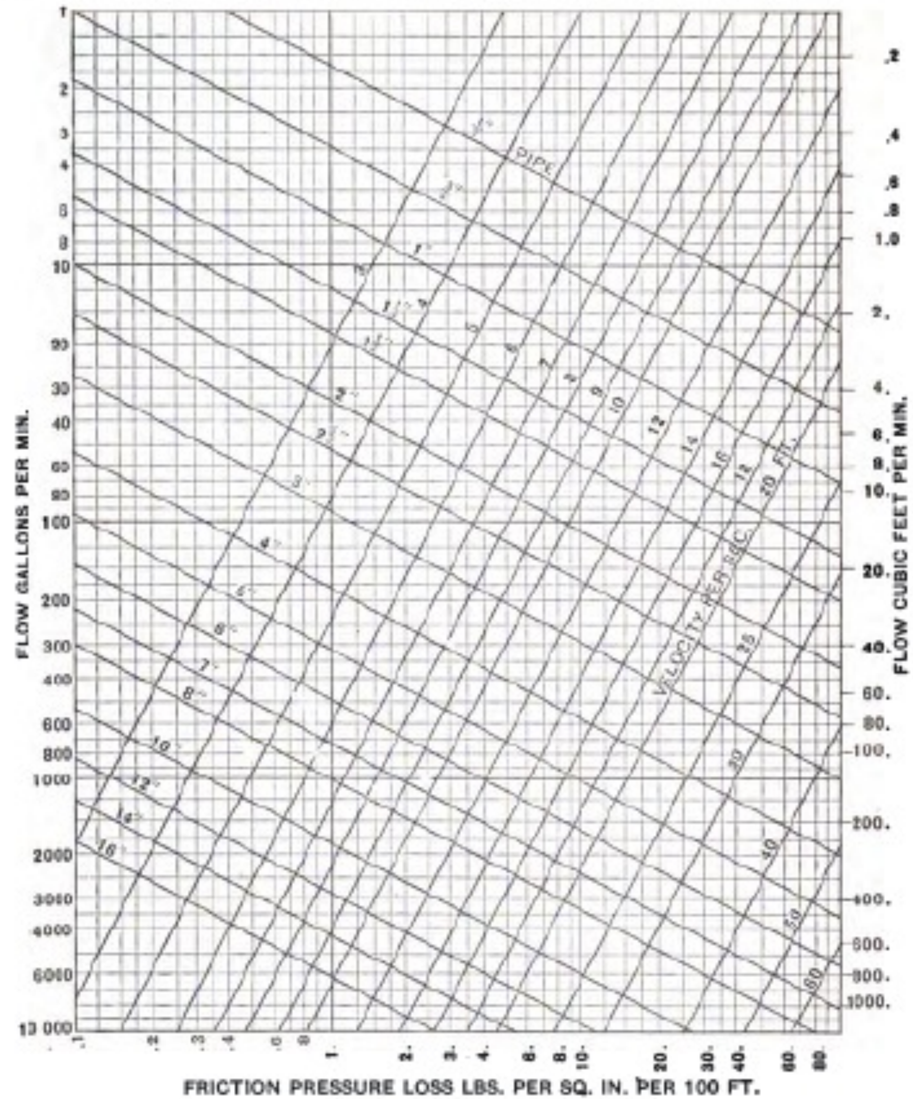


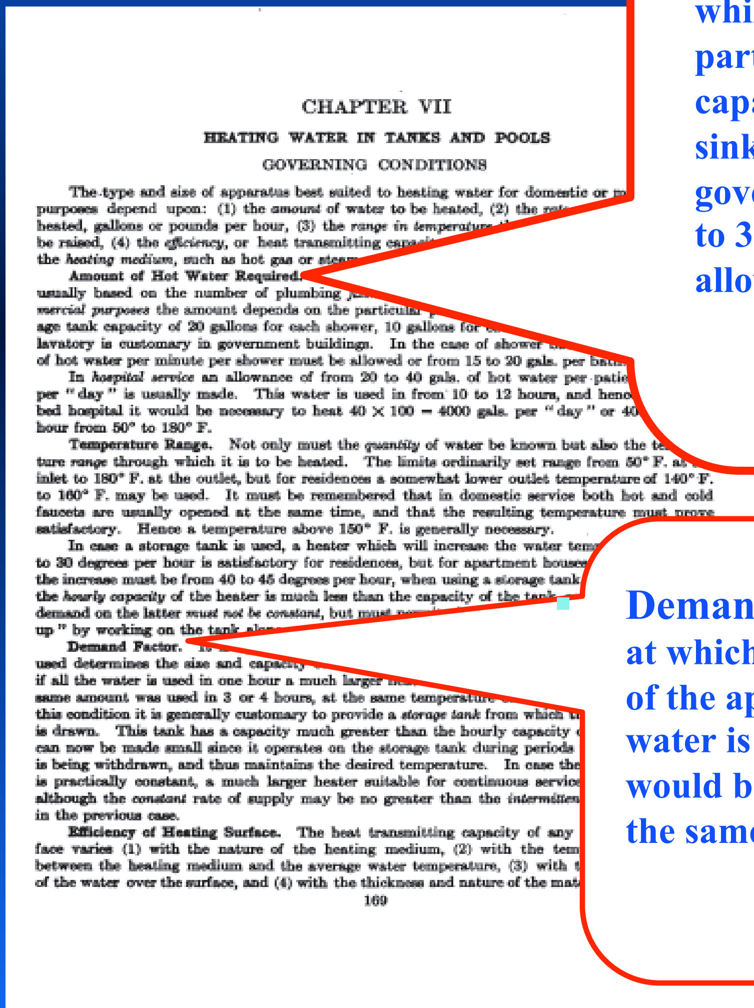
FIG. 6. FLOW OF WATER IN PIPES.

Example. 60 gals. per min. to be transmitted 300 ft. through a 2" standard steel pipe. Required the friction loss. From 60 gals. on the left trace horizontally to the intersection with the diagonal 2" pipe, and read 3.25 lb. per sq. in. at the bottom of the chart. The loss is then 3 × 3.25 = 9.75 lb. per sq. in.

Approximate Allowance for Ells and Globe Valves.

Add to the measured length of line 40 diams. for each 90° ell, and 60 diams. for each globe valve.

Quantity and Demand Factors are not new ideas…



Amount of Hot Water Required. In domestic service the amount of hot water required is usually based on the number of plumbing fixtures or occupants to be supplied, while for commercial purposes the amount depends on the particular process involved. An allowance in storage tank capacity of 20 gallons for each shower, 10 gallons for each sink and 5 gallons for each lavatory is customary in government buildings. In the case of shower baths from 2 to 3 gallons of hot water per minute per shower must be allowed or from 15 to 20 gallons per bath.

Demand Factor. It is apparent from the above that the rate at which the hot water is used determines the size and capacity of the apparatus for a given temperature range. Thus, if all the water is used in one hour a much larger heater is required than would be needed of the same amount was used in 3 to 4 hours at the same temperature of supply.

The Plumber's Handbook 1922

TABLE 3.—FLOW IN GALLONS PER MINUTE DELIVERED BY ORDINARY PLUMBING FIXTURES

Fixtures	Fair flow	Good flow	Excellent flow
Kitchen-sink bibbs	2	4	6
Pantry sink—high goose-neck bibbs	2	2	3
Pantry sink—large plain bibbs	4	6	8
Vegetable-sink bibbs	2	4	6
Laundry—tray bibbs	4	6	8
Slop-sink bibbs	3	4	6
Lavatory-basin bibbs	2	3	4
Bath-tub bibbs	3	4	6
Shampoo spray	½	1	2
Liver spray	1	2	3
Shower baths:			
5-in. rain heads	2	3	4
6½-in. rain heads	2	3	5
8-in. rain heads	4	6	8
8-in. tubular heads	6	8	10
Needle baths	20	30	40
Manicure table	1	1½	2

TABLE 4.—NUMBER OF TIMES FIXTURES ARE USED

Fixtures	Gallons per minute	Times used	Minutes per use	Total gallons
Lavatory	3	4	1	12
Tub	4	1	4	16
Sink	3	1	½	1½
Sink	3	1	2	6
Total hour's demand				35½

HOT WATER HEATERS

Capacity.—In fixing upon the capacity of heater best suited to heating water for domestic purposes, it is necessary to consider (1) the amount of water to be heated, (2) the rate at which it must be heated, (3) the range in temperature through which the water must be raised, and (4) the heating medium, such as hot gas.

Amount of Water.—In domestic service, the amount of hot water required is customarily based on the number of plumbing fixtures or occupants to be supplied. In government buildings, a storage tank allowance per day of 20 gal. for each shower, 10 gal. for each sink, and 5 gal. for each lavatory, is made. In the case of hospital service, an allowance of from 20 to 40 gal. of hot water per patient, per day, is usually made.

Rate of Water Supply.—If all the water is used in 1 hr., a much larger heater is required than would be needed if the same amount were used in 4 or 5 hr., at the temperature of the supply.

Enough History…

- Water heater technology can sometimes be as concerning today as it was a century ago…

Water Heating is sometimes not what you would expect.

- Other areas of the world look at water heating differently than we do.
- They will provide hot water for showers and bathing only.
- Certain locations use ambient temperature water for hand washing.
- And then there are others…


LORENZETTI
1 HOV TO USE THE HOT WATER: LET COLD,
WAT R RUN BEFORE TURNING ON THE UNIT TO
AVOI .TURNING THE HEATING ELEMENT.
2 TUR N OFF THE UNIT BEFORE YOU TURN OFF THE
WER.
THANK YOU

Amazon.com: CORAL MAX Tankless 220v Showerhead Electric Shower Head plus Nipple: Home Improveme - Windows Internet Explorer pro

http://www.amazon.com/Tankless-Showerhead-Electric-Shower-Nipple/dp/B0073A0SRU/ref=sr_1_2?ie=UTF8&qid=137

File Edit View Favorites Tools Help

Favorites | Online Performance Review... | Web Slice Gallery | Google | LinkedIn | join.me | Code Compliance

Amazon.com: CORAL MAX Tankless 220v Showerhea...

Page Safety Tools

amazon Try Prime

Joe's Amazon.com | Today's Deals | Gift Cards | Sell | Help

Off to College
Back to Amazon › Shop now
Sponsored by Philips Norelco

Shop by Department | Search All | electric shower head | Go | Hello, Joe Your Account | Try Prime | 0 Cart | Wish List

Home Improvement | Best Sellers | Gift Ideas | Lighting & Ceiling Fans | Kitchen & Bath Fixtures | Hardware | Power & Hand Tools | Woodworking | Safety & Security | Deals & Bargains

Roll over image to zoom in

CORAL MAX Tankless 220v Showerhead Electric Shower Head plus Nipple

by ExcelAmerica

Be the first to review this item

Available from these sellers.

- YOU WILL NEVER RUN OUT OF HOT WATER. EVERYONE GETS A HOT SHOWER
- WORKS GREAT EVEN WITH 2PSI WATER PRESSURE UP TO 150 PSI
- PERFECT FOR POOL SIDE HOT SHOWER RINSE OFFS
- CUT AND PASTE THIS VIDEO LINK FOR VIDEO CARTOON OF HOW THIS WORKS
- http://youtu.be/A840I3ljzC8

› See more product details

1 new from $69.00

Share

1 new from $69.00

See all buying options

Have one to sell? Sell on Amazon

Add to Wish List

Customers Who Viewed This Item Also Viewed

Page 1 of 1

CORAL MAX Tankless 110v Showerhead Electric Shower Head plus Nipple

CORAL Tankless Hot Water Heater Electric Shower Head 110 Volts Showerhead

Lorenzetti Advanced Tankless 110- 130v Showerhead Electric Shower Head

Camp Chef Triton Hot Water Heater - 5L

(176)

$114.00 - $150.00

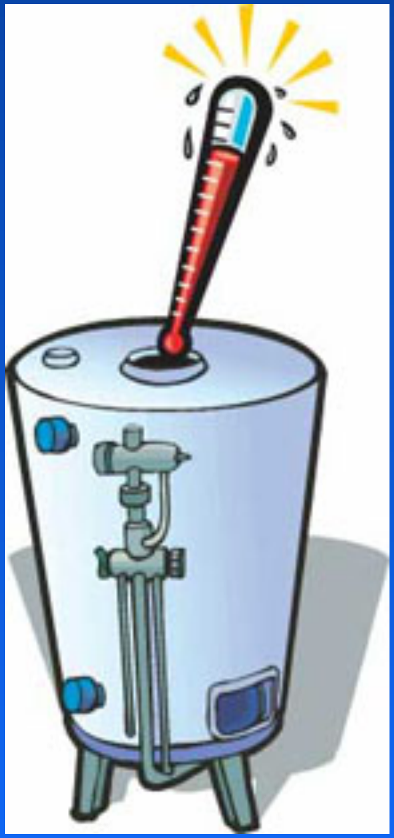
Lorenzetti Advanced Tankless 110v Showerhead Electric Shower Head

(6)

Hot Water Temperatures

- Generation Temperature
- Distribution Temperature
- Usable Temperatures

- You need to understand what each term means and why they are different.



Generation Temperature

- Generation Temperature – the temperature of the water out of the water heater.
- Generally, a minimum of 140 EF should be considered when generating hot water. This is to minimize bacterial growth in the water.

Legionella Pneumophila

Legionella Pneumophila, also known as Legionnaires' Disease, is a respiratory illness that can be fatal.

The bacteria that can cause Legionnaires' Disease are widespread in natural sources of water. In warm water, the bacteria can grow and multiply to high concentrations. Drinking water containing the Legionella bacteria has no known effects.

Legionella and Temperature

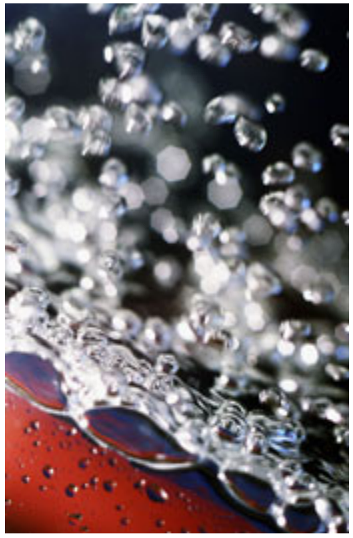
Careful consideration should be given to the generation temperature in the water heater.

ASPE recommends heating the water to 140 degrees F as does ASHRAE and others.

In residential water heaters the risk of scalding may be greater than the potential risk presented by legionella pneumophila.

Legionellae and Temperature

- 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 130°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)



Scalding

Water Temperature Effects on Adult Epidermis[1]

Temperature (F)	First Degree No Irreveribile Damage	Second Degree Full Thickness Injury
111	4.5 Hours	5 Hours
113	2.0 Hours	3 Hours
116.6	20 Minutes	45 Minutes
118.4	15 Minutes	20 Minutes
120	8 Minutes	10 Minutes
124	2 Minutes	4.2 Minutes
125.6	45 Seconds	1.5 Minutes
127.4	30 Seconds	60 Seconds
131	17 Seconds	30 Seconds
140	3 Seconds	5 Seconds
151	------	2 Seconds
158	------	1 Second

[1] *JCAH Hot Water Temperature Standard* (Chicago: American Society of Hospital Engineers, February, 1982) Technical Document No.:14:2-82

Scalding

- Scald potential and waterborne bacteria incubation (Legionella) are at cross purposes (keeping water temperatures up to versus keeping the water temperatures down) and must be reviewed.

Distribution Temperature

- Distribution temperature – The temperature of water being distributed to the various fixtures in the building. There may be two or three different distribution systems within the same building.
- 105 EF, 120 EF, 140 EF & 160 EF are common distribution temperatures.
- Separate piping loops and pumped returns for each temperature system are required.
- Do not mix temperatures within the recirculation piping system.

Usage Temperature

Usage Temperature – The temperature that actually comes into contact with the person or equipment using the water.

Fixture:	*Temperature (EF):*
Lavatory	102 - 105
Showers and Tubs	102 - 110
Commercial Laundry	140 – 160
Residential Dishwasher and Laundry	120 – 140
Commercial Kitchen	140 - 190

Mixed Water Temperature

- In order to provide water at various temperatures we are required to mix the hot water with cold water. Understanding how to mix water is vital in order to have a reliable system.

Mixed Water Temperature

Mixing water at different temperatures to make a desired water temperature is often required for domestic hot water distribution systems.

$$P = (T_m - T_c)/(T_h - T_c)$$

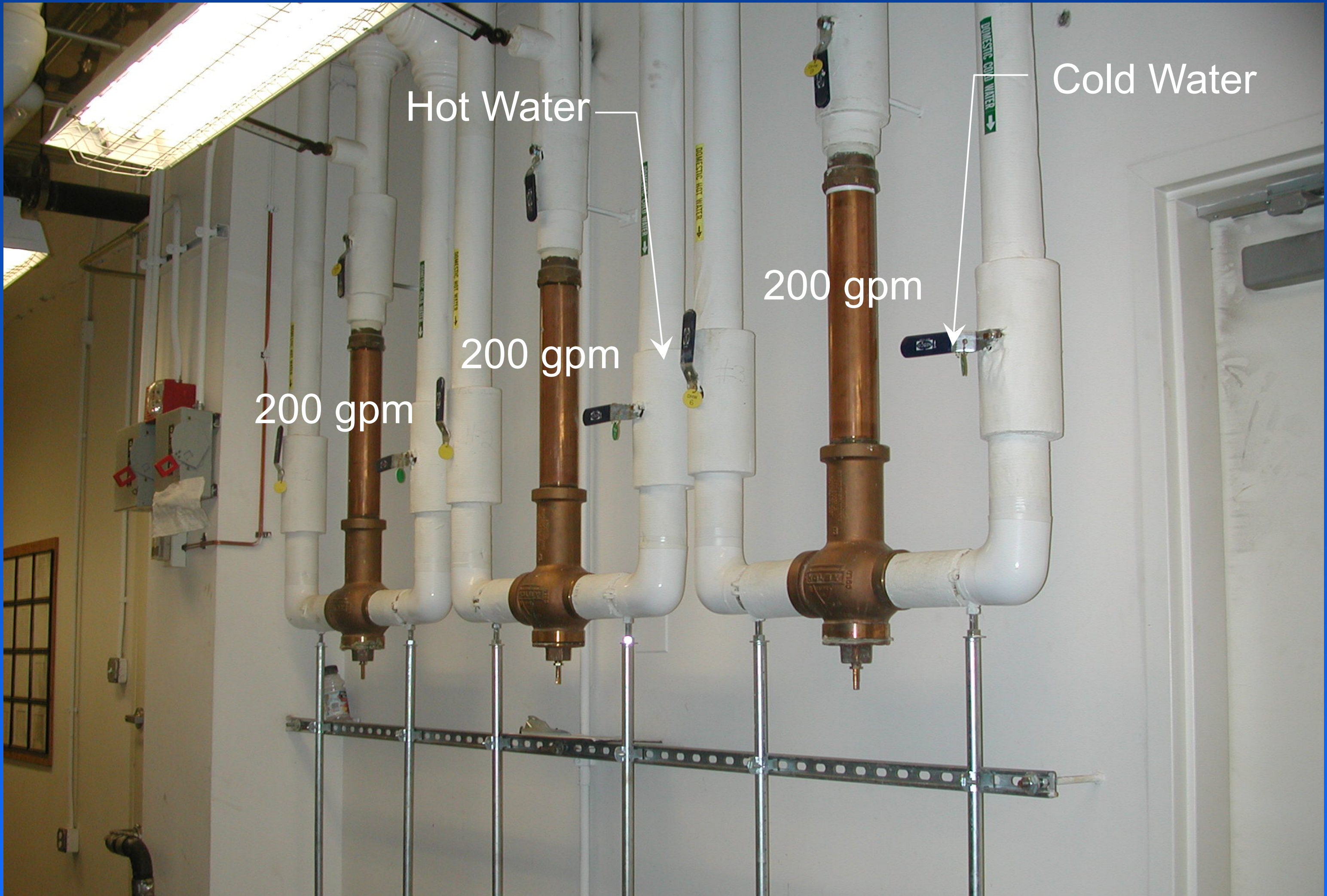
T_h = Supply hot water temperature
T_c = Inlet cold water temperature
T_m = Desired mixed water temperature

P is the hot water multiplier, which is expressed as a percentage.

Mixed Water Temperature

- There are several ways to mix water down to the distribution temperature. Thermostatic and electronic mixing devices are utilized to provide a reliable distribution temperature.
- Designers need to understand the devices they are using to limit the distribution temperatures in the hot water supply system.
- BAS, LAN and Web Enabled system interrogation, data logging and system safety alerts (via cell phone, e-mail, text messaging) are being embraced by the institutional community.

Thermostatic Mixing Valves:



Understanding the rate of heat transfer

The fundamental formula for a steady state heat balance for the heat input and output of the system.

$$q = r\ w\ c \in T$$

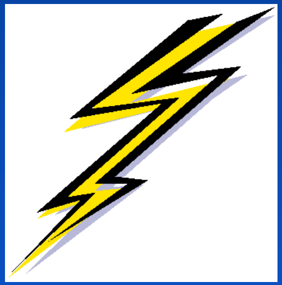
q = time rate of heat transfer, Btu/h
r = flow rate, gph
w = weight of heated water, lb/h
c = specific heat of water, Btu/lb/EF
∈T = change in heated water temperature, EF

Recovery Rates

- Depending on the fuel or energy that is used to fire the water heater, the input and recovery rate calculations are different.
- Common energy sources are natural gas, propane, fuel oil, electricity, steam and solar.
- Each energy source has advantages and disadvantages.

Electric Water Heaters

Assuming that 1 kilowatt of electrical power will raise 410 gallons of water 1EF. The kilowatt input of the electric water heater may be determined from the following formula:



kW = (gph)/(gal. of water per kW at ∈T)

∈T = temperature rise, EF
gph = gallons per hour of hot water required

Temperature Rise, T, F	Gallons of Water per kW
110	3.73
100	4.10
90	4.55
80	5.13
70	5.86
60	6.83
50	8.20
40	10.25

Gas Water Heaters

For the purposes of this presentation, the specific heat of water is constant at:

c = 1 Btu/lb/EF

and the weight of water is constant at:

8.33 lb/gal

thus:

q = gph[(1 Btu/lb/EF)(8.33 lb/gal)(∈T)]

q = quantity of gas in btuh.

Steam Water Heaters

The amount of steam required to heat water 100 EF with 15 psig steam:

Steam (lbs/hr) = (gpm)(500)(∈T)/950 btu/lb

∈T = temperature rise, EF
gpm = gallons per minute of hot water required
500 = the hydronic constant (8.33 lbs/gal x 60 min.)
950 = latent heat in btu/lb for 15 psi steam

Steam Water Heaters

- Steam water heaters should be sized utilizing the fixture unit method and the Modified Hunter's Curve unless the building has special conditions.
- The Modified Hunter's Curve is available from ASHRAE or various water heater manufacturers.

Modified Hunter’s Curve

Flo-Rite-Temp™ Instantaneous Water Heater Sizing Instructions

Armstrong®

Chart WHM-1

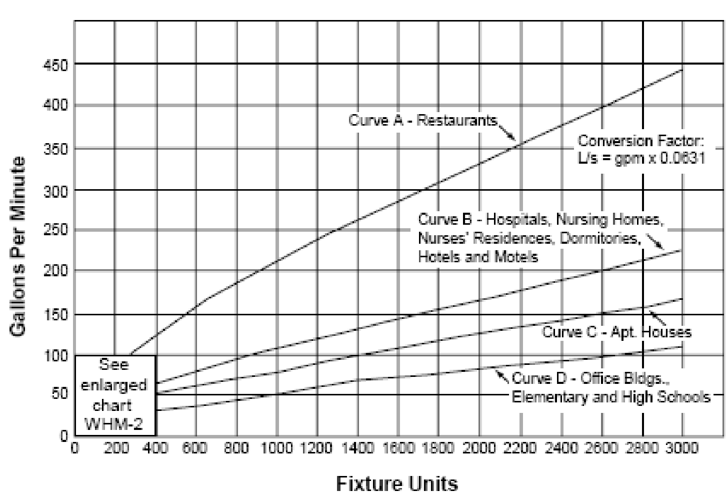
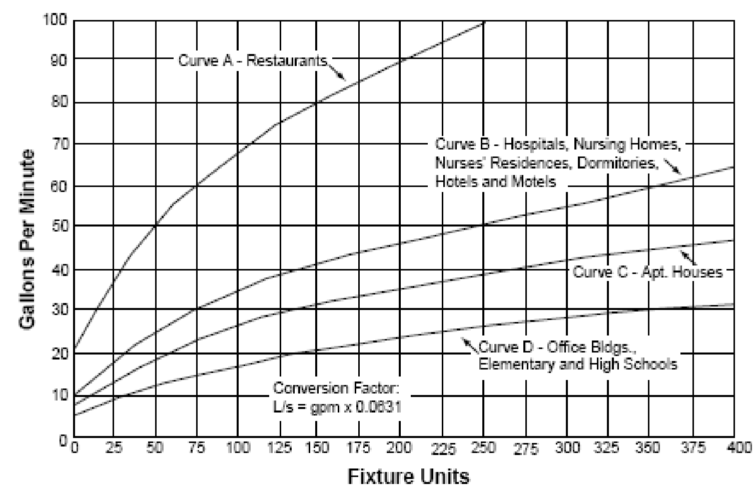


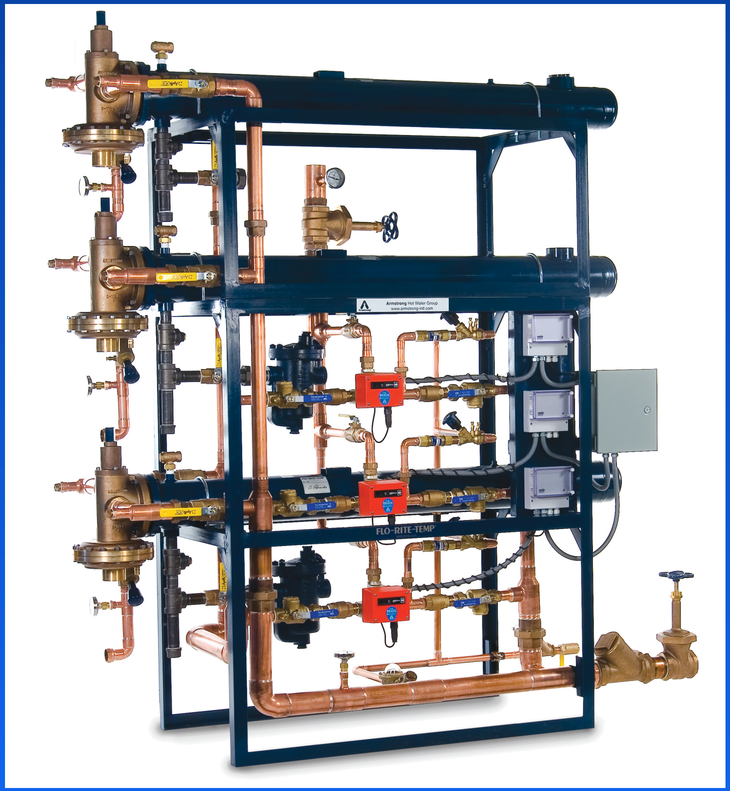
Chart WHM-2. Enlarged Section



Reprinted from the 1987 ASHRAE *Handbook–HVAC* with permission from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
Hunter curves should be used for intermittent, insignificant fixtures only.

Steam Water Heaters

Hospitals and Research Laboratories usually need steam for sterilization purposes. Using steam to heat water is a consideration when this type of energy source is available.



Recovery Rates & Energy Calculations

Spreadsheets can be utilized to easily perform the necessary calculations.

Calculations - Natural Gas & Electric		
Recovery (gph):	1200	gph
Temp. Rise (F)	100	F
Weight of Water (Lbs)	8.33	lbs
Efficiency (%)	85%	%
Input Nat. Gas (btuh)	1,176,000	btuh
Input Nat. Gas (mbh)	1,176	mbh
Input (kw)	292.7	kw
Calculations - Steam		
Recovery (gpm):	30	gpm
Temp. Rise (F)	100	F
Weight of Water (Lbs)	8.33	lbs
Input 15 lb Steam (lbs/hr)	1579	lbs/hr

Storage and Recovery

There is a relationship between storage and recovery. The recovery rate of the heater can be reduced if the amount of hot water in storage is increased.

Once the recovery rate of the heater is determined, the amount of storage required to keep up with the instantaneous demand for hot water should be reviewed.

Determining the exact relationship will depend on the building type being designed.

Flow Rates between Gas Fired Water Heaters and Storage Tanks

The flow rate between a gas fired water heater and a separate storage tank can be determined by using the following formula:

Flow Rate (gpm) = Btuh/(60 min x 8.33 lb/gal)($\in$T)

This is also explained in *Plumbing Systems & Design* July/August 2008 issue.

Selection of Equipment

Gas fired equipment and its operating temperature shall be selected to assure the operating temperature of the heater will not be less than the dewpoint temperature of the flue gas to avoid condensation.

In other words, the inlet temperature to certain types of gas fired water heaters and the final temperature of the heated water must checked with the manufacturer in order to verify the design parameters of the water heater have not been exceeded.

Stratification

Stratification is the fraction of usable stored water in the warm water layer that is formed by the natural tendency of the warmer water to rise to the top and occurs in all uncirculated tanks. It has been found that the amount of usable water in stratified horizontal and vertical tanks is about 65% and 75%, respectively.

75% Usable Water

65% Usable Water

Stratification, cont’d

Stratification during recovery periods can be reduced significantly by mechanical circulation of the water in the tank.

During periods of demand, however, it is useful to have good stratification since this increases the availability of water at a usable temperature.

Stratification, cont'd

For Example:
If a tank were equally stratified between 140EF at the top and 40EF at the bottom, this tank, in theory, could still deliver half its volume at 140EF. But, if the two layers were completely mixed, the tank temperature would drop to 90EF, which, in most cases, is an unusable temperature.

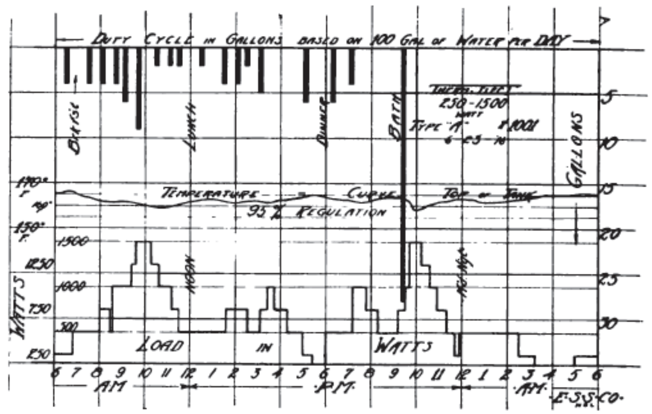
One way to encourage stratification in tanks is by limiting the velocity of water entering the tank.

Sizing the Water Heater

- Why is sizing a water heater so difficult?
- Understanding key issues about the building and hot water system can make the sizing of a water heater much easier.

Understand Your Building Typology

- You must understand your building type to understand how the building will use hot water.
- Fitness centers, dorms, hotels, sports arenas, hospitals, laboratories, prisons, schools, etc – all have the same fixtures but different load profiles.



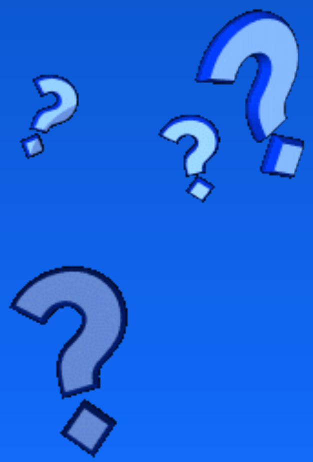
Performance Curves Therm Elect Water Heater.
Temperature and Load Regulation, 24 hrs.

Various building types have different load profiles

- The type of building served will assist in determining what kind of water heater should be used.
- Office buildings, Hospitals and Hotels all have different characteristics that make them unique.
- The availability of various energy sources will also assist in determining what kind of water heater should be used.

Key Questions for every building…

- How is hot water in the building used?
- How many hours per day is hot water needed?
- Is there something unique about the operation of the building that could effect the amount of hot water required?



Key Questions for every building…

Hospitals
Nursing Homes
Schools
Laboratories
Prisons
Health Clubs
Dormitories
Multi-Family Dwelling

- Building Occupancy
- Simultaneous usage
- Hours of operation
- Building Occupant Demographic
- Peak hour (or should it be two hours)
- Special fixtures or equipment requirements

Sizing the Water Heater

- The quantity of fixtures can be important, but the demand of the building is the determining factor.
- A building can have many fixtures that are not used.
- Example: A nursing home could have 48 toilet rooms with showers, but if the residents require assisted bathing then the shower load is dependent on the number of staff available and not the number of showers.

Careful of your Assumptions

- Further investigation is often required when using modern equipment and fixtures. Flow rates and water usage has decreased in the past decade and most of the information available has not accounted for the reduction in water usage.
- The trend of reducing the amount of hot water being used will continue as the industry embraces sustainability issues.

Chapter 1: Fundamentals

- Introduction
- Basic Relationships and Units
- Thermal Efficiency
- Heat Recovery - Electric Water Heaters
- Mixed Water Temperature
- Delivered Hot Water Temperature
- Safety and Health Concerns
  - Legionella Pneumophila
  - Scalding
- Relief Valves
- Thermal Expansion
- Controls
- Storage and Recovery
  - Stratification
- Codes and Standards
- System Alternative Considerations

Basic Relationships and Units

The fundamental formula for a steady state heat balance for the heat input and output of the system.

Equation 1.1

$$q = rwc{\in}T$$

q = time rate of heat transfer, Btu/h
r = flow rate, gph
w = weight of heated water, lb/h
c = specific heat of water, Btu/lb/EF
∈T = change in heated water temperature, EF

Basic Relationships and Units

For the purposes of this manual, the specific heat of water is constant:

c = 1 Btu/lb/EF

and the weight of water is constant at:

8.33 lb/gal

thus:

Equation 1.2:

$$q = \text{gph}\left[(1\ \text{Btu/lb/EF})(8.33\ \text{lb/gal})(\in \text{T})\right]$$

Example: 1.1

Calculate the heat output rate required to heat 600 gph with 50EF incoming cold water and heating the water to 140EF.

$$q = 600\ \text{gph}\left[(1\ \text{Btu/lb/EF})(8.33\ \text{lb/gal})(140\text{-}50\text{EF})\right]$$

$$q = 449{,}820\ \text{Btu/h}$$

Thermal Efficiency

Thermal Efficiency, E_t , is defined as the heat actually transferred to the domestic water divided by the total heat input to the water heater.

Equation 1.3:

$$E_t = \left[q/(q+B)\right] \times 100\%$$

B = Internal heat loss of the water heater, Btu/h

This percentage applied to the output Btu/h of the water heater allows us to determine the total heat input.

Heat Input = q/ E_t , or, in the case of Example 1.1:

449,820 Btu/h/0.80 = 562,275 Btu/h

Heat Recovery - Electric Water Heaters

Assuming that 1 kilowatt of electrical power will raise 410 gallons of water 1EF. The kilowatt input of the electric water heater may be determined from the following formula:

kW = (gph)/(gal. of water per kW at ∈T)

∈T = temperature rise, EF
gph = gallons per hour of hot water required

Heat Recovery - Electric Water Heaters

Temperature Rise, T, F	Gallons of Water per kW
110	3.73
100	4.10
90	4.55
80	5.13
70	5.86
60	6.83
50	8.20
40	10.25

Example: 1.4

A group of showers requires 25 gpm of 105EF mixed water temperature. Determine how much 140EF hot water must be supplied to the showers when the cold water is 50EF.

P = (105EF- 50EF)/(140EF- 50EF)

P = 0.61

Therefore, 0.61(25 gpm) = 15.25 gpm of 140EF hot water required.

Note: Table 1.1 may also be used to determine P.

Delivered Hot Water Temperature

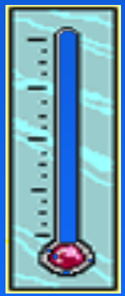
Use	***Temp* (F)**
Lavatory	**105**
Showers and Tubs	**110**
Commercial and Institutional Laundry	**140 to 180**
Residential dishwashing and laundry	**140**
Commercial spray type dishwashing (per NSF):	
Single or multiple tank hood or rack type: Wash	**150**
Final Rinse	**180 to 195**
Single tank conveyor type: Wash	**160**
Final Rinse	**180 to 195**
Single tank rack or door type	
Single temperature wash and rinse	**165**
Chemical sanitizing glassware: Wash	**140**
Rinse	**75**

Hot Water Temperature

What is the maximum temperature to be distributed to the plumbing fixture according to the code?

ASHRAE 90.1-2010:

- **7.4.4.3 Outlet Temperature Controls.** Temperature controlling means shall be provided to limit the maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110 EF.



International Energy Conservation Code 2012

- **C404.3** Temperature controls. Service water-heating equipment shall be provided with controls to allow a setpoint of 110°F (43°C) for equipment serving dwelling units and 90°F (32°C) for equipment serving other occupancies. The outlet temperature of lavatories in public facility rest rooms shall be limited to 110°F (43°C).

- **C404.4** Heat traps. Water-heating equipment not supplied with integral heat traps and serving noncirculating systems shall be provided with heat traps on the supply and discharge piping associated with the equipment.

- **C404.5** Pipe insulation. For automatic-circulating hot water and heat-traced systems, piping shall be insulated with not less than 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h × ft^2 × °F (1.53 W per 25 mm/m^2 × K). The first 8 feet (2438 mm) of piping in non-hot-water-supply temperature maintenance systems served by equipment without integral heat traps shall be insulated with 0.5 inch (12.7 mm) of material having a conductivity not exceeding 0.27 Btu per inch/h × ft^2 × °F (1.53 W per 25 mm/m^2× K).

  Exception: Heat-traced piping systems shall meet the insulation thickness requirements per the manufacturer's installation instructions. Untraced piping within a heat traced system shall be insulated with not less than 1inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h × ft^2 × °F (1.53 W per 25 mm/m^2 × K).

- **C404.6** Hot water system controls. Circulating hot water system pumps or heat trace shall be arranged to be turned off either automatically or manually when there is limited hot water demand. Ready access shall be provided to the operating controls.

International Energy Conservation Code 2012

- **R403.4** Service hot water systems. Energy conservation measures for service hot water systems shall be in accordance with Sections R403.4.1 and R403.4.2.
- **R403.4.1** Circulating hot water systems (Mandatory). Circulating hot water systems shall be provided with an automatic or readily accessible manual switch that can turn off the hot-water circulating pump when the system is not in use.
- **R403.4.2** Hot water pipe insulation (Prescriptive). Insulation for hot water pipe with a minimum thermal resistance (R-value) of R-3 shall be applied to the following:
- 1. Piping larger than $^3/_4$ inch nominal diameter.
- 2. Piping serving more than one dwelling unit.
- 3. Piping from the water heater to kitchen outlets.
- 4. Piping located outside the conditioned space.
- 5. Piping from the water heater to a distribution manifold.
- 6. Piping located under a floor slab.
- 7. Buried piping.
- 8. Supply and return piping in recirculation systems other than demand recirculation systems.
- 9. Piping with run lengths greater than the maximum run lengths for the nominal pipe diameter given in Table R403.4.2.
- All remaining piping shall be insulated to at least R-3 or meet the run length requirements of Table R403.4.2.

International Energy Conservation Code 2012

TABLE R403.4.2
MAXIMUM RUN LENGTH (feet)[a]

Nominal Pipe Diameter of Largest Diameter Pipe in the Run (inch)	$^3/_8$	$^1/_2$	$^3/_4$	$> {}^3/_4$
Maximum Run Length	30	20	10	5

For SI: 1 inch = 25.4 mm, 1 foot 304.8 mm.
a. Total length of all piping from the distribution manifold or the recirculation loop to a point of use.

International Plumbing Code 2012

- **SECTION 416**
- **LAVATORIES**

- **416.5** Tempered water for public hand-washing facilities. Tempered water shall be delivered from lavatories and group wash fixtures located in public toilet facilities provided for customers, patrons and visitors. Tempered water shall be delivered through an approved water-temperature limiting device that conforms to ASSE 1070 or CSA B125.3.

International Plumbing Code 2012

- **SECTION424**
  FAUCETS AND OTHER FIXTURE FITTINGS

- **424.1.1** Faucets and supply fittings. Faucets and supply fittings shall conform to the water consumption requirements of Section 604.4.

- **424.2** Hand showers. Hand-held showers shall conform to ASME A112.18.1/CSA B125.1. Hand-held showers shall provide backflow protection in accordance with ASME A112.18.1/ CSA B125.1 or shall be protected against backflow by a device complying with ASME A112.18.3.

- **424.3** Individual shower valves. Individual shower and tub-shower combination valves shall be balanced-pressure, thermostatic or combination balanced-pressure/thermostatic valves that conform to the requirements of ASSE 1016 or ASME A112.18.1/CSA B125.1 and shall be installed at the point of use. Shower and tub-shower combination valves required by this section shall be equipped with a means to limit the maximum setting of the valve to 120°F (49°C), which shall be field adjusted in accordance with the manufacturer's instructions. In-line thermostatic valves shall not be utilized for compliance with this section.

International Plumbing Code 2012

- **SECTION424**
- **FAUCETS AND OTHER FIXTURE FITTINGS**

- **424.4** Multiple (gang) showers. Multiple (gang) showers supplied with a single-tempered water supply pipe shall have the water supply for such showers controlled by an approved automatic temperature control mixing valve that conforms to ASSE 1069 or CSA B125.3, or each shower head shall be individually controlled by a balanced-pressure, thermostatic or combination balanced-pressure/thermostatic valve that conforms to ASSE1016 or ASME A112.18.1/CSA B125.1 and is installed at the point of use. Such valves shall be equipped with a means to limit the maximum setting of the valve to 120°F (49°C), which shall be field adjusted in accordance with the manufacturers' instructions.

- **424.5** Bathtub and whirlpool bathtub valves. The hot water supplied to bathtubs and whirlpool bathtubs shall be limited to a maximum temperature of 120°F (49°C) by a water-temperature limiting device that conforms to ASSE 1070 or CSA B125.3, except where such protection is otherwise provided by a combination tub/shower valve in accordance with Section 424.3.

International Plumbing Code 2012

- **SECTION424**
  FAUCETS AND OTHER FIXTURE FITTINGS

- **424.7** Temperature-actuated, flow reduction valves for individual fixture fittings. Temperature-actuated, flow reduction devices, where installed for individual fixture fittings, shall conform to ASSE 1062. Such valves shall not be used alone as a substitute for the balanced pressure, thermostatic or combination shower valves required in Section 424.3.

- **424.8** Transfer valves. Deck-mounted bath/shower transfer valves containing an integral atmospheric vacuum breaker shall conform to the requirements of ASME A112.18.7.

International Plumbing Code 2012

- SECTION 607
- HOT WATER SUPPLY SYSTEM

- 607.1 Where required. In residential occupancies, hot water shall be supplied to plumbing fixtures and equipment utilized for bathing, washing, culinary purposes, cleansing, laundry or building maintenance. In nonresidential occupancies, hot water shall be supplied for culinary purposes, cleansing, laundry or building maintenance purposes. In nonresidential occupancies, hot water or tempered water shall be supplied for bathing and washing purposes.

- 607.1.1 Temperature limiting means. A thermostat control for a water heater shall not serve as the temperature limiting means for the purposes of complying with the requirements of this code for maximum allowable hot or tempered water delivery temperature at fixtures.

- 607.1.2 Tempered water temperature control. Tempered water shall be supplied through a water temperature limiting device that conforms to ASSE 1070 and shall limit the tempered water to a maximum of 110ºF (43ºC). This provision shall not supersede the requirement for protective shower valves in accordance with Section 424.3.

International Plumbing Code 2012

- SECTION 607
- HOT WATER SUPPLY SYSTEM

- 607.2 Hot or tempered water supply to fixtures. The developed length of hot or tempered water piping, from the source of hot water to the fixtures that require hot or tempered water, shall not exceed 50 feet (15 240 mm). Recirculating system piping and heat-traced piping shall be considered to be sources of hot or tempered water.

- [E] 607.2.1 Hot water system controls. Automatic circulating hot water system pumps or heat trace shall be arranged to be conveniently turned off, automatically or manually, when the hot water system is not in operation.

- 607.2.2 Recirculating pump. Where a thermostatic mixing valve is used in a system with a hot water recirculating pump, the hot water or tempered water return line shall be routed to the cold water inlet pipe of the water heater and the cold water inlet pipe or the hot water return connection of the thermostatic mixing valve.

International Plumbing Code 2012

- SECTION 607
- HOT WATER SUPPLY SYSTEM

- 607.3 Thermal expansion control. A means of controlling increased pressure caused by thermal expansion shall be provided where required in accordance with Sections 607.3.1 and 607.3.2.

- 607.3.1 Pressure-reducing valve. For water service system sizes up to and including 2 inches (51 mm), a device for controlling pressure shall be installed where, because of thermal expansion, the pressure on the downstream side of a pressure-reducing valve exceeds the pressure-reducing valve setting.

- 607.3.2 Backflow prevention device or check valve. Where a backflow prevention device, check valve or other device is installed on a water supply system utilizing storage water heating equipment such that thermal expansion causes an increase in pressure, a device for controlling pressure shall be installed.

International Plumbing Code 2012

- SECTION 607
- HOT WATER SUPPLY SYSTEM

- **607.4** Flow of hot water to fixtures. Fixture fittings, faucets and diverters shall be installed and adjusted so that the flow of hot water from the fittings corresponds to the left-hand side of the fixture fitting.
- Exception: Shower and tub/shower mixing valves conforming to ASSE 1016 or ASME A112.18.1/ CSA B125.1, where the flow of hot water corresponds to the markings on the device.

- [E] **607.5** Pipe insulation. Hot water piping in automatic temperature maintenance systems shall be insulated with 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h • ft^2 • °F (1.53 W per 25 mm/m^2 • K). The first 8 feet (2438 mm) of hot water piping from a hot water source that does not have heat traps shall be insulated with 0.5 inch (12.7 mm) of material having a conductivity not exceeding 0.27 Btu per inch/h • ft^2 • °F (1.53 W per 25 mm/m^2 • K).

International Plumbing Code 2012

TABLE 604.4

MAXIMUM FLOW RATES AND CONSUMPTION FOR PLUMBING FIXTURES AND FIXTURE FITTINGS

PLUMBING FIXTURE OR FIXTURE FITTING	MAXIMUM FLOW RATE OR QUANTITY[b]
Lavatory, private	2.2 gpm at 60 psi
Lavatory, public (metering)	0.25 gallon per metering cycle
Lavatory, public (other than metering)	0.5 gpm at 60 psi
Shower head[a]	2.5 gpm at 80 psi
Sink faucet	2.2 gpm at 60 psi
Urinal	1.0 gallon per flushing cycle
Water closet	1.6 gallons per flushing cycle

For SI: 1 gallon = 3.785 L, 1 gallon per minute = 3.785 L/m,
1 pound per square inch = 6.895 kPa.
a. A hand-held shower spray is a shower head.
b. Consumption tolerances shall be determined from referenced standards.

New Standards to look for:

- Hot Water Distribution

- Efficient Hot or Tempered Water Distribution Systems. For the purposes of this section, sources of hot or tempered water include water heaters, boilers, hot water circulation loops, and electrically heat-traced pipe. The volume of water in the piping between water heaters or boilers and fixture fittings the serve shall not exceed 32 ounces (0.945 L). The volume of water contained in fixture branch piping that connects to a hot water circulation loop or electrically heat- traced pipe shall not exceed 16 ounces (0.47 L). The volume shall be calculated in accordance with Table 6-3.

- Volume Calculation. The volume of water between the source of hot or tempered water and a given outlet shall be calculated by adding the internal volume of all piping, fittings, valves, meters, and manifolds between the source and the outlet. Piping volumes shall be calculated using Table 6-3. Where water is supplied by a circulating hot or tempered water system or an electrically heat-traced pipe, the hot water source shall be the loop or the heat-traced pipe, and the volume shall include the portion of the fitting on the loop that supplies the fixture branch.

New Standards to look for:

TABLE 6-3 Internal Volume of Various Types of Water Distribution Pipe and Tubing

Nominal Pipe or Tube Size (inch)	Type of Piping								
	Copper			CPVC			PE	PEX	
	Copper Type M	Copper Type L	Copper Type K	CPVC CTS SDR 11	CPVC SCH 40	CPVC SCH 80	PE-AL-PE	PEX CTS SDR 9	PEX-AL-PEX
	Liquid Ounces Per Foot Of Length								
3/8	1.06	0.97	0.84	NA	1.17	0.86	0.63	0.64	0.63
1/2	1.69	1.55	1.45	1.25	1.89	1.46	1.31	1.18	1.31
3/4	3.43	3.22	2.90	2.67	3.38	2.74	3.39	2.35	3.39
1	5.81	5.49	5.17	4.43	5.53	4.56	5.56	3.91	5.56
1 1/4	8.70	8.36	8.09	6.61	9.66	8.24	8.49	5.81	8.49
1 1/2	12.18	11.83	11.45	9.22	13.20	11.38	13.88	8.09	13.88
2	21.08	20.58	20.04	15.79	21.88	19.11	21.48	13.86	21.48

New Standards to look for:

Length of Pipe that Holds 8 oz of Water

	3/8" CTS			1/2" CTS			3/4" CTS			1" CTS		
	ID, in	gal/ft	ft/cup	ID, in	gal/ft	ft/cup	ID, in	gal/ft	ft/cup	ID, in	gal/ft	ft/cup
"K" copper	0.402	0.0066	9.48	0.527	0.0113	5.52	0.745	0.0226	2.76	0.995	0.0404	1.55
"L" copper	0.440	0.0079	7.92	0.545	0.0121	5.16	0.785	0.0251	2.49	1.025	0.0429	1.46
"M" copper	0.450	0.0083	7.57	0.569	0.0132	4.73	0.811	0.0268	2.33	1.055	0.0454	1.38
CPVC	N/A	N/A	N/A	0.489	0.0098	6.41	0.715	0.0209	3.00	0.921	0.0346	1.81
PEX	0.356	0.0052	12.09	0.481	0.0094	6.62	0.677	0.0187	3.34	0.871	0.0309	2.02

Ave	**8 feet**	**5 feet**	**2.5 feet**	**1.5 feet**

Gary Klein, California Energy Commission

Hot Water Recirculation

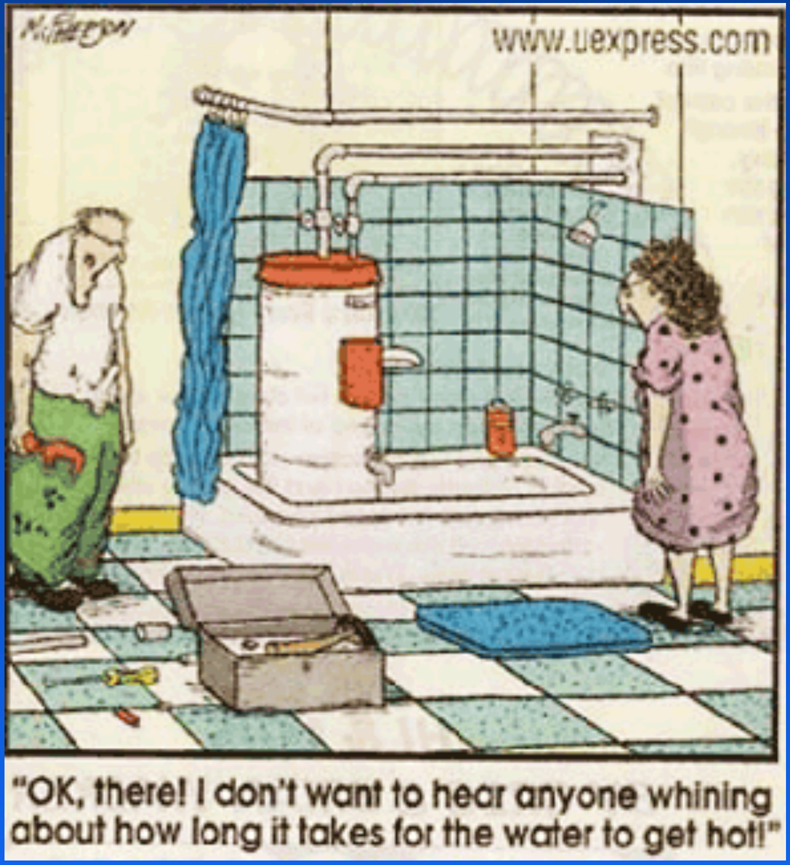
- Key Considerations:
  - Minimize dead legs
  - Recirculate any piping run over ~~25~~ 10 feet.
  - Hot water temperature is critical.
  - Redundant hot water recirculating pumps are recommended.

Purpose of Temperature Maintenance in Domestic Hot Water Systems:

- To minimize the delay in obtaining the desired hot water temperature at the point of use.
  - In a static system, the temperature of the domestic hot water will drop continuously as it loses heat to the surroundings.
  - Proper temperature maintenance will minimize the delay in obtaining the desired temperature of hot water to an acceptable time limit.
- *"The correct sizing and operation of water heaters depends on the appropriateness of the hot water temperature maintenance system"*

Penalties for Inadequate Temperature Maintenance

- Time delay in obtaining the desired temperature hot water at the point of use.
- Wasted water as the cooled water is discharged down the drain.
- Wasted energy that was used to heat the cooled water.



Acceptability of Delays for Obtaining Desired Hot Water Temperature at Fixture

- 0 – 10 seconds is normally acceptable for residential and public fixtures in office buildings
- 11 – 30 seconds is marginal, but possibly accetable
- 31 seconds or longer is not acceptable

Formula for Calculating Time Delay for Obtaining the Desired Hot Water Temperature at the Point of Use

$$\text{Delay (Seconds)} = \frac{\text{Water volume/foot of pipe (gal)} \times \text{Length of Pipe (ft)} \times 60}{\text{Fixture flow rate (gpm)}}$$

- See Table 14.1 and Table 14.2 of the Domestic Water Heating Design Manual.

Table 14.1 Water Contents and Weight of Tube or Piping per Linear Foot

Nominal Diameter	Copper Pipe Type L		Copper Pipe Type M		Steel Pipe Schedule 40		CPVC Pipe Schedule 40	
(in.)[a]	Water (gal/ft)	Wgt. (lb/ft)	Water (gal/ft)	Wgt. (lb/ft)	Water (gal/ft)	Wgt. (lb/ft)	Water (gal/ft)	Wgt. (lb/ft)
½	0.012	0.285	0.013	0.204	0.016	0.860	0.016	0.210
¾	0.025	0.445	0.027	0.328	0.028	1.140	0.028	0.290
1	0.043	0.655	0.045	0.465	0.045	1.680	0.045	0.420
1¼	0.065	0.884	0.068	0.682	0.077	2.280	0.078	0.590
1½	0.093	1.14	0.100	0.940	0.106	2.720	0.106	0.710

[a]Pipe sizes are indicated for mild steel pipe sizing.

Table 14.2 Approximate Fixture and Appliance Water Flow Rates

Fittings	Maximum Flow Rates[a] GPM	L/Sec
Lavatory faucet	2.0	1.3
Public non-metering	0.5	0.03
Public metering	0.25 gal/cycle	0.946 L/cycle
Sink faucet	2.5	0.16
Shower head	2.5	0.16
Bathtub faucets		
Single-handle	2.4 minimum	0.15 minimum
Two-handle	4.0 minimum	0.25 minimum
Service sink faucet	4.0 minimum	0.25 minimum
Laundry tray faucet	4.0 minimum	0.25 minimum
Residential dishwasher	1.87 aver	0.12 aver
Residential washing machine	7.5 aver	0.47 aver

[a]Unless otherwise noted.

Formula for Calculating Time Delay for Obtaining the Desired Hot Water Temperature at the Point of Use

- Table 14.3 lists the approximate time delays to get hot water to a fixture based on flow rate, pipe size and length of pipe. This table is conservative and includes an allowance to heat the pipe. *"Normally there should be a maximum distance of approximately 25 feet from the domestic hot water temperature maintenance system and each plumbing fixture."*

Table 14.3 Approximate Time Required to Get Hot Water to a Fixture

		Delivery Time (sec)							
Fixture Flow Rate (gpm)		0.5		1.5		2.5		4.0	
Piping Length (ft)		10	25	10	25	10	25	10	25
Copper Pipe	½ in.	25	63[a]	8	21	5	13	3	8
	¾ in.	48[a]	119[a]	16	40[a]	10	24	6	15
Steel Pipe Sched. 40	½ in.	63[a]	157[a]	21	52[a]	13	31[a]	8	20
	¾ in.	91[a]	228[a]	30	76[a]	18	46[a]	11	28
CPVC Pipe Sched. 40	½ in.	64[a]	159[a]	21	53[a]	13	32[a]	8	20
	¾ in.	95[a]	238[a]	32	79[a]	19	48[a]	12	30

Note: Table based on various fixture flow rates, piping materials, and dead-end branch lengths. Calculations are based on the amount of heat required to heat the piping, the water in the piping, and the heat loss from the piping. Based on water temperature of 140°F and an air temperture of 70°F.

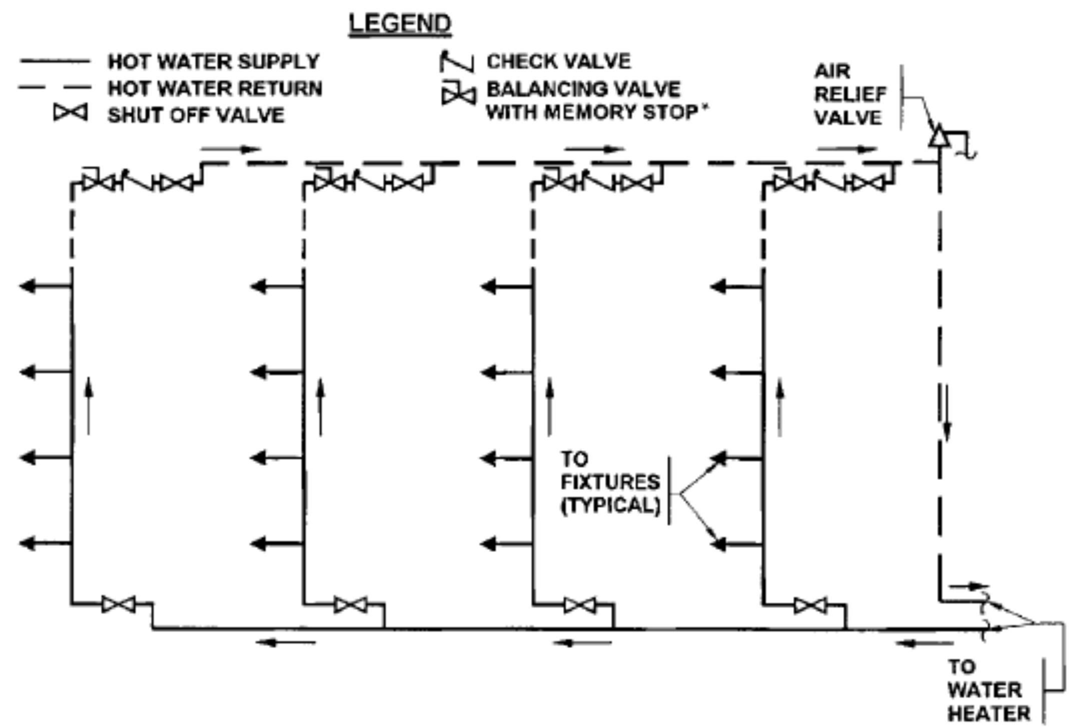
[a]Delays longer than 30 sec are not acceptable.

Methods of Delivering Domestic Hot Water at the Point of Use Within Acceptable Time Limits

- Domestic hot water temperature maintenance systems can be grouped into three basic categories:
  - Circulation Systems
  - Electric Cable Heat Trace Systems
  - Point of Use Water Heaters

Circulation Systems

- A circulation system includes:
  - Hot water supply piping
  - Hot water return piping
  - Circulating pumps
  - Balance valves
  - Shut off valves
  - Check valves
  - Controls for the pumps



Fixture 14.1 Upfeed Hot Water System with Heater at Bottom of System.

* See text for requirements for strainers.

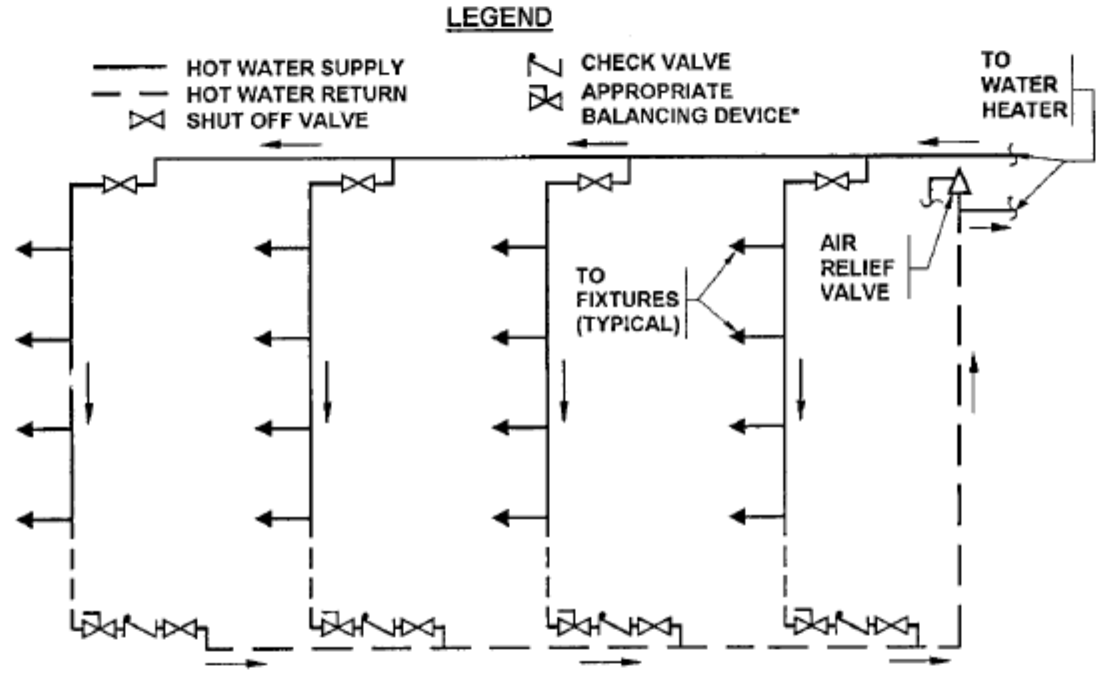


Figure 14.2 Downfeed Hot Water System with Heater at Top of System.

* See text for requirements for strainers.

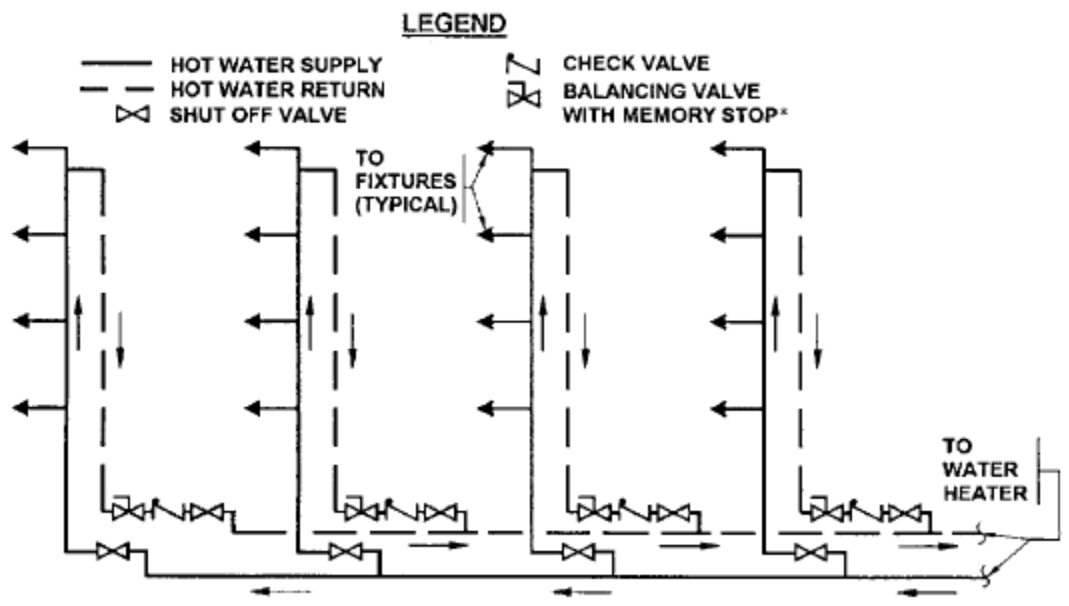


Figure 14.3 Upfeed Hot Water System with Heater at Bottom of System.

* See text for requirements for strainers.

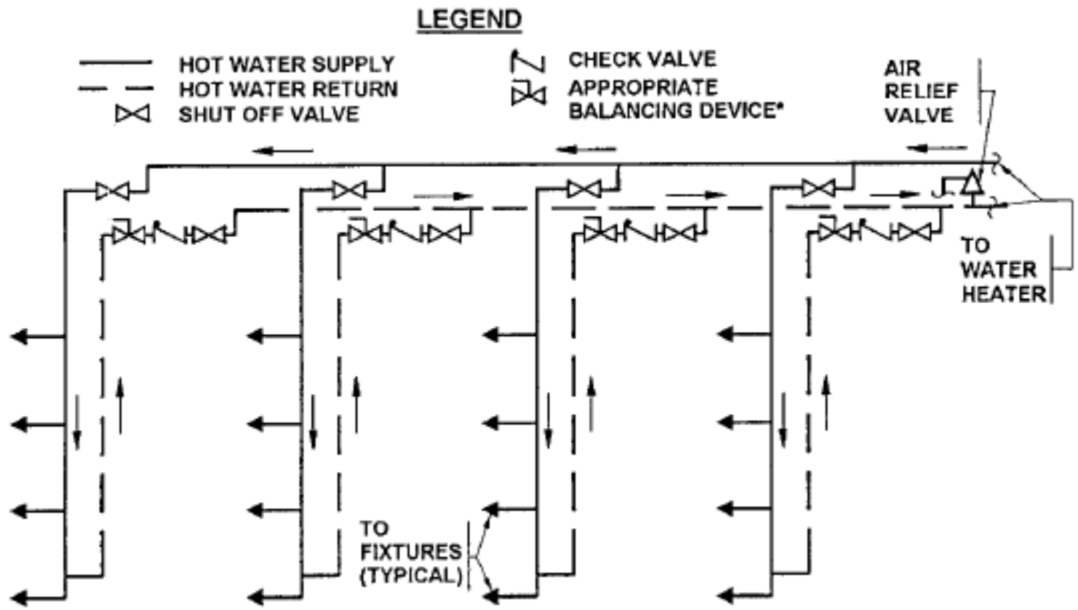


Figure 14.4 Downfeed Hot Water System with Heater at Top of System.

* See text for requirements for strainers.

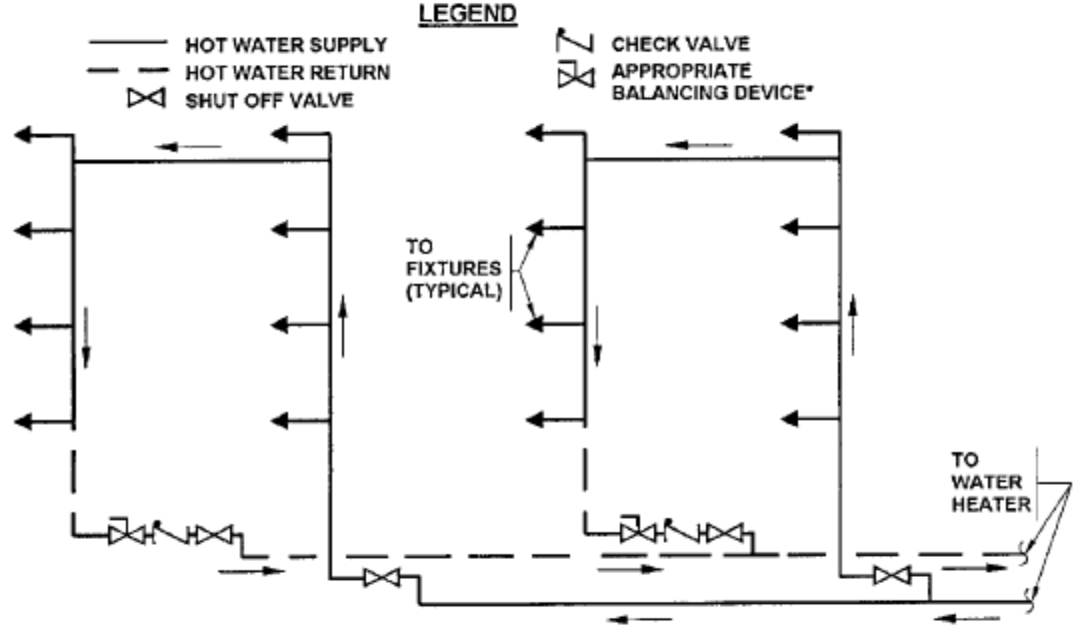


Figure 14.5 Combination Upfeed and Downfeed Hot Water System with Heater at Bottom of System.

Note: This piping system increases the developed length of the HW system over the upfeed systems shown in Figures 14.1 and 14.3.

* See text for requirements for strainers.

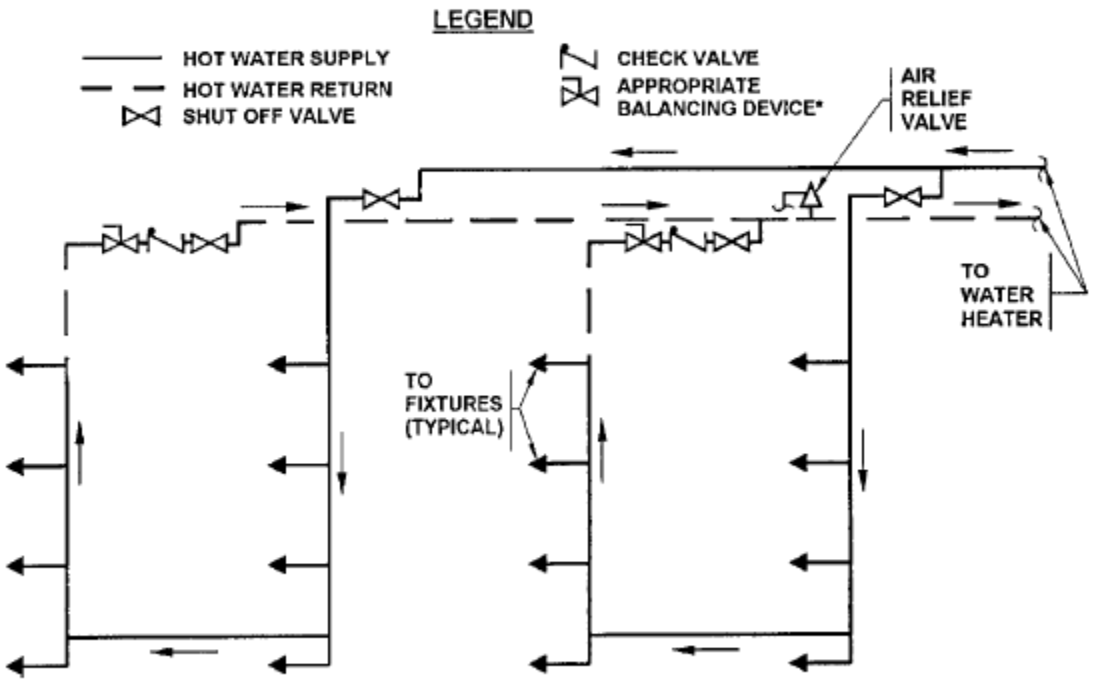


Figure 14.6 Combination Downfeed and Upfeed Hot Water System with Heater at Top of System.

Note: This piping system increases the developed length of the HW system over the downfeed systems shown in Figures 14.2 and 14.4.

* See text for requirements for strainers.

Sizing Hot Water Return Piping Systems and Recirculation Pumps

- Design the hot water supply and return piping systems based on the parameters for total developed length, prompt delivery of hot water to fixtures, and velocities in the piping.
- **Hot water return pipe sizes will be assumed because the return water flow rates are not known.**
- Create a diagram of the hot water supply system and assumed hot water return system showing pipe sizes and approximate length.
- Determine the hourly heat loss from the circulated piping. To do this, determine the heat loss per foot of pipe based on the minimum required insulation thickness from Table 14.5, and multiply the heat loss per foot by the length of pipe for each pipe size.

Sizing Hot Water Return Piping Systems and Recirculation Pumps (cont'd)

- Determine the heat loss from the hot water storage tank from Table 14.6 if a separate tank is provided. Not that this step is required only if the storage tank is separate from the water heater.
- Calculate the total heat loss for the piping and for the storage tank. This is the "system heat loss" that should be applied to Equation 14.2 to calculate the recirculation water flow requirement.

$$(14.2) \quad \text{gpm} \approx \frac{\text{system heat loss (Btu/h)}}{500 \times {}^{\circ}\text{F temperature drop}}$$

TABLE 6.8.3 Minimum Pipe Insulation Thickness[a]

Fluid Design Operating Temp. Range (°F)	Insulation Conductivity		Nominal Pipe or Tube Size (in.)				
	Conductivity Btu·in./(h·ft²·°F)	Mean Rating Temp. °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
Heating Systems (Steam, Steam Condensate, and Hot Water)[b,c]							
>350	0.32 – 0.34	250	2.5	3.0	3.0	4.0	4.0
251 – 350	0.29 – 0.32	200	1.5	2.5	3.0	3.0	3.0
201 – 250	0.27 – 0.30	150	1.5	1.5	2.0	2.0	2.0
141 – 200	0.25 – 0.29	125	1.0	1.0	1.0	1.5	1.5
105 – 140	0.22 – 0.28	100	0.5	0.5	1.0	1.0	1.0
Domestic and Service Hot-Water Systems							
105+	0.22 – 0.28	100	0.5	0.5	1.0	1.0	1.0
Cooling Systems (Chilled Water, Brine, and Refrigerant)[d]							
40 – 60	0.22 – 0.28	100	0.5	0.5	1.0	1.0	1.0
<40	0.22 – 0.28	100	0.5	1.0	1.0	1.0	1.5

[a] For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:
$T = r\{(1 + t/r)^{K/k} - 1\}$
where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu·in.[h·ft²·°F]); and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

[b] These thicknesses are based on energy *efficiency* considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

[c] Piping insulation is not required between the control valve and coil on run-outs when the control valve is located within 4 ft of the coil and the pipe size is 1 in. or less.

[d] These thicknesses are based on energy *efficiency* considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

ASHRAE 90.1 - 2007

Table 14.5 Approximate Insulated Piping Heat Loss and Surface Temperature

Table 14.5 Approximate Insulated Piping Heat Loss and Surface Temperature

Nominal Pipe Size (in.)	Insulation Thickness (in.)	Heat Loss (Btu/h/ linear ft)	Surface Temperature (°F)
½	1	8	68
¾	1	10	69
1	1	10	69
1¼	1	13	70
1½	1	13	69
2 or less	½[a]	24 or less	74
2	1	16	70
2½	1½	12	67
3	1½	16	68
4	1½	19	69
6	1½	27	69
8	1½	32	69
10	1½	38	69

Note: Figures based on average ambient temperature of 65°F and annual average wind speed of 7.5 mph.

[a]Uncirculating hot water runout branches only.

Table 14.6 Heat Loss from Various Size Tanks with Various Insulation Thicknesses

Table 14.6 Heat Loss from Various Size Tanks with Various Insulation Thicknesses

Insulation Thickness (in.)	Tank Size (gal)	Approx. Energy Loss from Tank at Hot Water Temperature 140°F (Btu/h)[a]
1	50	468
1	100	736
2	250	759
3	500	759
3	1000	1273

Source: From Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Table 2 data.

[a]For unfired tanks, federal standards limit the loss to no more than 6.5 Btu/h/ft^2 of tank surface.

Sizing Hot Water Return Piping Systems and Recirculation Pumps (cont'd)

- As the temperature drop across the recirculation system in increased, the required recirculation water flow rate will decrease. However, the supply water temperature at the most remote fixtures will also decrease accordingly. The hot water temperature in the storage tank can be maintained at a higher temperature to offset the temperature loss, but this will result in increased energy losses. *"The recommended hot water system temperature drop is in the magnitude of 5 degrees F."*
- Calculate the proper hot water return pipe sizes based on the calculated flow rates, and verify the previously assumed sizes. Also verify the return piping heat loss.

DOMESTIC HOT WATER CIRCULATION SYSTEM DESIGN SCHEMATIC

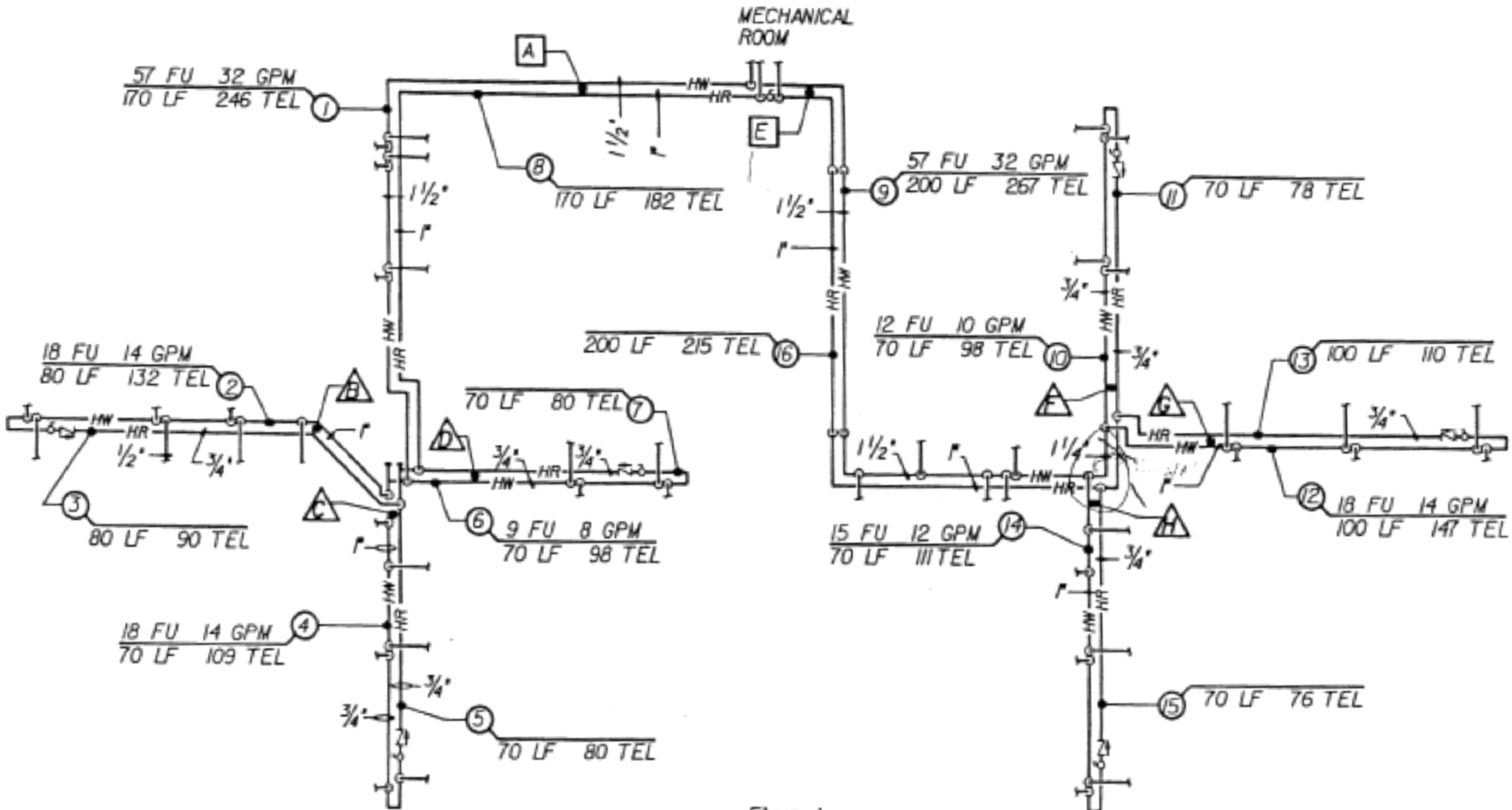


Figure I

Legend of Symbols / Abbreviations

A	MAIN MARK	LF	LINEAL FEET	FU	SUPPLY FIXTURE UNITS
G (triangle)	LOOP MARK	TEL	EQUIVALENT LINEAL FEET (TOTAL FOR FITTINGS + STRAIGHT RUN)	GPM	GALLONS PER MINUTE HOT WATER DEMAND
3 (circle)	PIPE SECTION MARK				

PROJECT: ______________________ DATE: __________
PROJECT NO: ______________________ DESIGN PHASE: __________
LOCATION: ______________________ BY: __________

HOT WATER RECIRCULATING PUMP CALCULATIONS

Heat Loss of Pipe [At 70° F Temperature Difference]			
Equivalent Length of Pipe	Pipe Size In.	0.5 -in. Glass Fiber Insulated Copper Tubing Btu/h ft	Heat Loss Btu/h ft
0	1/2	18.20	0.00
0	3/4	21.60	0.00
0	1	23.00	0.00
0	1 1/4	20.70	0.00
0	1 1/2	23.50	0.00
0	2	26.80	0.00
0	2 1/2	33.90	0.00
0	3	35.80	0.00
0	4	42.90	0.00
0	6	47.00	0.00
			0.00 **Total Heat Loss Btu/h Ft**

PUMP CAPACITY

HEAT LOSS (Btu/h) 0.00 btuh

Weight of Water / GAL 8.33 lbs

TIME in MINUTES: 60 min

ALLOWABLE TEMP DROP: 10 °F

Capacity of Recirc. Pump: **0.00** GPM

Number of Recirculation Loops: ______

Quantity of Balancing Valves*: ______

* Typically you need a minimum of 1.0 gpm per balancing valve in order to be able to accurately set the flow rate across the valve.

Example to Determine Required Circulation Flow Rate

EXAMPLE 14.1—CALCULATION TO DETERMINE REQUIRED CIRCULATION RATE

1. Assume that the hot water supply piping system has 800 ft (244 m) of average size 1 ¼ in. (DN32) pipe. From Table 14.5, determine the heat loss per linear foot (meter). To find the total heat loss, multiply length times heat loss per foot (meter):

   800 ft × 13 Btu/h/ft = 10,400 Btu/h supply piping losses

   (244 m • 12.5 W = 3050 W supply piping losses)

2. Assume that the hot water return piping system for the system in no. 1 above has 100 ft (30.5 m) of average ½ in. (DN15) piping and 100 ft (30.5 m) of average ¾ in. (DN20) pipe. From Table 14.5 determine the heat loss per linear foot (meter):

   100 ft × 8 Btu/h/ft = 800 Btu/h piping loss

   100 ft × 10 Btu/h/ft = 1000 Btu/h piping loss

   1800 Btu/h piping loss

Example to Determine Required Circulation Flow Rate

3. Determine the hot water storage tank heat loss. Assume the system in no. 1 above has a 200-gal (757-L) hot water storage tank. From Table 14.6 determine the heat loss of the storage tank @ 759 Btu/h (222 W).

4. Determine the hot water system's total heat losses by totaling the various losses:

A.	Hot water supply piping losses	10,400 Btu/h
B.	Hot water return piping losses	1,800 Btu/h
C.	Hot water storage tank losses	759 Btu/h
	Total system heat losses	12,959 Btu/h

Total system piping heat losses (A + B) = 12,200 Btu/h

From Equation 14.2, using a system piping loss of 12,200 Btu/h (3577 W) and a 5°F (3°C) temperature drop,

$$\frac{12{,}200 \text{ Btu/h}}{5°\text{F temperature difference} \times 500} = 4.88 \text{ gpm (say 5 gpm)}$$

required hot water return circulation rate

Example to Determine Required Circulation Flow Rate

- Note that the 5 GPM recirculation flow rate in the ¾ inch Type L copper return main has an average velocity of 3.4 feet per second which exceeds the maximum velocity criteria of 3 feet per second in piping 1 inch and smaller. Therefore, the return pipe sizing has to be increased and the losses and flow rates must be recalculated.

1. The supply pipe heat loss remains unchanged at 10,400 Btu/h
2. Assume the hot water return piping has 100 feet of average ½ inch pipe, 25 feet of average ¾ inch pipe and 75 feet of average 1 inch pipe.

$$
\begin{aligned}
100\text{ ft} \times 8\text{ Btu/h/ft} &= 800\text{ Btu/h piping loss}\\
25\text{ ft} \times 10\text{ Btu/h/ft} &= 250\text{ Btu/h piping loss}\\
75\text{ ft} \times 10\text{ Btu/h/ft} &= \underline{\ \ 750}\text{ Btu/h piping loss}\\
&\ 1800\text{ Btu/h piping loss}
\end{aligned}
$$

Example of Calculation to Determine Required Circulation Flow Rate

1. The storage tank heat loss remains unchanged at 759 Btu/h

4. Calculate the total system heat loss by summing the results from steps 1., 2., and 3:

A.	Hot water supply losses	10,400 Btu/h
B.	Hot water return losses	1,800 Btu/h
C.	Hot water storage tank losses	759 Btu/h
	Total system heat losses	12,959 Btu/h

5. The req… GPM.

- The recalculation determined that the hot water system heat loss and the 5 gpm recirculation flow rate remained unchanged. However, the velocity in the 1 inch return main is approximately 2.4 feet per second which meets the aforementioned maximum velocity limits.

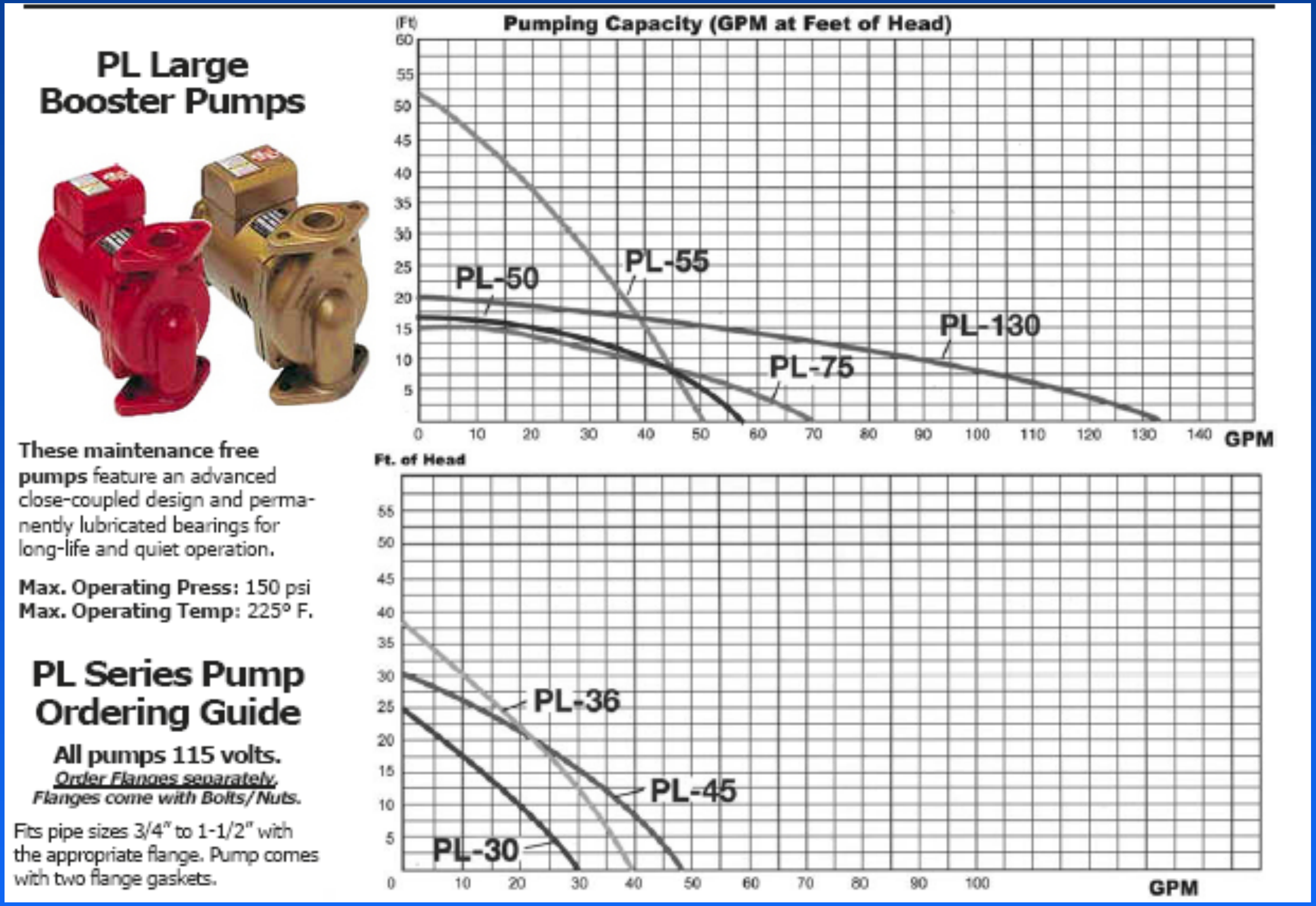
Establishing the Head Capacity of the Hot Water Circulating Pump

- The hot water circulating pump capacity selection is based on:
  - The hot water recirculation flow rate calculated from Equation 14.2
  - The friction loss through the hot water return circuits and the associated valves (including the thermostatic mixing valve which can be significant)
    - The friction loss through supply piping is generally negligible and is ignored unless the hot water supply pipe is less than one pipe size larger than the return pipe. In this situation, it is recommended that the size of the hot water supply pipe be increased one pipe size.
    - When there is no water being drawn from fixtures, the hot water recirculation system is a closed system. Therefore, no static heads should be included in the pump head calculation.

Hot Water Circulating Pumps

- Hot water circulating pumps are generally centrifugal type and either in-line for small systems or base mounted for larger systems.
- Pumps should be all bronze, brass or stainless steel. There are bronze fitted pumps that can also be used.
  - Cast iron pumps will deteriorate rapidly in a domestic hot water system!
- Care should be taken when considering the pump to be used in a hot water recirculation system. *A pump that has a curve matched to the system requirements is necessary.*

Pump Curves


PL Large Booster Pumps
These maintenance free pumps feature an advanced close-coupled design and permanently lubricated bearings for long-life and quiet operation.
Max. Operating Press: 150 psi
Max. Operating Temp: 225° F.
PL Series Pump Ordering Guide
All pumps 115 volts.
Order Flanges separately.
Flanges come with Bolts/Nuts.
Fits pipe sizes 3/4" to 1-1/2" with the appropriate flange. Pump comes with two flange gaskets.
Pumping Capacity (GPM at Feet of Head)
(Ft)
60
55
50
45
40
35
30
25
20
15
10
5
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
GPM
PL-50
PL-55
PL-75
PL-130
Ft. of Head
PL-36
PL-45
PL-30

Service Water Heating System Controls

7.4.4 Service Water Heating System Controls

7.4.4.1 Temperature Controls. Temperature controls shall be provided that allow for storage temperature adjustment from 120°F or lower to a maximum temperature compatible with the intended use.

Exception: When the *manufacturers'* installation instructions specify a higher minimum thermostat setting to minimize condensation and resulting corrosion.

7.4.4.2 Temperature Maintenance Controls. Systems designed to maintain usage temperatures in hot-water pipes, such as recirculating hot-water systems or heat trace, shall be equipped with automatic time switches or other controls that can be set to switch off the usage temperature maintenance system during extended periods when hot water is not required.

7.4.4.3 Outlet Temperature Controls. Temperature controlling means shall be provided to limit the maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110°F.

7.4.4.4 Circulating Pump Controls. When used to maintain storage tank water temperature, recirculating pumps shall be equipped with controls limiting operation to a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle.

ASHRAE 90.1 - 2007

Controls for Hot Water Recirculating Pumps

- There are three primary methods for controlling hot water circulating pumps:
  - Manual Switching
    - Should only be used when hot water is needed all the time (24 hours per day), or during all the periods of a building’s operation.
  - Thermostat (aquastat)
    - An aquastat is a device inserted or strapped to the hot water piping to sense the temperature and activate the pump when the water temperature drops below a preset value.
  - Time clock
    - Activates the pump during specific hours plumbing fixtures would be used.
  - Time clock and aquastat can be used together so that the pump cycles from the aquastat while the building is occupied and is completely de-energized while the building is unoccupied.

7.8 Product Information

TABLE 7.8 Performance Requirements for Water Heating Equipment

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required [a]	Test Procedure [b]
Electric water heaters	≤12 kW	Resistance ≥20 gal	0.93–0.00132V EF	DOE 10 CFR Part 430
	>12 kW	Resistance ≥20 gal	$20 + 35\sqrt{V}$ SL, Btu/h	ANSI Z21.10.3
	≤24 Amps and ≤250 Volts	Heat Pump	0.93–0.00132V EF	DOE 10 CFR Part 430
Gas storage water heaters	≤75,000 Btu/h	≥20 gal	0.62–0.0019V EF	DOE 10 CFR Part 430
	>75,000 Btu/h	<4000 (Btu/h)/gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	ANSI Z21.10.3
Gas instantaneous water heaters	>50,000 Btu/h and <200,000 Btu/h	≥4000 (Btu/h)/gal and <2 gal	0.62–0.0019V EF	DOE 10 CFR Part 430
	≥200,000 Btu/h [c]	≥4000 (Btu/h)/gal and <10 gal	80% E_t	ANSI Z21.10.3
	≥200,000 Btu/h	≥4000 (Btu/h)/gal and ≥10 gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	

between stored water and ambient requirements. In the EF equation, V is the rated volume in gallons. In the SL equation, V is the rated volume in gallons and Q is the nameplate input rate in Btu/h.

[b] Section 12 contains a complete specification, including the year version, of the referenced test procedure.

[c] Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures of 180°F or higher.

ASHRAE 90.1 - 2007

TABLE 6.8.3 Minimum Pipe Insulation Thickness[a]

Fluid Design Operating Temp. Range (°F)	Insulation Conductivity		Nominal Pipe or Tube Size (in.)				
	Conductivity Btu·in./(h·ft²·°F)	Mean Rating Temp. °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
Heating Systems (Steam, Steam Condensate, and Hot Water)[b,c]							
>350	0.32 – 0.34	250	2.5	3.0	3.0	4.0	4.0
251 – 350	0.29 – 0.32	200	1.5	2.5	3.0	3.0	3.0
201 – 250	0.27 – 0.30	150	1.5	1.5	2.0	2.0	2.0
141 – 200	0.25 – 0.29	125	1.0	1.0	1.0	1.5	1.5
105 – 140	0.22 – 0.28	100	0.5	0.5	1.0	1.0	1.0
Domestic and Service Hot-Water Systems							
105+	0.22 – 0.28	100	0.5	0.5	1.0	1.0	1.0
Cooling Systems (Chilled Water, Brine, and Refrigerant)[d]							
40 – 60	0.22 – 0.28	100	0.5	0.5	1.0	1.0	1.0
<40	0.22 – 0.28	100	0.5	1.0	1.0	1.0	1.5

[a] For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$T = r\{(1 + t/r)^{K/k} - 1\}$

where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu·in.[h·ft²·°F]); and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

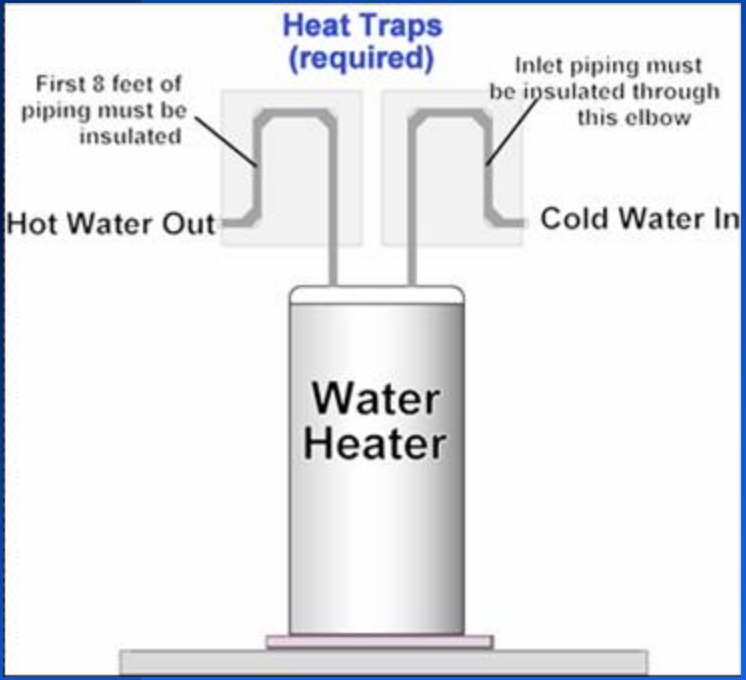
[b] These thicknesses are based on energy *efficiency* considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

[c] Piping insulation is not required between the control valve and coil on run-outs when the control valve is located within 4 ft of the coil and the pipe size is 1 in. or less.

[d] These thicknesses are based on energy *efficiency* considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

ASHRAE 90.1 - 2007

Heat Traps

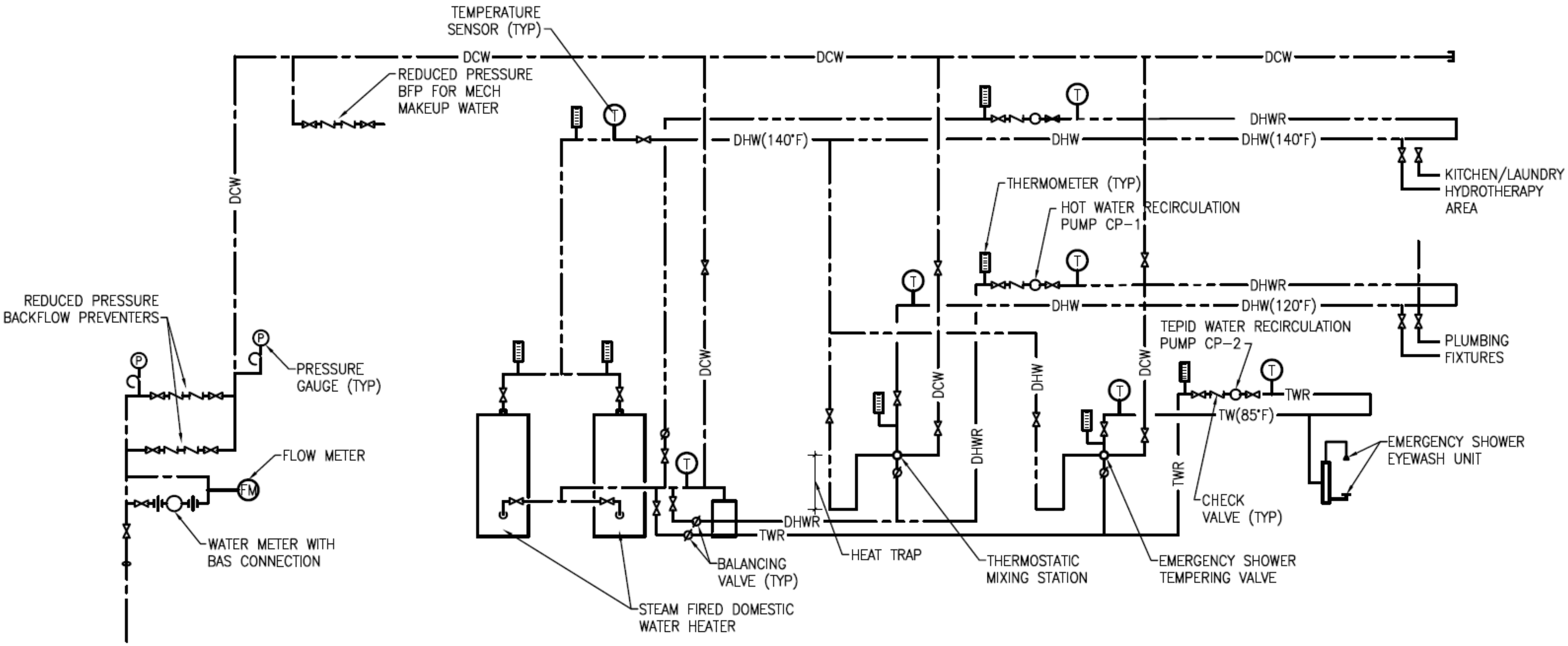


7.4.6 Heat Traps. Vertical pipe risers serving storage water heaters and storage tanks not having integral heat traps and serving a nonrecirculating system shall have heat traps on both the inlet and outlet piping as close as practical to the storage tank. A heat trap is a means to counteract the natural convection of heated water in a vertical pipe run. The means is either a device specifically designed for the purpose or an arrangement of tubing that forms a loop of 360 degrees or piping that from the point of connection to the water heater (inlet or outlet) includes a length of piping directed downward before connection to the vertical piping of the supply water or hot-water distribution system, as applicable.

ASHRAE 90.1 - 2007

Air Elimination

- Provisions must be made for elimination of air from high points of the hot water return piping.
  - Air is buoyant, and typically water flow velocities less than 2 feet per second will not carry the air through the piping system.
  - Air collecting at high points in the hot water return system will eventually block the flow of hot water.
  - Air vents must be accessible.
- Air vents are not required in the hot water supply piping because the discharge of hot water from the fixtures will eliminate the entrapped air.



TEMPERATURE SENSOR (TYP)
DCW
DCW
DCW
REDUCED PRESSURE BFP FOR MECH MAKEUP WATER
DHWR
DHW(140°F)
DHW
DHW(140°F)
KITCHEN/LAUNDRY HYDROTHERAPY AREA
THERMOMETER (TYP)
HOT WATER RECIRCULATION PUMP CP-1
DHWR
DHW
DHW(120°F)
PLUMBING FIXTURES
TEPID WATER RECIRCULATION PUMP CP-2
TWR
TW(85°F)
EMERGENCY SHOWER EYEWASH UNIT
REDUCED PRESSURE BACKFLOW PREVENTERS
PRESSURE GAUGE (TYP)
FLOW METER
FM
WATER METER WITH BAS CONNECTION
DHWR
TWR
BALANCING VALVE (TYP)
HEAT TRAP
THERMOSTATIC MIXING STATION
EMERGENCY SHOWER TEMPERING VALVE
CHECK VALVE (TYP)
STEAM FIRED DOMESTIC WATER HEATER

ASHRAE 90.1

- What else does the Energy code say about hot water systems and how does that impact our design?

Required pre-heating?

6.5.6.2 (ASHRAE 90.1 2004)

- Requires Condenser Heat Recovery for Service Water Heating when all of the following are true:
  - 24 hr / day operation
  - Heat rejection of 6,000,000 Btu/h of heat rejection
    (about 400 ton electric or 250-330 tons of gas or heat absorption)
  - Design water heating load > 1,000,000 Btu/h

- Typical applications:
  - Hotels
  - Dormitories
  - Mixed-use retail/residential projects
  - Commercial kitchens
  - Institutions (prisons and hospitals)

- Condenser heat recovery required to provide the smaller of either:
  - 60% of peak heat rejection load

  Or
  - Preheat Peak service hot water to 85°F (29.4°C)

Required pre-heating

6.5.6.2 Exceptions (ASHRAE 90.1 2004)

- Requires Condenser Heat Recovery for Service Water Heating when all of the following are true:
  - 24 hr / day operation
  - Heat rejection of 6,000,000 Btu/h of heat rejection
    (about 400 ton electric or 250-330 tons of gas or heat absorption)
  - Design water heating load > 1,000,000 Btu/h

- Exceptions:
  - a) Facilities that employ condenser heat recovery for space heating with a heat recovery design exceeding 30% of the peak water cooled condenser load at design conditions
  - b) Facilities that provide 60% of their service water heating from site solar or site recovered energy or from other sources (engine jacket heat for instance)

Scalding

Water Temperature Effects on Adult Epidermis[1]

Temperature (F)	***First Degree*** *No Irreverible Damage*	***Second Degree*** *Full Thickness Injury*
111	**4.5 Hours**	**5 Hours**
113	**2.0 Hours**	**3 Hours**
116.6	**20 Minutes**	**45 Minutes**
118.4	**15 Minutes**	**20 Minutes**
120	**8 Minutes**	**10 Minutes**
124	**2 Minutes**	**4.2 Minutes**
125.6	**45 Seconds**	**1.5 Minutes**
127.4	**30 Seconds**	**60 Seconds**
131	**17 Seconds**	**30 Seconds**
140	**3 Seconds**	**5 Seconds**
151	**-------**	**2 Seconds**
158	**------**	**1 Second**

[1] *JCAH Hot Water Temperature Standard* (Chicago: American Society of Hospital Engineers, February, 1982) Technical Document No.:14:2-82

Legionella Pneumophila

Legionella Pneumophila, also known as Legionnaires' Disease, is a respiratory illness that can be fatal.

The bacteria that can cause Legionnaires' Disease are widespread in natural sources of water. In warm water, the bacteria can grow and multiply to high concentrations. Drinking water containing the Legionella bacteria has no known effects.

Legionella Pneumophila

However, inhalation of the bacteria into the lungs, i.e. during showers, can cause Legionnaires Disease.

It is incumbent upon designers to familiarize themselves with the latest information on the subject and to take this data into account when designing their systems.

Legionella Pneumophila

- Careful consideration should be given to the temperature the water in the heater is heated to.
- ASPE recommends heating the water to 140 degrees F. as does ASHRAE and others.

Relief Valves

Pressure and Temperature Relief Valves are different and have different applications.

Combination temperature/pressure relief valves are available and are generally used in domestic systems.

It is recommended the designer research the various relief valves, ratings and their applications.

Relief Valves

Location of relief valves:

Since heat rises, the hottest water in the water heater will be at the top of the tank. The relief valve should be located where the hottest water will be.

Due to temperature lag (under no flow conditions), the relief valve must be located in the uppermost 6 inches of the tank. (Temperature lag is the decrease in temperature in the piping leaving the tank).

Relief Valves

Pressure and Temperature Relief Valves also rated by different methods and usually have multiple ratings listed on the valve. The various listing agencies, AGA, ANSI, ASME, NBBPVI, have ratings which are on each relief valve.

Depending on the listing agency, the criteria for the relieving characteristics changes.

Relief Valves:

- And certainly cannot be plugged for any reason…

Thermal Expansion

As water is heated, it expands and thus increases its volume. If this extra volume of water is not compensated for the pressure in the entire hot water system increases.

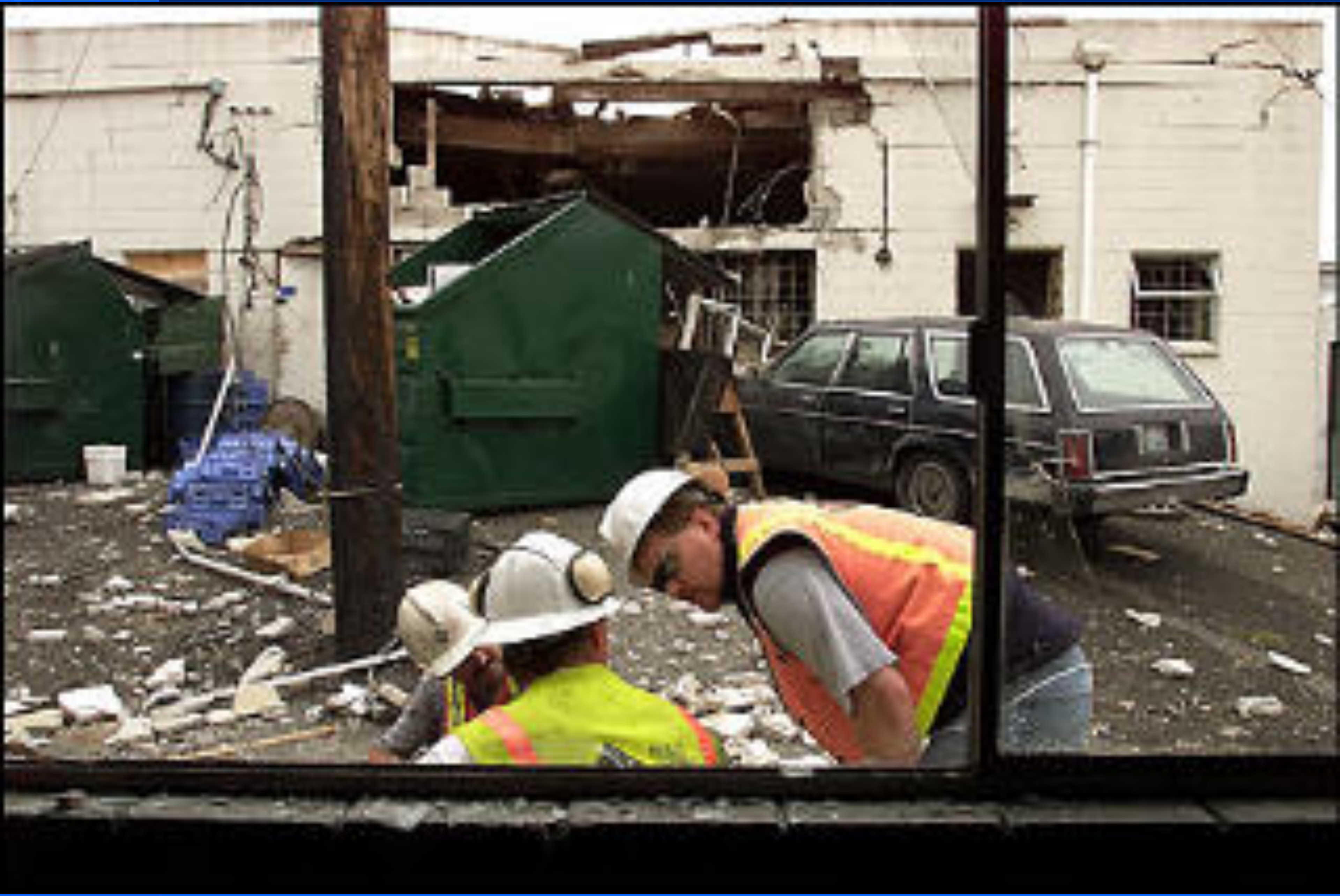
This is complicated by the addition of a check valve, backflow prevention device, pressure reducing valve or even a water softener ahead of the water heater.

12 Gallons, 4500 Watt Heater (www.serviceroundtable.com)

Proof…..

SERVICE ROUNDTABLE

www.ServiceRoundtable.com



Thermal Expansion

One method to compensate for the expansion of hot water is the installation of a thermal expansion tank.

The increase in volume can be calculated by multiplying the water heater tank volume by an expansion factor. The expansion factor will change depending on the change in temperature of the water.

Thermal Expansion

For example: A temperature change from 40EF to 140EF will increase the volume of the water heater by 0.0150 gallons per gallon of capacity.

500 gallons (0.0150) = 7.5 gallons of expanded water volume.

If this expansion in the volume of water is not compensated for, the pressure in the system will increase.

Storage and Recovery

The design of a domestic water heating system begins with estimating the facility's load profile and identifying the peak demand times.
To accomplish these steps, the designer must conduct discussions with the users of the space, determine the building type, and learn of any owner requirements. The information thus gathered will establish the required capacity of the water heating equipment and the general type of system to be used.

Storage and Recovery

There is a relationship between storage and recovery. The recovery rate of the heater can be reduced if the amount of hot water in storage is increased.

Once the recovery rate of the heater is determined, the amount of storage required to keep up with the instantaneous demand for hot water should be reviewed.

Determining the exact relationship will depend on the building type being designed.

Selection of Equipment

Gas fired equipment and its operating temperature shall be selected to assure the operating temperature of the heater will not be less than the dewpoint temperature of the flue gas to avoid condensation.

In other words, the inlet temperature to certain types of gas fired water heaters and the final temperature of the heated water must checked with the manufacturer in order to verify the design parameters of the water heater have not been exceeded.

Stratification

Stratification is the fraction of usable stored water in the warm water layer that is formed by the natural tendency of the warmer water to rise to the top and occurs in all uncirculated tanks. It has been found that the amount of usable water in stratified horizontal and vertical tanks is about 65% and 75%, respectively.

75% Usable Water

65% Usable Water

Stratification, cont'd

Stratification during recovery periods can be reduced significantly by mechanical circulation of the water in the tank.

During periods of demand, however, it is useful to have good stratification since this increases the availability of water at a usable temperature.

Stratification, cont'd

For Example:

If a tank were equally stratified between 140EF at the top and 40EF at the bottom, this tank, in theory, could still deliver half its volume at 140EF. But, if the two layers were completely mixed, the tank temperature would drop to 90EF, which, in most cases, is an unusable temperature.

One way to encourage stratification in tanks is by limiting the velocity of water entering the tank.

Codes and Standards

Some of the most often used codes and standards are:

Regional, State and Local plumbing codes
ASHRAE/IES 90.1
ASME code for fired and unfired pressure vessels
ASME and AGA codes for relief valves
UL listing for electrical components
NSF listing
AGA approval for gas burning components
NFPA Standards
NEC - National Electrical Code

Chapter 2: Multi-Family Dwellings

- Introduction
- Background
  - Weekday Vs. Weekend Demand Patterns
  - Seasonal Demand Patterns
  - Demand Flow Patterns
- Identification of Demand
- Demand Determination
- Application of LMH Values
- Peak Demand Vs. Average Demand
  - Potential of Generating Storage
  - Time of Day Peak Flows
  - Peak Demand and Average Demand
- Retrofit to Existing Systems (Customized Sizing)
- Examples
- Possible Traps
- References

Multifamily Buildings

In order to properly design a domestic hot water system for multifamily buildings it is useful to understand the consumption and demand patterns of this type of occupancy.

Weekday Vs. Weekend Demand Patterns:

The weekday Vs. weekend comparison of domestic hot water in gallons consumed in buildings reveals that there are generally a slightly higher total consumption and a greater peak demand on weekends (Saturday and Sunday) than on weekdays (Monday through Friday). The average weekend day consumption is 7.5% greater than the average weekday level.

Multifamily Buildings

Seasonal Demand Patterns:

Multifamily buildings have distinct seasonal variations in domestic hot water demand levels. Figure 2.2 indicates the hot water demand is greater in winter than any other season. The obvious explanation being that people take warmer showers in the winter and cooler showers in the summer, particularly in colder climates.

The variance can account for as much as 45% reduction in demand from winter to summer.

Multifamily Buildings

Demand Flow Patterns:

There is a distinct difference between weekday and weekend demand patterns. Weekdays have minimal overnight usage, then a morning peak, followed by lower afternoon demand and then an evening or nighttime peak. Weekend days have just one major peak, which begins later in the morning and continues until around 1:00 to 2:00 P.M. Usage then tapers off for the rest of the day.

Examination of the composite weekday and weekend graphs (Figure 2.1) illustrates that the weekend day peak is greater than any of the weekday peaks.

Multifamily Buildings

Identification of Demand:

The first step in calculating the demand is to determine the demographic profile of the project and building occupants.

Different types of building occupants have been found to have fairly predictable patterns of hot water consumption. Users can be divided into three categories - "low," "medium," and "high volume" (LMH) water consumers as a function of the building occupant demographics.

Multifamily Buildings

Table 2.1 Occupant Demographic Classifications

No occupants work	
Public assistance and low income (mix)	**High**
Family and single-parent households (mix)	**Demand**
High number of children	
Low income	
Families	
Public assistance	***Medium***
Singles	***Demand***
Single-parent households	
Couples	
High population density	
Middle income	**Low**
Seniors	**Demand**
One person works, 1 stays home	
All occupants work	

Multifamily Buildings

Table 2.2 Low, Medium, and High Guidelines:
Hot Water Demands and Use for Multifamily Buildings

	Peak 5 Min, gal/person	Peak 15 Min, gal/person	Peak 30 Min, gal/person	Maximum H, gal/person
Low	0.4	1.0	1.7	2.8
Medium	0.7	1.7	2.9	4.8
High	1.2	3.0	5.1	8.5

	Maximum 2 H, gal/person	Maximum 3 H, gal/person	Maximum Day, gal/person	Average Day, gal/person
Low	4.5	6.1	20.0	14.0
Medium	8.0	11.0	49.0	30.0
High	14.5	19.0	90.0	54.0

Note: The figures represented are for centrally fired systems.

Multifamily Buildings

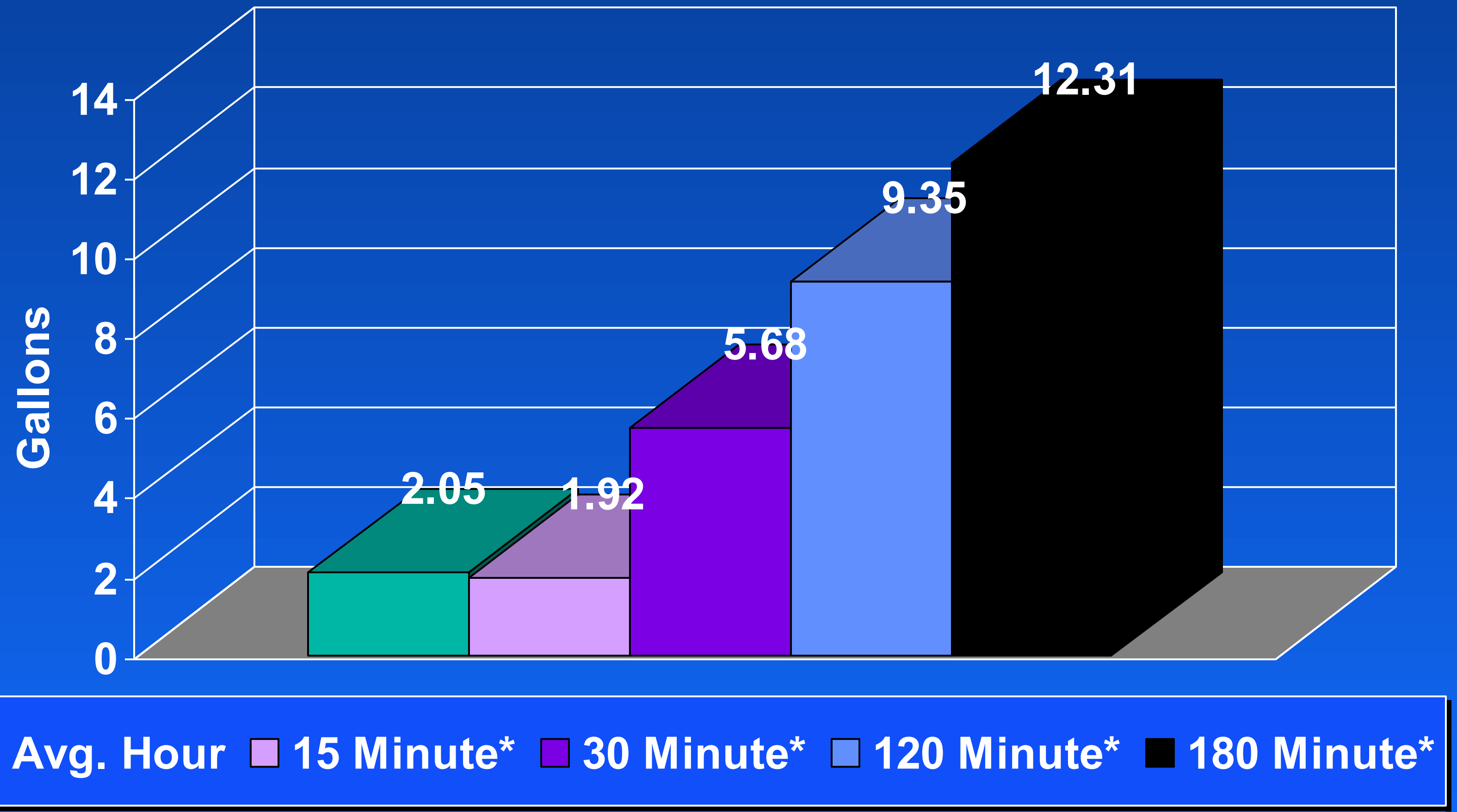
Application of LMH Values:

Once a portion of the range has been selected, the figures should be converted into per apartment or building gallonage by multiplying them with the maximum potential occupancy levels, based on persons per apartment size/type.

For example, studios = 2 persons, 1-bedroom apartments = 3 persons and 2-bedroom apartments = 3-5 persons.

Multifamily Buildings

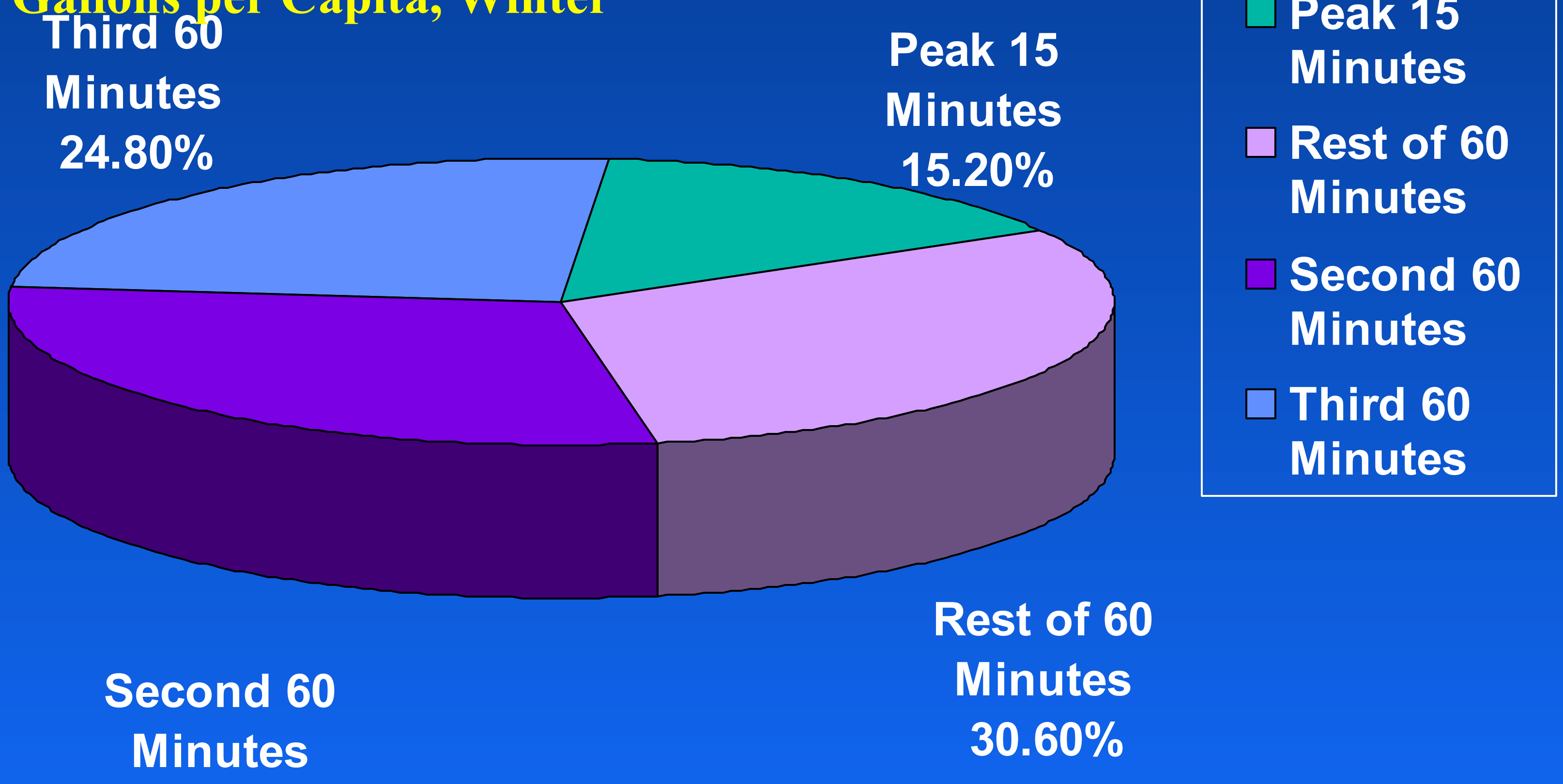
Figure 2.5: Comparison of Peak Consumption, Gallons per Capita, Winter



* Maximums

Multifamily Buildings

Figure 2.6: Parts of 3 hour Peak Consumption, Gallons per Capita, Winter



Note: The peak 60 minutes equals 45.8% of the peak consumption.

Multifamily Buildings

Recent research reveals that the most cost-effective designs for multifamily buildings are based on either the “30/3 guideline” (systems with generators and storage tanks) or the 5-minute peak demand (instantaneous systems).

According to the 30/3 guideline, generator size is based on the peak 30 minute demand and storage tank volume is based on the maximum 3-hour demand. The research indicates that selection of either an instantaneous hot water heater or a separate boiler and unfired storage tank configuration will produce the optimum mix of low life cycle costs and high energy efficiencies.

Multifamily Buildings

Examples:

Apartment Size:	Number of Apartments		Occupancy Per Apt.		Total Persons
3-Bedroom	4	x	5	=	20
2-Bedroom	14	x	4	=	56
1-Bedroom	25	x	3.5	=	87.5
Studio	15	x	2.25	=	33.75
			Total persons:		197.25

LMH Usage Factor From Table 2.2

LMH Factor	Number of People		Demand Factor (gpd)		System Load (gal/day)
Medium	198	x	30	=	5940

Instantaneous System:

LMH Factor	Peak No. of People		Demand Peak 5 Min.		Number of Periods per Hour		Recovery GPH	Recovery GPM
Medium	198	x	0.7	x	12	=	1663	27.72

Multifamily Buildings

Examples:

Btuh Conversion

Recovery GPH		Weight of Water		Temperature Rise (degrees F)	Efficiency Percentage		Heater Input (btuh)
1663	x	8.33	x	90	0.8	=	1558626

Storage System:

Heater Recovery:

LMH Factor	Peak No. of People		Demand Peak 30 Min.		Number of Periods per Hour		Recovery GPH
Medium	198	x	2.9	x	2	=	1148

Storage Tank Sizing:

LMH Factor	Peak No. of People		Demand Max. 3 Hr.		Recovery GPH
Medium	198	x	11	x	2178

Chapter 3: **Dormitories**

- Introduction
- Student Dormitories
- Example 3.1
- Assumptions
- Calculations
- Conclusions
- Institutional Dormitories
- Example 3.2
- Assumptions
- Calculations
- Conclusions

Dormitories

- There are two basic types of buildings classified as dormitories. Student dormitories that have non-structured hot water use and Institutional dormitories that have a structured water use.

Dormitories

- Student Dormitories
  - Peak demand is more spread out.
  - Students tend to create their own schedules.
  - Additional loads could be anticipated.
    - Laundries
    - Kitchens or kitchenettes

Dormitories

- Institutional dormitories
  - Hot water loads are based on shower and lavatory use occurring in a short period of time.
  - Specialized areas such as laundries and kitchens usually have their own water heaters as they may be located in another area or building.
  - Check with the Owner, they may have their own requirements for hot water demand.

Chapter 4: Elementary and Secondary Schools

- Introduction
- Types of School
- Information Gathering
- Kitchen and Food Service
- Showers
- School Population
- Calculating The Hot Water Demand
- General Purpose Demand
- Kitchen Demand
- Shower Load
- Examples
- General Considerations
- References

Elementary & Secondary Schools

It is very important to know what type of school you are designing. Knowing the type of school can lead you to what hot water loads you can expect in the school.

Table 3.1 School Grade Divisions:

Grade Levels												
K	1	2	3	4	5	6	7	8	9	10	11	12
	Elementary					Junior High				Senior High		
	Elementary				Middle School					Senior High		
	Elementary					Junior High			Senior High			
	Elementary								Senior High			

Elementary & Secondary Schools

Table 3.2 Potential Areas of Hot Water Usage:

Area	*Elementary*	*Jr./Middle*	*High*
	Type of School		
Classroom Toilets	X		
Kitchen	X	X	X
Laundry	X	X	X
Art Room	X	X	X
Science Room	X	X	X
Health Clinic	X	X	X
Teachers' Lounge	X	X	X
Teachers' Workroom	X	X	X
Principal's Toilet	X	X	X
Student Toilet Rooms	X	X	X
Special Ed. Room	X	X	X
Showers		X	X
Car Wash			X
Shop Room			X

Elementary & Secondary Schools

Kitchen and Food Service:

The following should be determined for a full service kitchen:

- **Dishwashing requirements.**
- **Rinse and sterilization requirements.**
- **Sinks and other kitchen hot water users, such as a can wash, steamers, rinse sprays, or possibly a water wash kitchen hood.**
- **Hours of operation.**
- **Are breakfast and lunch both served?**
- **Evenings or Weekends?**
- **Is disposable table service used?**

Elementary & Secondary Schools

Showers:

The shower load is the most significant part of the hot water requirement in secondary schools. Beyond the number of showers, the hot water requirement can be affected by such things as:

- Gym class size and schedule.
- Time period available for showers.
- What temperature(s) are required.
- Maximum flow of the shower head.
- Special fixtures.
- Types of extracurricular activities.

Elementary & Secondary Schools

Calculating The Hot Water Demand:

Hot water demand for schools can be divided into three categories: General Purpose, Kitchen and Shower. It is important to determine which, if any of these loads occur at the same time and what the duration of the overlap is.

As a general rule, if there is a kitchen, a system sized for the kitchen demand may also handle the general purpose demand. If there are also showers, the system must be sized for concurrent shower and kitchen load.

Elementary & Secondary Schools

Table 3.3 Hot Water Demand per Fixture for Schools	Demand[b] (at 140 F Final Temp.)
Fixture	(gph/Fixture)
Lavatory (private)	2
Lavatory (public)	4
Dishwasher (residential type)	20
Sink (classroom, workroom, science)	8
Clothes washer (residential type)	30
Service sink/mop basin[a]	20

[a] Hot water demand for general purpose sinks and mop basins in schools is not included when supplied from general purpose water heaters.
[B] Demands shown represent the quantity of 140EF water required to produce the desired usable water temperature at the fixture.

Elementary & Secondary Schools

Table 3.4 General Purpose Hot Water Requirements for Kitchen Equipment	Demand (at 140 F)
Fixture	(gph)
Vegetable Sink	45
Single Compartment Sink	30
Double Compartment Sink	60
Triple Compartment Sink	90
Prescrapper (open type)	180
Prerinse (hand operated)	45
Prerinse (closed type)	240
Recirculating preinse	40
Lavatory or hand sink	5

Elementary & Secondary Schools

Table 3.5 Rinse Water (180-195 F) Requirements of Commercial Dishmachines		Flow Rate	Consumption
Fixture		(gpm)	(gph)
Door Type	16x16 in.	6.94	69
Inches Rack	18x18 in. rack	8.67	87
	20x20 in. rack	10.4	104
	Undercounter type	5	70
Conveyor Type - Single tank		6.94	416
	Multiple tank (flat)	5.78	347
	Multiple tank (inclined)	4.62	277
Silverware washers		7	45
Utensil washers		8	75
Makeup water (180 F) on certain conveyor types		2.31	139

Elementary & Secondary Schools

Shower Load:

The shower load is derived by multiplying the number of showerheads by the flow rate per shower, by the amount of time the showerheads are used per hour. The total load is expressed in gallons per hour.

Generally, the water to showers is tempered by mixing the hot and cold water; therefore the actual requirement for hot water will be only a portion of the total shower flow.

Mixed Water Temperature

Mixing water at different temperatures to make a desired mixed water temperature is the main purpose of domestic hot water systems.

Equation 1.4:

$$P = (T_m - T_c)/(T_h - T_c)$$

T_h = Supply hot water temperature,EF
T_c = Inlet cold water temperature,EF
T_m = Desired mixed water temperature,EF

P is the hot water multiplier, which is expressed as a percentage.

HOT WATER CALCULATION								
		FLOW	DURATION	GPH	GPH	GPH	GPH	TOTAL GPH
FIXTURE	QTY.	RATE	OF FLOW	DEMAND	DEMAND	DEMAND	DEMAND	OF 140 F
		GPM	MIN./HR.	@ 105 F	@ 110 F	@ 140 F	OTHER	@ SOURCE
LAVATORY - PRIVATE	1	2.2	4	9				6
LAVATORY - PUBLIC	1	0.5	10	5				3
WASHFOUNTAIN	1	2	10	20				13
SHOWER	1	2.5	30	75				47
BATHTUB	1	4	10	40				25
LAUNDRY TUB	1	4	5		20			14
SERVICE SINK	1	3	1			3		3
LOW FLOW LAVATORY	1	0.5	4	2				1
HYDROTHERAPY TUB	1	15	15	225				142
CLINICAL SINK	1	4.5	1		5			3
SINK	1	2.5	1	3				2
DISPOSER	1	9	5			45		45
1 COMP SK	1	9	3.3			30		30
2 COMP SK	1	9	6.75			61		61
3 COMP SK	1	9	10			90		90
DISHWASHER - RESIDENTIAL	1	5	6			30		30
HOSE STATION	1	9	10			90		90
WASHING MACHINE - RESIDENTIAL	1	5	6			30		30
DISHWASHER - COMMERCIAL	1	3	10			30		30
WASHER EXTRACTOR	1					0		0
EMERGENCY SHOWER	1	20	15				300	135
			SUBTOTALS	378	25	408		798

Emergency Shower temperature is calculated at 85 degrees F

Elementary & Secondary Schools

Design Considerations

The criteria for determining the hot water demand has been (see examples) presented as if one central system were being designed. In fact, the best choice may be to use multiple systems. This may be necessitated by criteria calling for a dedicated kitchen water heater or by isolating small loads.

Chapter 5: **Hotels and Motels**

- Introduction
- Hotel & Motel Classification
  - Convention Hotel or Motel
  - Business Travelers Hotel or Motel
  - Resort Hotel or Motel
  - General Occupancy Hotel or Motel
- Guest Room Demand
  - Questions and Assumptions
- Food Service Demand
  - Questions and Assumptions
- Laundry Demand
  - Questions and Assumptions
- General Notes
  - Systems Considerations
  - Design Criteria Considerations

Hotels & Motels

Hotel and Motel Classification

Convention Hotel or Motel

This type of facility has an adequate number of guest rooms, meeting rooms,
ballrooms, food service, etc. to support large groups with common schedules making high shower demands within a short period of time a real possibility.

Business Travelers' Hotel or Motel

It is estimated that 45 to 50% of all hotels and motel business fits into this category. Showering is again the key issue.

Hotels & Motels

Hotel and Motel Classification

Resort Hotel or Motel

This type of facility generally has a longer period of peak demand due the guests lack of common time tables, however, you must be careful when the hotel is located near a theme park or race track for instance.

General Occupancy Hotel or Motel

This is generally a mix of the other three classifications, the effect of which is the lengthening of the peak demand period.

Hotels & Motels

Guest Room Demand

Questions and Assumptions:

- How many guest rooms are there?
- What type of occupancy does the facility serve?
- What is the average occupancy per room expected during peak occupancy?
  - Convention hotel or motel: 1.5 persons
  - Business travelers' hotel or motel: 1.5 persons
  - Resort hotel or motel: 2.5 persons
  - General occupancy hotel or motel: 1.5 to 2 persons

Hotels & Motels

Guest Room Demand

Questions and Assumptions:

- What will the peak demand period be?
  - Convention hotel or motel: 1-hour peak
  - Business travelers' hotel or motel: 1-hour peak
  - Resort hotel or motel: 3-hour peak
  - General occupancy hotel or motel: 2-hour peak

Hotels & Motels

Guest Room Demand, Cont'd.

Questions and Assumptions, Cont'd:

- What will be the greatest contributor to the guest room demand?

  The shower demand is almost always the greatest contributor to the guest room demand. Some small factor can be assumed for the lavatory demand. Watch out for the hot tubs or whirlpool baths.

Hotels & Motels

Guest Room Demand, Cont'd.

Questions and Assumptions, Cont'd:

- **What percentage of guests will shower during any given peak demand period?**
  - **One number that may be considered is 70%. In situations where the peak demand period is 2 hours, consider 70% for the entire period, then use 70% of that number for the second hour. Apply the same logic for 3-hour peak demand periods.**
- **What is the maximum flow potential of the shower heads?**
- **What is the average length of a guest shower?**
  - **Five minutes is a reasonable assumption.**

Hotels & Motels

Guest Room Demand, Cont'd.

Questions and Assumptions, Cont'd:

- **How much hot water should be stored?**

  This is value judgment based on the recovery chosen by the designer and the estimate of simultaneous shower use-both of which are affected by the classification and location of the facility.

  If it's decided to provide recovery equal to the full peak demand, then it seems reasonable to accommodate 10 to 20% of the guests showering simultaneously.

Hotels & Motels

Examples

Water Heater:

300 rooms(1.5 guests /room) = 450 guests
450 guests(70%) = 315 guests showering during the peak hour
315 guests(5 min./guest)(2.5 gpm) = 3938 gallons of 105EF water required

The heat required to raise 3938 gallons of 40EF water to 105EF is:

3938 gallons(8.33 lb/gal)(105-40EF) = 2,132,230 Btu/h output required

2,132,230 Btu/h divided by 80% efficiency of the heater equals a Btu/h input to the heater of 2,665,288 Btu/h.

Hotels & Motels

Examples

Storage Tank:

The designer has decided to provide storage to accommodate the showering of 15% of the guests simultaneously.

3938 gallons(15%) = 591 gallons

Since 140EF water is going to be stored, the gallons of 105EF is multiplied by the mixed water percentage of 65% to result in a minimum storage tank size of 381 gallons.

With a storage tank efficiency of 80%, the minimum storage tank should be selected greater than 480 gallons.

Hotels & Motels

Food Service Demand

Questions and Assumptions:

- What type of food service is being offered (full restaurant, fast food, etc,.)?
- What hours will food service be offered?
- Are there multiple kitchens? Will there be a time when they operate simultaneously?

Hotels & Motels

Food Service Demand

Hot Water Demand:

Since hot water demand is driven by the kitchen equipment, the following questions need to be asked:

- **What will the time period (total hours) of the kitchen's longest cleanup mode?**
- **What fixtures that utilize hot water will be in the kitchen?**
- **What temperature water is required by each?**
- **What are the hot water needs of the dishwasher?**
- **Is a booster heater being used to furnish 180EF water to the dishwasher?**

Hotels & Motels

Selection Of The Equipment

To select a storage tank, first multiply the expected initial fill requirement by 1.1; to provide a 10% safety factor.

Then select the nominal tank size by dividing the gallons of water required by the manufacturers published tank efficiency. (Or assume 75%).

Select the next larger size standard storage tank. If heaters with full demand recovery are specified, the water drawn from storage during high demand periods will be quickly replaced and no greater storage capacity should be required.

Hotels & Motels

Selection Of The Equipment

Required Recovery:

For a kitchen, you may want to calculate full recovery, not taking into consideration storage since it is normally an insignificant percentage of the demand, particularly when a conveyor type dishwasher is used.

Hotels & Motels

Laundry Demand

This demand is driven by the equipment used and the peak operation times. For a large facilities, it can be a significant demand. For small facilities, small residential or light commercial equipment is often used. You must check the maximum operating water temperature and the gallons per hour required by each machine.

For large machines, the draw down rate can be high, so adequate storage is necessary. One manufacturer suggests storing 75% of the peak hourly demand, but not less than 50%. You don’t want temperature degradation due to the addition of cold water during periods of high demand.

Chapter 6: **Hospitals**

- Introduction
- Design Considerations
  - Safety and Health Concerns
- User Group Analysis
  - General Outline
  - User Groups

Patient Areas	Nurses' Station
Hydrotherapy	Dietary and Food Service
Surgical Suite	Laundry
Central Sterile Supply	Obstetrics/Nursery
Miscellaneous	

- Worksheets, Tables and Questions Descriptions
- Worksheets and Tables
- Questions for Owner or Client
- Examples

Hospitals

User Group Analysis

The specific areas of a facility, called "user groups" should be considered when determining the hot water usage. The user groups identified are typical of either a large or small hospital facility.

General Outline:

Identify the following for each user group:

- Fixtures requiring hot water.
- Whether the fixtures are public or private.
- Water temperature and pressure requirements for each fixture.
- Flow rates from each fixture.
- The usage pattern of each fixture.
- The acceptable time delay between the opening of a hot water tap and the delivery of hot water.

Hospitals

User Groups

Patient Areas:

Items that need to be determined include:

- **Are patient rooms private or semi-private - or are wards used?**
- **Does each patient room have a shower/tub, or is there a central bathing area?**
- **Check whether patient bathing is assisted and, if so, how many staff are available to provide assistance.**
- **Determine the flow from each type of fixture.**

Areas of concern:

- **Many codes require 110EF water to be used in the patient area to prevent scalding. (See Chapter 1).**
- **Due to the number of showers/bathtubs in this area, a high use of hot water is possible.**
- **In an intensive care area or isolation room, the hand washing sink/ lavatory is used more frequently than in a typical patient area.**

Hospitals

User Groups

Nurses Station:

Typically a staff toilet with a hand washing lavatory is located nearby. Nourishment and medication rooms typically have sinks in them. The clean and soiled utility rooms are in the vicinity of the station. The clean utility room has a single bowl sink while the soiled utility room typically has a double bowl sink, hand washing lavatory, and a flushing rim sink (also known as a clinical sink) with a bedpan washer.

The nurses station is not a heavy hot water use area and is typically part of another specific user group.

Hospitals

User Groups

Hydrotherapy:

Items that should be determined include:

•The number and sizes of all the tubs/baths in the area.

•For each type of tub, the planned number of therapies per hour.

•The hours the department is in use.

•Desired fill time of each tub. Also determine whether the tubs are fully or partially filled for cleaning between therapies.

•Water temperatures used for the therapies.

•Is there a shower for bathing purposes in the area?

Areas of concern:

•Tub filling is desired to be as fast as possible.

•Temperature is critical.

•Before running tempered water to a thermostatic mixing valve, check to make sure it will function properly under the expected conditions.

Hospitals

User Groups

Dietary and Food Service:

Items that need to be determined include:

•The number of meals provided for each meal or day.

•The number of dishwashers and, for each, its type, size, gallons per cycle, cycles per hour, and required temperature.

•Number of sinks in the area and the type of each (prerinse, etc.).

•Are cart washers used? During what hours and at what temperatures?

•Are the elevated temperatures (e.g., 180EF) to be boosted at the equipment or is a separate water heating system desired.

Areas of concern:

•Water temperature in the area. Typically three temperatures are needed, 110EF for hand washing, 140EF for dietary use, and 180EF for sanitizing purposes.

•Early operating hours and runs simultaneously with other departments.

Hospitals

User Groups

Surgical Suite:

Items that need to be determined include:

•Hours of scheduled surgery and typical starting time.

•Number of scrub sinks in the suite and length of time required to wash.

•Equipment used in the area and the water temperature it requires.

•Number of showers in the suite’s locker rooms.

Areas of concern:

•The time of the suite’s startup. Note that the suite typically begins operation in the A.M., sometimes early A.M., which is the same time other areas of the facility are beginning startup, i.e., during hot water peak demand.

•The average number of emergency operations from the trauma unit or emergency room at night.

Hospitals

User Groups

Laundry:

Items that need to be determined include:

- The number and size of each washing machine in the area.
- The planned number of laundry operations (loads) per hour per machine.
- The department’s start time and hours of operation.
- Temperatures of water used.

Areas of concern:

- The laundry department’s schedule of operation. The department commonly begins operating in the early A.M., which is at the same time as other areas of the facility are starting up.
- The probability of the washing machines will fill simultaneously is high during startup.
- Some of the laundry may be considered contaminated and require special treatment. Verification of this possibility is required.

Hospitals

User Groups

Central Sterile Supply:

Items that need to be determined include:

- Hours that central sterile supply is in operation and when startup begins.
- Number of times each piece of equipment is used per hour.
- Equipment requirements with regard to water temperature, flow, water quality, and pressure.

Areas of concern:

- The department's schedule of operation. The department commonly begins operating in the early A.M., which is at the same time as other areas of the facility are starting up.
- Water pressures, quality and temperatures are critical in this area.

Hospitals

User Groups

Obstetrics/Nursery:

Items that need to be determined include:

•Does each room have a tub/shower or are there central bathing facilities, or both?

•Determine the shower head flow and/or tub flow/capacity.

Miscellaneous Areas:

Items that need to be determined include:

•Where are showers located?

•Determine the shower head flow.

•Determine the water temperatures needed. Maintenance areas may desire 140EF temperatures for cleanup and washdown areas.

Hospitals

Usage Factors

Patient Area:

- The 0.10 (10%) usage factor for the gpm is based on only the shower being in use (i.e., the lavatory is not in use during the same minute).

  Also, it is assumed that not all patients are using the fixtures at the same time.
- The 0.40 (40%) usage factor for the gph is based on either the shower or the lavatory being used in an hour during peak usage time.

Nurses' Station:

- The 0.05 (5%) usage factor for the gpm is based on the relationship between the staff and patients.
- The 0.5 (50%) usage factor for the gph is based on the staff heavily using the fixtures when at the nurses' station and not with the patient.

Hospitals

Usage Factors

Hydrotherapy:

- The 0.25 (25%) usage factor for the gpm is based on the cyclical use of the therapy tubs and on the assumption that staff members are also doing physical therapy.
- The 0.90 (90%) usage factor for the gph is based on the assumption that during peak usage times almost all the fixtures in this area are used.

Dietary and Food Service:

- The 0.40 (40%) usage factor for the gpm is based on the assumption that cleaning (the washing of dishes) does not occur in the same minute as food preparation.
- The 0.90 (90%) usage factor for the gph is based on the assumption that most of the area fixtures are being used during one of the hours of the facility's peak usage time.

Hospitals

Usage Factors

Surgical Suite:

•The 0.50 (50%) usage factor for the gpm and gph is based on the scrub sinks are used intermittently during a procedure and not at the same time as the showers.

Central Sterile Supply:

•The 0.20 (20%) usage factor for the gpm is based on the assumption that some of the equipment is in a fill cycle during any one minute.

•The 0.90 (90%) usage factor for the gph is based on most of the equipment being used during the facility’s peak hour.

Hospitals

Usage Factors

Obstetrics/Nursery

- The 0.10 (10%) usage factor for the gpm is based on the unpredictable nature of the birthing process, thus, only 10% of the fixtures being in use during any one minute.
- The 0.40 (40%) usage factor for the gph is based on the patient wing area. Many patients remain in the birthing rooms after delivery.

Miscellaneous Areas:

- The 0.05 (5%) usage factor for the gpm is based on the assumption that only a minor number of the fixtures are used during any 1 minute of the facility’s peak usage time.
- The 0.10 (10%) usage factor for the gph is based on the assumption that most of the fixtures in these areas are used outside of the facility’s peak usage hour.

Chapter 7: Spas, Pools, Health Clubs and Athletic Centers

- Introduction
- Information Gathering
- Hot Water Requirements
  - Therapies / Special Needs
  - Shower Rooms
  - Other Demands
- Calculating the hot water demand

Spas, Pools, Health Clubs and Athletic Centers

- Questions:
  - Shower room requirements.
  - Peak usage times.
  - Specialty treatments required.
  - Hot water temperatures.
  - Special equipment requirements

Spas, Pools, Health Clubs and Athletic Centers

- Shower room requirements are generally determined with input from the Owner and how they intend to operate their facility.
- Peak usage times can last from one to turee hours usually.

Spas, Pools, Health Clubs and Athletic Centers

- Therapies / Special Needs
  - Vichy showers
  - Hydro showers and tubs
  - Body showers and tubs
  - Water temperatures are critical with these units and care must be taken to be sure all requirements can be met.

Spas, Pools, Health Clubs and Athletic Centers

- Therapies / Special Needs
  - The maximum flow rate of the fixtures must be determined.
  - The actual time of operation and duration must be determined.

Chapter 8: Nursing/Intermediate Care & Retirement Homes

- Introduction
- Design Considerations
  - Safety and Health Concerns
- User Group Analysis
  - General Outline
- User Groups - Nursing and Intermediate Care
  - Resident Areas
  - Nurses' Station
  - Hydrotherapy
  - Dietary and Food Service
  - Central Bathing
  - Laundry
  - Miscellaneous Areas
- User Groups - Retirement Homes
- Worksheets, Tables and Questions Descriptions
- Worksheets and Tables
- Questions for Owner or Client
- Examples

Nursing/Intermediate Care and Retirement Homes

User Group Analysis

The specific areas of a facility, called "user groups" should be considered when determining the hot water usage. The user groups identified are typical of either a large or small hospital facility.

General Outline:

Identify the following for each user group:

- **Fixtures requiring hot water.**
- **Whether the fixtures are public or private.**
- **Water temperature and pressure requirements for each fixture.**
- **Flow rates from each fixture.**
- **The usage pattern of each fixture.**
- **The acceptable time delay between the opening of a hot water tap and the delivery of hot water.**

Nursing/Intermediate Care and Retirement Homes

User Groups - Nursing/Intermediate Care Facility

Resident Areas:

Items that need to be determined include:

- Are resident rooms private or semi-private - or are wards used?
- Does each resident room have a shower/tub, or is there a central bathing area?
- Check whether resident bathing is assisted and, if so, how many staff are available to provide assistance.
- Does each room have a lavatory?
- Determine the flow from each type of fixture.

Areas of concern:

- Many codes require 110EF water to be used in the patient area to prevent scalding. (See Chapter 1).
- Due to the number of showers/bathtubs in this area, a high use of hot water is possible.

Nursing/Intermediate Care and Retirement Homes

User Groups - Nursing/Intermediate Care Facility

Nurses Station:

Typically a staff toilet with a hand washing lavatory is located nearby. Nourishment and medication rooms typically have sinks in them. The clean and soiled utility rooms are in the vicinity of the station. The clean utility room has a single bowl sink while the soiled utility room typically has a double bowl sink, hand washing lavatory, and a flushing rim sink (also known as a clinical sink) with a bedpan washer.

The nurses station is not a heavy hot water use area and is typically part of another specific user group.

Nursing/Intermediate Care and Retirement Homes

User Groups - Nursing/Intermediate Care Facility

Hydrotherapy:

Items that should be determined include:

- The number and sizes of all the tubs/baths in the area.
- For each type of tub, the planned number of therapies per hour.
- The hours the department is in use.
- Desired fill time of each tub. Also determine whether the tubs are fully or partially filled for cleaning between therapies.
- Water temperatures used for the therapies.
- Is there a shower for bathing purposes in the area?

Areas of concern:

- Tub filling is desired to be as fast as possible.
- Temperature is critical.
- Before running tempered water to a thermostatic mixing valve, check to make sure it will function properly under the expected conditions.

Nursing/Intermediate Care and Retirement Homes

User Groups - Nursing/Intermediate Care Facility

Dietary and Food Service:

Items that need to be determined include:

•The number of meals provided for each meal or day.

•The number of dishwashers and, for each, its type, size, gallons per cycle, cycles per hour, and required temperature.

•Number of sinks in the area and the type of each (prerinse, etc.).

•Are cart washers used? During what hours and at what temperatures?

•Are the elevated temperatures (e.g., 180EF) to be boosted at the equipment or is a separate water heating system desired.

Areas of concern:

•Water temperature in the area. Typically three temperatures are needed, 110EF for hand washing, 140EF for dietary use, and 180EF for sanitizing purposes.

Nursing/Intermediate Care and Retirement Homes

User Groups - Nursing/Intermediate Care Facility

Central Bathing:

Items that need to be determined include:

- **Hours of scheduled bathing and the typical starting time.**
- **The type of specialized tubs and the amount of water used.**
- **The layout of the fixtures.**

Areas of concern:

- **The suite's scheduled operating hours and the number of planned baths per hour.**
- **Determine the maximum number of baths that may be performed per hour in each tub.**

Nursing/Intermediate Care and Retirement Homes

User Groups - Nursing/Intermediate Care Facility

Laundry:

Items that need to be determined include:

- **The number and size of each washing machine in the area.**
- **The planned number of laundry operations (loads) per hour per machine.**
- **The department's start time and hours of operation.**
- **Temperatures of water used.**

Areas of concern:

- **The laundry department's schedule of operation. The department commonly begins operating in the early A.M., which is at the same time as other areas of the facility are starting up.**
- **The probability of the washing machines will fill simultaneously is high during startup.**

Nursing/Intermediate Care and Retirement Homes

User Groups - Nursing/Intermediate Care Facility

Miscellaneous Areas:

Items that need to be determined include:

- **Where are showers located?**
- **Determine the shower head flow.**
- **Determine the water temperatures needed. Maintenance areas may desire 140EF temperatures for cleanup and washdown areas.**

Nursing/Intermediate Care and Retirement Homes

User Groups - Retirement Home

Resident Areas:

Items that need to be determined include:

•Number of bedrooms in each apartment and thus, the number of occupants to be considered.

•The number and type of fixtures in each apartment.

•Does each apartment have a dishwasher and/or separate laundry area?

•Determine the flow from each type of fixture.

Areas of concern:

•Though the codes may not require 110EF water to be used in this type facility it is recommended appropriate measures be taken to prevent scalding. (See Chapter 1).

Nursing/Intermediate Care and Retirement Homes

User Groups - Retirement Homes

Items that need to be determined include:

•The number and size of each washing machine in the area.

•The planned number of laundry operations (loads) per hour per machine.

•The room's start time and hours it is open for use.

•Temperatures of water used.

Areas of concern:

•The laundry room's scheduled hours of operation. Since residents use this area, its hours of use are not regulated - thus, it could be used at any time.

• There is a possibility that the washing machines will fill simultaneously.

Nursing/Intermediate Care and Retirement Homes

User Groups - Retirement Homes

Miscellaneous Areas:

Items that need to be determined include:

•The facility may have other areas with fixtures requiring hot water besides those mentioned above. The facility may also be connected to a Nursing Home where the facilities may have shared components and fixtures.

Nursing/Intermediate Care and Retirement Homes

Usage Factors - Nursing/Intermediate Care Facility

Resident Area:

- The 0.10 (10%) usage factor for the gpm is based on not all residents are using the fixtures at the same time.
- The 0.30 (30%) usage factor for the gph is based on the fact that fixtures in this user group use less water than fixtures elsewhere and are used for short periods of time.

Nurses' Station:

- The 0.05 (5%) usage factor for the gpm is based on the relationship between the staff and residents.
- The 0.5 (50%) usage factor for the gph is based on the staff heavily using the fixtures when at the nurses' station and not with the resident.

Nursing/Intermediate Care and Retirement Homes

Usage Factors - Nursing/Intermediate Care Facility

Hydrotherapy:

- The 0.25 (25%) usage factor for the gpm is based on the cyclical use of the therapy tubs and on the assumption that staff members are also doing physical therapy.
- The 0.90 (90%) usage factor for the gph is based on the assumption that during peak usage times almost all the fixtures in this area are used.

Dietary and Food Service:

- The 0.40 (40%) usage factor for the gpm is based on the assumption that cleaning (the washing of dishes) does not occur in the same minute as food preparation.
- The 0.90 (90%) usage factor for the gph is based on the assumption that most of the area fixtures are being used during one of the hours of the facility's peak usage time.

Nursing/Intermediate Care and Retirement Homes

Usage Factors - Nursing/Intermediate Care Facility

Central Bathing:

- The 0.25 (25%) usage factor for the gpm is based on the use of 1 tub at a time in each room in each room (assuming each room has a shower, a residential tub, and a non-ambulatory residents' bathing tub. Also, the time needed for staff to get the residents and to dry them off.
- The 0.90 (90%) usage factor for the gph is based on the fact that during peak usage time almost all of the fixtures in this area are used.

Nursing/Intermediate Care and Retirement Homes

Usage Factors - Nursing/Intermediate Care Facility

Miscellaneous Areas:

- The 0.05 (5%) usage factor for the gpm is based on the assumption that only a minor number of the fixtures are used during any 1 minute of the facility's peak usage time.
- The 0.10 (10%) usage factor for the gph is based on the assumption that most of the fixtures in these areas are used outside of the facility's peak usage hour.

Nursing/Intermediate Care and Retirement Homes

Usage Factors - Retirement Homes

Resident Area:

- The 0.10 (10%) usage factor for the gpm is based on the fact that when the shower is in use, the lavatory and kitchen sink are not in use during the same minute and not all residents are using the fixtures at the same time.
- The 0.40 (40%) usage factor for the gph is based on the fact that the kitchen sink and either the shower or the lavatory are used during an hour of peak usage time.

Nursing/Intermediate Care and Retirement Homes

Usage Factors - Retirement Homes

Laundry:

- The 0.50 (50%) usage factor for the gpm is based on the assumption that when 1 washer starts its filling cycle, another is being filled with clothes.
- The 0.75 (75%) usage factor for the gph is based on most of the washers being used during the peak demand period.

Miscellaneous Areas:

- The 0.05 (5%) usage factor for the gpm is based on the assumption that only a minor number of the fixtures are used during any 1 minute of the facility's peak usage time.
- The 0.10 (10%) usage factor for the gph is based on the assumption that most of the fixtures in these areas are used outside of the facility's peak usage hour.

Chapter 9: Jail and Prison Housing Units

- Introduction
- General
- Hot Water Demand
  - Primary Considerations
- Jail Example
  - Questions
- Auxiliary Equipment Demand Example
  - Recommendation
    - Heater Sizing
    - Storage Tank Sizing
- Prison Example
  - Design Criteria and Assumptions
  - Questions
  - Calculations for Inmate Housing Units
  - Storage Tank Sizing
  - Kitchen considerations
  - Laundry Considerations

Jail & Prison Housing Units

General

It is required that hot water temperature for the showers and lavatories in jails and prisons be limited to between 100 and 110EF . This temperature range has been established to prevent inmates from using hot water as a weapon. The generally used standard is 105EF . Push-button type self-closing or timed control valves are used to deliver hot water to the showers and lavatories.

Jail & Prison Housing Units

Hot Water Demand

The usual fixtures requiring hot water found in housing units are showers and lavatories. Some units also have small kitchens or serving areas, which may have additional sinks and small dishwashers.

In jails, very often 1 or 2 residential type clothes washers are required for each housing unit pod (a group of 10 to 20 cells).

Currently it is recommended that there be 1 shower for every 8 inmates and a lavatory in each cell. The shower operation is the factor that determines the required sizes for the water heater and storage tank.

Jail & Prison Housing Units

Primary Considerations

•The standard recommendation of 8 inmates per shower was made so that all inmates could shower during a 1-hour period. This arrangement allows an average of 7 minutes for each inmate to shower. About half that time is taken up by drying and switching inmates, leaving only about 3.5 minutes of actual water usage per inmate.

•Showers are the main factor affecting water heater size.

•The efficiency of storage systems varies from manufacturer to manufacturer but 65 to 80% is a good efficiency range to use depending on the arrangement of the tank and manufacturers data.

Jail & Prison Housing Units

Questions

- Will the inmates be required to shower at a specific time?
- Will all the cell pods release their inmates for showering within the same hour?
- Will the shower duration per inmate be limited?
- Does the facility anticipate double bunking inmates, either now or in the future?

Jail & Prison Housing Units

Example

Determine the mixed water temperature percentage from Chapter 1.
Then;
With each shower flowing 2.5 gpm, the amount of 140EF hot water required is determined by:

2.5 gpm(0.61) = 1.53 gpm of 140EF hot water

8 inmates(3.5 minutes per shower) = 28 minutes of water flowing per shower head during the peak hour.

6 cell pods with 3 showers per pod = 18 showers total

18 showers(28 minutes) = 504 minutes total

504 minutes(1.53 gpm) = 771.12 gallons of 140EF hot water per peak hour demand

Jail & Prison Housing Units

Heater Input

$$\frac{\text{gph(8.33 lb/gal)(140-50EF)}}{\text{efficiency}} = \text{Btu/h}$$

[771.12(8.33)(90)]/0.80 = 722,636 Btu/h input

Auxiliary Equipment

A judgment will need to be made if the auxiliary equipment will be used during the peak showering period. If the auxiliary equipment is anticipated to be used during the peak showering demand, it should be added to the shower demand when sizing the water heater.

Jail & Prison Housing Units

Heater Sizing

Two heaters should be selected, each sized to serve between 60 and 100% of the total demand. In jail and prison housing units some redundancy in the water heating system is necessary.

Storage Tank Sizing

If the water heater is sized to meet the recovery required to handle the peak shower demand, the storage tank should be sized to handle approximately 50% of the shower demand during peak use. The storage tank should be large enough to prevent the heater from cycling on and off more than 4 times per hour during the off-peak hours.

Chapter 10: Industrial Facilities

- Introduction
- Examples of Industrials

  Manufacturing
  Pharmaceuticals
  Pilot Plants
  Food Products
  Chemicals
  Mining.... Foundries
  Publishing
  Central Utility Generating Facilities
  Laboratories
  Warehouses
  Facilities

- General Criteria
  - Personnel Classification
  - Specific Areas Within Facilities
  - Facility Discussion
- Food Product Facilities
- Tables

Industrial Facilities

"Industrial Facility" is such a general term that it would be impossible to describe each specific type. For the purposes of this manual, the term will mean a location where any or all of the general activities described below take place and where domestic hot water is used for personnel washing as required by code and for other purposes unrelated to process or product that are described in this chapter.

Industrial Facilities

Examples of Industrials

- Manufacturing Facilities
- Pharmaceutical Facilities
- Pilot Plants
- Food Product Facilities
- Chemical Processing Plants
- Steel Mills, Foundries, Mining, Ore Processing and Petroleum Refining
- Printing and Publishing Facilities
- Central Utility Generating Facilities
- Laboratories
- Warehouses
- Fluid Treatment Facilities

Industrial Facilities

Areas within Industrial Facilities

•Washrooms and Toilets
•Wash Fixtures
•Showers

Selection of Equipment

Water Heater:

The shower room is considered a "dump" load, which means that almost the entire storage and recovery volume is used during the shower period. Experience has shown that 20 minutes is typically enough tome to allow for an entire shift to shower. Each shower is assumed to last 5 minutes.

Chapter 11: **Sports Arenas and Stadiums**

- Introduction
- Gathering Information
- System Design
  - Design Considerations
  - Water Heating System Temperature
  - Design Traps to Avoid
  - Types of Systems
    - Central hot water system
    - Distributed hot water system
    - Point of use
  - Special Considerations: Commercial Laundries
  - Assumptions
  - Examples

Sports Arenas and Stadiums

- Areas that require hot water include:
  - Showers
  - Laundries
  - Concessions
  - Grounds service areas
  - Suites
  - Kitchens
  - Toilet Rooms
  - Training Rooms

Sports Arenas and Stadiums

- Gathering information:
  - System design parameters for the various areas of the building.
  - Water temperatures required.
  - Duration of peak demands and what demands occur at the same time.
  - Training rooms often have special needs.
  - Kitchen and concessions equipment requirements.
  - Special equipment requirements (e.g. Zambonis)

Sports Arenas and Stadiums

- Design Considerations:
  - Pipe routing.
  - Fixture types.
  - Mount shower heads at a minimum of 6’-6”.
  - Shower and Therapy loads are usually the main criteria in sizing the water heaters.
  - Concessions are usually on the upper portions of the building and localized water heating should be investigated.

Sports Arenas and Stadiums

- Water Temperatures
  - Central Distribution Systems: 120 - 140 deg. F
  - Point of Use Systems: 110 - 120 deg. F
  - Kitchens: 140 – 180 deg. F
  - Laundries: 140 – 160 deg. F
  - Food Service Areas: 140 deg. F
  - Showers: 120 deg. F ?????

Chapter 13: **Miscellaneous Facilities**

- Religious Facilities
  - Kitchen
  - Baptistries
  - Toilet Rooms
  - Other Considerations
- Grocery and Convenience Stores
  - Toilet Rooms
  - Other Considerations
- Retail Centers
- Fast Food Resturants
  - Toilet Rooms
- Office Buildings

Chapter 12: **Laundries**

- Introduction
- Laundry Design Questions
- Storage Required
- Recovery
- Example

Laundries

System Design Questions

- Will the laundry hot water system be separate from or combined with other systems?
- Will the laundry demand occur at the same time as other demands for hot water?
- What will the laundry's hot water usage be (gallons per hour and/or gallons per pound of laundry)?
- How many washers will there be and what is the pound capacity of each?
- What is the maximum flow rate per machine (gpm)?
- What is the average cycle time of each washer?
- How many cycles will there be per hour?
- What hot water temperature is required?
- What hours does the owner expect to operate the laundry?
- What is the minimum temperature of the supply water?
- Is there a heat recovery system available to preheat the water?

Laundries

Storage

Unless otherwise directed by the Owner, assume that all the washers will operate simultaneously. Provide an amount of hot water storage equivalent to 50 to 75% of the hourly demand. Evaluate the operating characteristics of the washers before deciding on storage.

Recovery

The water heating system should be designed for full recovery of the hourly demand.

Laundries

Example

A hospital laundry has three 135-pound and two 75-pound washers which use 160EF water for sanitation and blood removal. The washer manufacturers' date indicates that all washers require 2 gallons of hot water per hour per pound.

3(135 lb.) + 2(75 lb.) = 555 lb. total capacity

555 lb.(2 gph/lb.) = 1,110 gph of 160EF water

The manufacturer suggests usable storage of between 50 and 75% of the hourly recovery. For this example, we will use 60%.

60%(1,110 gallons) = 666 gallons
Using a 75% tank efficiency, the required minimum tank is 888 gallons.

Laundries

Motels/Hotels and Resorts

- one bed per room in ***economy hotel***:
  - 8 lb./day x rooms x 7 days x occupancy % / 40 hours = lb./hr.
- two beds per room in ***economy hotel***:
  - 14 lb./day x rooms x 7 days x occupancy % / 40 hours = lb./hr.
- one bed per room in ***luxury hotel or resort***:
  - 11 lb./day x rooms x 7 days x occupancy % / 50 hours = lb./hr.
- two beds per room in ***luxury hotel or resort***:
  - 20 lb./day x rooms x 7 days x occupancy % / 50 hours = lb./hr.

With larger facilities, increase poundage because of pool, spa, fitness, banquet and/or dining facilities used by both guests and non-guests.

Assume laundry to process 1.5 loads per hour.

Laundries

Nursing Homes

- 50 lb./bed/week x number of beds / 37.5 hr. = lb./hr
- This includes patient clothing in the average home.
  If a higher number of incontinent patients, increase the per bed per week poundage to 60

Assume laundry to process 1.3 loads per hour.

Hospitals

- 15 lb./day x number of beds x 7 days / 37.5 hr. = lb./hr
- For the division of work, assume 60% flat work (i.e.: sheets), 40% fluff/dry.

Assume laundry to process 1.3 loads per hour.

Correctional Facilities

- 6 lb./day x number of inmates x 7 days / 50 hours = lb./hr.

Assume laundry to process 1.3 loads per hour.

Shirt Laundry / DryCleaning Plant

- 1/2 lb. x number of shirts/day x 6 days / 40 hours = lb./hr.

Assume washer to process 1.5 loads per hour.

Laundries

- Rules of Thumb:
  - Generally washers require 2.5 gallons per pound of laundry.
  - Approximately 70% of the water will be hot water.
  - Storage capacity of the laundry heater should be a minimum of 50% of the hourly demand.

Laundry Drains

Determine the total number of gallons to be dumped at one time by all present and future machines. Use high level rinse figures to get this total.

Divide total gallons by 7.48 gallons/cubic foot to get the total cubic feet required.

Example:
300 gallons / 7.48 = 40 cubic feet of trough area

The trough depth should usually be 12 inches, and the width 14 inches.
In the example above, assume a 12 inch deep and 14 inches wide trough:

14" x 12" = 168 sq. inches

168/144 (one sq. ft.) = 1.166 sq. feet (trough area)

40 (cubic feet required) / 1.166 = 34.3 feet (length of trough)

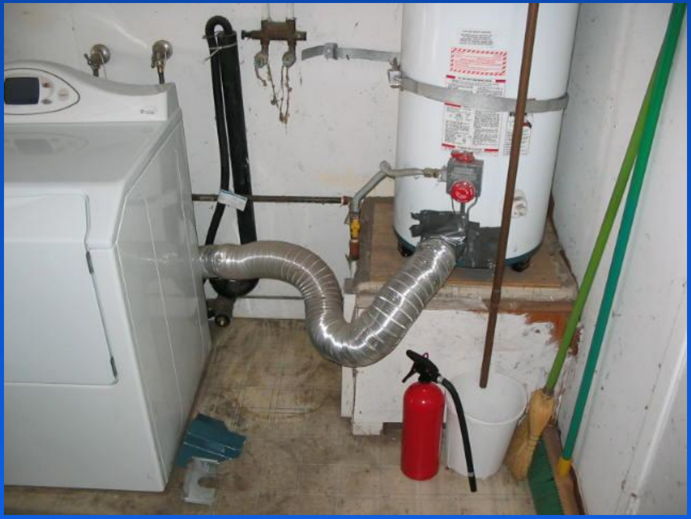
Drain trough should slope 1/4" per linear foot to the outlet drain. On long troughs, this can be decreased to 1/8" per linear foot to keep the depth from becoming too great.

Rational Method

HOT WATER CALCULATION								
		FLOW	DURATION	GPH	GPH	GPH	GPH	TOTAL GPH
FIXTURE	QTY.	RATE	OF FLOW	DEMAND	DEMAND	DEMAND	DEMAND	OF 140 F
		GPM	MIN./HR.	@ 105 F	@ 110 F	@ 140 F	OTHER	@ SOURCE
LAVATORY - PRIVATE	1	2.2	4	9				6
LAVATORY - PUBLIC	1	0.5	10	5				3
WASHFOUNTAIN	1	2	10	20				13
SHOWER	1	2.5	30	75				47
BATHTUB	1	4	10	40				25
LAUNDRY TUB	1	4	5		20			14
SERVICE SINK	1	3	1			3		3
LOW FLOW LAVATORY	1	0.5	4	2				1
HYDROTHERAPY TUB	1	15	15	225				142
CLINICAL SINK	1	4.5	1		5			3
SINK	1	2.5	1	3				2
DISPOSER	1	9	5			45		45
1 COMP SK	1	9	3.3			30		30
2 COMP SK	1	9	6.75			61		61
3 COMP SK	1	9	10			90		90
DISHWASHER - RESIDENTIAL	1	5	6			30		30
HOSE STATION	1	9	10			90		90
WASHING MACHINE - RESIDENTIAL	1	5	6			30		30
DISHWASHER - COMMERCIAL	1	3	10			30		30
WASHER EXTRACTOR	1					0		0
EMERGENCY SHOWER	1	20	15				300	135
			SUBTOTALS	378	25	408		798

Emergency Shower temperature is calculated at 85 degrees F

Gives all new meaning to the term "combustion air".



Special Considerations

- Fixtures to watch for: Vichy showers, Arm/ leg bath, Hot tubs, emergency showers.

Laboratory Hot Water?

- Emergency showers can be the largest almost user of hot water in a laboratory.
- Emergency equipment water supply must be evaluated depending on the risk.
- ANSI Z358.1 indicates tepid water should be used. This is generally accepted to be 85 degrees F.
- This water must be potable.

Equipment?

- Equipment to watch for:
  - Washer/extractors
  - Glass washers, dishwashers, kitchen equipment, process equipment, rack washers, cart washers
  - Zamboni's (200 gallons every 20 minutes)

Various Hot Water Requirements

TABLE 14

Hot Water Requirements for Fixtures and Machines

TYPE OF FIXTURE OR MACHINE	FLOW RATE	DEMAND	TEMPERATURE
BATHTUB	4 GPM	20 GPH	120°F to 110°F
SINK	3 GPM	5 GPH	120°F to 110°F
CIRCULAR WASH FOUNTAIN, 54" DIAMETER	7 GPM	70 GPH	120°F to 110°F
SEMICIRCULAR WASH FOUNTAIN, 54" DIAMETER	3.5 GPM	35 GPH	120°F to 110°F
5-IN-A-GROUP SHOWER	12.5 GPM	125 GPH	120°F to 110°F
3-IN-A-GROUP SHOWER	7.5 GPM	75 GPH	120°F to 110°F
CORNER SHOWER	5 GPM	50 GPH	120°F to 110°F
CIRCULAR COLUMN SHOWER	12.5 GPM	125 GPH	120°F to 110°F
SEMI-CIRCULAR COLUMN SHOWER	7.5 GPM	75 GPH	120°F to 110°F
HAIR SALON FIXTURE/STATION	3 GPM	12 GPH	120°F to 110°F
BARBER SHOP LAVATORY	3 GPM	5 GPH	120°F to 110°F
RESTAURANT AUTOMATIC DISHWASHER	4 GPM	7 GPH	140°F
MOP SINK	3 GPM	15 GPH	140°F
BAR SINK	3 GPM	25 GPH	140°F
SINGLE POT SINK	4 GPM	25 GPH	140°F
DOUBLE POT SINK	4 GPM	50 GPH	140°F
TRIPLE POT SINK	4 GPM	75 GPH	140°F
VEGETABLE SINK	4 GPM	40 GPH	140°F
HANDSPRAY DISH PRE-RINSE	4 GPM	45 GPH	140°F
BRUSH-TYPE DISH PRE-RINSE	3 GPM	180 GPH	140°F
CONVEYOR DISH PRE-RINSE *	4 GPM	240 GPH	140°F
AUTOMATIC 9 LB. TO 12 LB. CLOTHES WASHER	5 GPM	36 GPH	160°F
STATIONARY RACK DISHWASHING MACHINE	SEE FOOD SERVICE SECTION		140°F TO 180°F
CONVEYOR DISHWASHING MACHINE	SEE FOOD SERVICE SECTION		140°F TO 180°F

* May be built into dishwasher; frequently used as separate appliance

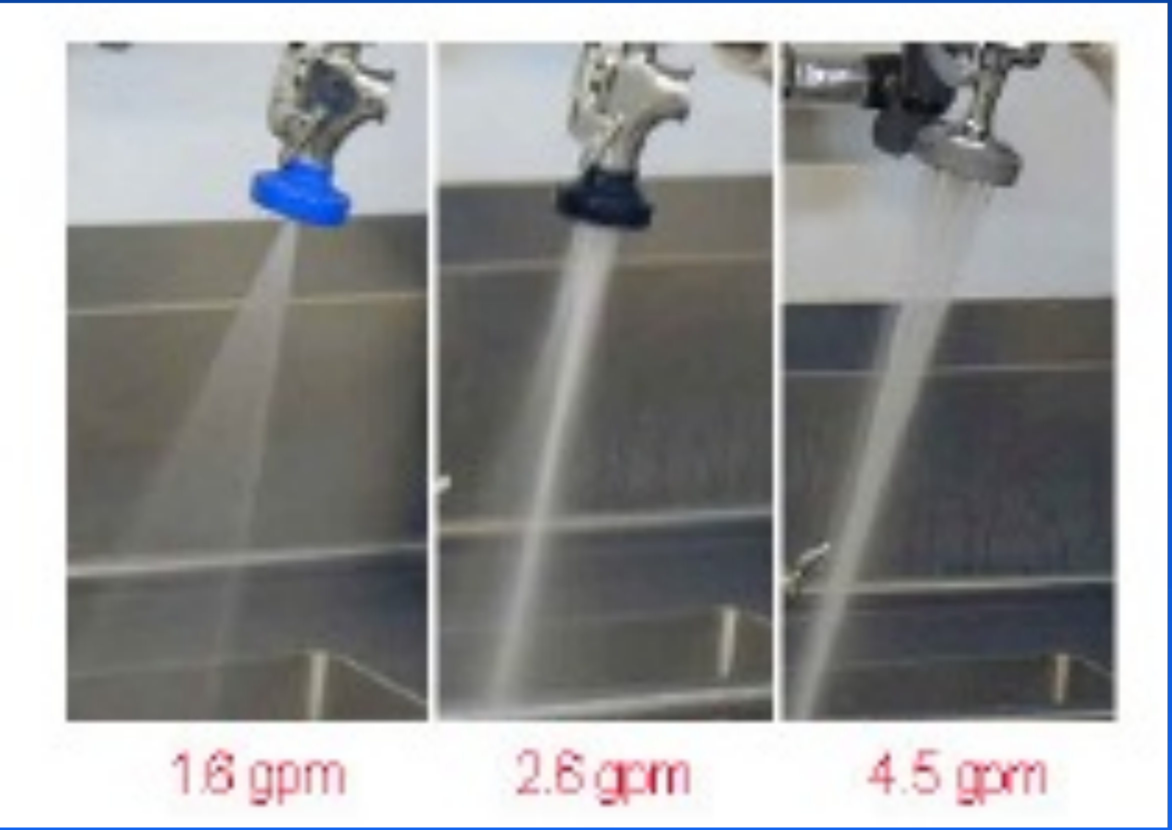
Changing flow rates

Table 1. Water-Usage Rates for Domestic Fixtures

Technology	Pre-1990 Usage	Pre-EPAct Usage	EPAct Requirement (1994–1997)	2000 Efficient Models
Faucet	5–7 gpm [a] (18.9-26.5 lpm)	4 gpm (15.1 lpm)	2.5 gpm (9.5 lpm)	0.5 gpm (1.9 lpm)
Showerhead	4.5–8 gpm (17–30.3 lpm)	3.5 gpm (13.2 lpm)	2.5 gpm (9.5 lpm)	1.5 gpm (5.7 lpm)
Tank toilet	4–7 gpf [b] (15.1–26.5 lpf)	3.5 gpf (13.2 lpf)	1.6 gpf (6.1 lpf)	1 gpf (3.8 lpf)
Flushometer toilet	4.5 gpf (17 lpf)	3.5 gpf (13.2 lpf)	1.6 gpf (6.1 lpf)	1 gpf (3.8 lpf)
Urinal	3.5–5 gpf (13.2–18.9 lpf)	1.5 gpf (5.7 lpf)	1 gpf (3.8 lpf)	Waterless urinal
Clothes washer		45–55 gpu [c] (170.3–208.2 lpu)	No requirement, 45 gpu average (170.3 lpu)	25 gpu (94.6 lpu)
Dishwasher		10–5 gpu (37.9–56.8 lpu)	No requirement, 10–15 gpu average (37.9-56.8 lpu)	4.5–6 gpu (17–22.7 lpu)

[a] gpm = gallons per minute; lpm = liters per minute
[b] gpf = gallons per flush; lpf = liters per flush
[c] gpu = gallons per use; lpu = liters per use

Changing water demands



Kitchens

1. Warewashing Sinks (utensil, pot, glass, and bar sinks).

a) Measure the length, width, and height of each of the sink's compartments to determine the total volume capacity of the sink(s).
b) The following formula is used for determining the volume of hot water needed for the sink(s).

$$V = \frac{L \times W \times H \times C \times .5}{231}$$

V	= Volume (in gallons) of hot water needed
L	= Length of one sink's compartment in inches
W	= Width of one of the sink's compartments in inches
H	= Height of one of the sink's compartments in inches
231	= The number of cubic inches per gallon
C	= The number of compartments within the sink
.5	= The percentage of 140°F water used in the sink

c) If all compartment sizes of the sink are not the same, then the calculation must be done for each compartment and the totals are then added to obtain the total gallon per hour of hot water needed.

Kitchens

Note #1	Dishwasher (____ gals/hr. FINAL RINSE x 70%)
Note #2	Cloth Washer Calculation A. Limited Use/Cloth washer used one to two times per day; beginning or ending of day operation GPH = 60 GPH x 25%. B. Intermediate Use/Cloth washer used three to four times per day; GPH = 60 GPH x 45%. C. Heavy Use/Cloth washer used once every two hours; GPH = 60 GPH x 80%. D. Continuous Use/Cloth washer used every hour; GPH = 60 GPH x 100%.
Note #3	Hose reels @ 20 GPH for first reel & 10 GPH for each additional reel.
Note #4 - GPH Requirements for sink	$\text{GPH} = \dfrac{\text{(Sink size in cu.in. x 7.5 gal./cu.ft. x \# compartments x .75 capacity)}}{\text{(1,728 cu.in./cu.ft.)}}$
Short version for above	GPH = Sink size in cu. in. X # compartments x .003255/cu. in. Example 24"x 24"x 14" x 3 compartments x .003255 = 79 GPH
Water heater storage capacity. (______ Gallons Storage)	
Water heater recovery rate in gallons per hour at a 100°F temperature Rise. (______Gallons per hour)	

Kitchens

Table 4.5 Rinse Water (180–195°F) Requirements of Commercial Dishmachines

Dishmachine Type	Dishmachine Size		Flow Rate (gpm)	Consumption (gph)
Door type	16 x 16 in.		6.94	69
Inches rack	18 x 18 in. rack		8.67	87
	20 x 20 in. rack		10.4	104
	Undercounter type		5	70
Conveyor type	Single tank		6.94	416
	Multiple tank	Dishes flat	5.78	347
		Dishes inclined	4.62	277
Silverware washers			7	45
Utensil washers			8	75
Make-up water requirements—180°F on certain conveyor types			2.31	139

Note: Based on water pressure of 20 psig at equipment. Based on operation at 100% mechanical capacity. Seventy percent is normal operating capacity except for rackless conveyor machines. Designer should contact equipment manufacturer for actual demand. Designer also should check local codes and regulations. Some agencies require that domestic water heating systems be sized to provide 100% capacity for dishwashers.

Dishwashers

TABLE 17

MACHINE DISHWASHING REQUIREMENTS

MAKE & MODEL NUMBER	180ºF WATER REQUIRED GPH	A BOCK WATER HEATER MODEL TO BOOST EXISTING 140ºF WATER TO 180ºF				B BOCK WATER HEATER MODEL TO SUPPLY 180ºF WATER AT 140ºF RISE			
		OIL	ELECT.	GAS	POWER GAS	OIL	ELECT.	GAS	POWER GAS
ADAMATION									
10-20	234	1-51E	1-24KW	1-75G-8	1-51PG	1-361E	2-40KW	1-100W-199SD	1-361PG
SL-3, CA2M	420	1-72E	1-45KW	1-80G	1-72PG	2-361E	3-54KW	1-80W-505SD	2-361PG
CA, CA-1	417	1-72E	1-45KW	1-80G	1-72PG	2-361E	3-54KW	1-80W-505SD	2-361PG
CA-2, CA-4	417	1-72E	1-45KW	1-80G	1-72PG	2-361E	3-54KW	1-80W-505SD	2-361PG
CA-4 SUPER WASH	288	1-51E	1-30KW	1-75G-8	1-51PG	2-73E	2-54KW	1-100W-300SD	2-73PG
SL-1390	294	1-51E	1-30KW	1-75G-8	1-51PG	2-73E	2-54KW	1-65W-370SD	2-73PG
CSL-1390	294	1-51E	1-30KW	1-75G-8	1-51PG	2-73E	2-54KW	1-65W-370SD	2-73PG
AMERICAN DISH SERVICE									
AHC, L90-3DW, WC, ET-AH	44	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
HT-25	61	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
AC, ETA	51	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
AH, L72-3DW, WC	55	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
A, AFC, AFC-3D, AF-3D (10 SEC), L60-3DW, WC, AF, AFC-3D, AF-3D (90 SEC)	68	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
AF-B	88	1-51E	1-30KW	1-75G-8	1-51PG	2-73E	2-54KW	1-75G-8	2-73PG
5AH	101	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	1-40KW	1-80G	1-72PG
ADC-44	120	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	2-40KW	1-80G	1-72PG
5	126	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	2-40KW	1-80G	1-72PG
5AG	168	1-51E	1-24KW	1-80G	1-51PG	1-72E	2-40KW	1-80G	1-72PG
BLAKESLEE									
A-7, B-7, BC-7, D-7, DC-7	117	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	2-40KW	1-80G	1-72PG
1-E, 1-ER, 1-L, 1-LR, 1-M, 1-MR, F1-E, F1-ER, F1-L, F1-LR, F1-M, F1-MR, XFA2-E, XF2-ER, XFA2-ER, XF2-L, XFA2-L, XF2-LR, FA2-LR, XF2-M, XFA2-M, XF2-MR, XFA2-MR, XF3-E, XFA3-E, XF3-L, XFA3-L, XF3-M, XFA3-M	420	1-72E	1-45KW	1-80G	1-72PG	2-361E	3-54KW	1-150G-400	2-361PG
2-E, 2-ER, 2-L, 2-LR, 2-M, 2-MR, 3-E, 3-L, 3-M, F2-E, F2-ER, F2-L, FA2-L, F2-LR, FA2-LR, F2-M, FA2-M, F2-MR, FA2-MR, F3-E, FA3-E, F3-L, FA3-L, F3-M, FA3-M	288	1-51E	1-30KW	1-75G-8	1-51PG	2-73E	2-54KW	1-100W-300SD	2-73PG
XF1-E, XFA1-E, XF1-ER, XFA1-ER, XF1-L, XFA1-L, XF1-LR, XFA1-LR, XF1-M, XFA1-M, XF1-MR, XFA1-MR	720	1-361E	2-36KW	2-75G-8	1-361PG	3-361E	5-54KW	1-200G-850	3-361PG
UC-21, D-9	35	1-51E	1-15KW	1-75G-8	1-51PG	1-32E	1-24KW	1-75G-8	1-51PG
D-8, D8-LT	72	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-27KW	1-75G-8	1-51PG
DOUBLE D-8, DOUBLE D8-LT, R-L,R-M, R-PL, R-PM, FA-L, FA-M, FA-PL, FA-PM	144							1-75G-8	
RA-L, RA-M, RA-PL, RA-PM	262	1-51E	1-30KW	1-75G-8	1-51PG	2-73E	2-54KW	1-100W-300SD	2-73PG
F-L, F-M, F-PL, F-PM, R-CC, R-EE, R-LL, R-MM	262	1-51E	1-30KW	1-75G-8	1-51PG	2-73E	2-54KW	1-100W-300SD	2-73PG
FA-EE, FA-LL, FA-MM, RA-EE, RA-LL, RA-MM, R-PCC, R-PEE, R-PLL, R-PM, FA-PEE, RA-PLL, RA-PMM, RA-PEE, RA-PLL, RA-PMM, R-EEE, R-LLL, R-MMM, FA-EEE, FA-LLL, FA-MMM, RA-EEE, RA-LLL, RA-MMM, F-EE, F-LL, F-MM, F-PEE, F-PLL, F-PMM, F-EEE, F-LLL, F-MMM, XF-EE, XF-LL, XF-MM, XF-PEE, XF-PLL, XF-PMM	288	1-51E	1-30KW	1-75G-8	1-51PG	2-73E	2-54KW	1-100W-300SD	2-73PG
XF-LLL, XF-XMM	360	1-72E	1-40KW	1-80G	1-72PG	2-361E	3-40KW	1-80W-450SD	-----
XF-MMM, XF-L, XF-M, XF-PL, XF-PM	720	1-361E	2-36KW	2-75G-8	1-361PG	3-361E	5-54KW	1-200G-850	3-361PG
CHAMPION									
T-6A, T-7A, T-7AC	74	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-27KW	1-75G-8	1-51PG
1-KAB, 1-KACB	107	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	1-40KW	1-80G	1-72PG
20K Series, 30K Series	416	1-72E	1-40KW	1-75G-8	1-72PG	1-150-400E	3-54KW	1-150G-400	----
40K Series, 60K Series, PR-96, PR-120	282	1-51E	1-30KW	1-75G-8	1-51PG	1-73E	2-54KW	1-100W-300SD	2-73PG
64K Series	348	1-71E	1-36KW	1-80G	1-71PG	1- 361E	3-40KW	1-80W-425SD	---
UC Series	426	1-72E	1-45KW	1-80G	1-72PG	2-361E	3-54KW	1-80W-505SD	2-361PG
U-HB, U-H1	33	1-51E	1-15KW	1-75G-8	1-51PG	1-32E	1-24KW	1-75G-8	1-51PG
TUW	37	1-51E	1-15KW	1-75G-8	1-51PG	1-32E	1-24KW	1-75G-8	1-51PG
U-LD	44	1-51E	1-15KW	1-75G-8	1-51PG	1-32E	1-24KW	1-75G-8	1-51PG
D-HB, D-H1, D-LF	66	1-51E	1-15KW	1-75G-8	1-51PG	1-32E	1-24KW	1-75G-8	1-51PG
44WS, 66WS, 64KB, 64-KPRB	130	1-51E	1-15KW	1-75G-8	1-51PG	1-51E		1-75G-8	1-51PG

TABLE 17

MACHINE DISHWASHING REQUIREMENTS

MAKE & MODEL NUMBER	180ºF WATER REQUIRED GPH	A BOCK WATER HEATER MODEL TO BOOST EXISTING 140ºF WATER TO 180ºF				B BOCK WATER HEATER MODEL TO SUPPLY 180ºF WATER AT 140ºF RISE			
CHAMPION, cont.		OIL	ELECT.	GAS	POWER GAS	OIL	ELECT.	GAS	POWER GAS
40KB, 40-PKRB, 44KB, 44-KPRB, KL-44, KL-66	300	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	2-54KW	1-65W-370SD	___
54-KB, 54-KBRP	325	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	2-54KW	1-65W-399SD	___
UC-C	336	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	2-54KW	1-65W-399SD	___
UC-CW	426	1-72E	1-45KW	1-80G	1-72PG	2-361E	3-54KW	1065W-625SD	2-361PG
W-6	852	2-71E		1-65W-370SD	___	2-150E-400		1-250G-1000	___
FOOD EQUIPMENT DIVISION – Mc-GRAW-EDISON									
TKM-20	60	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
TKM-27, TKMC-27	116	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	1-40KW	1-80G	1-72PG
TKM-44, TKM-66R	420	1-72E	1-45KW	1-80G	1-72PG	2- 361E	3-54KW	1-80W-505SD	2-361PG
TKM-64 thru TKM-115	624	1-241E	2-30KW	2-75G-8	1-241PG	1-200E-650	4-54KW	1-150G-800	----
TKM-215 thru TKM-324	414	1-72E	1-40KW	1-80G	1-72PG	2-361E	3-54KW	1-80W-5-5SD	2-361PG
GENERAL ELECTRIC FOOD SVS. EQPT.									
3T-30B, SK-10B, SK-30B	77	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-27KW	1-75G-8	1-51PG
50-20, SK Series, 50SMT	103	1-51E	1-15KW	1-75G-8	1-51PG	1-71E	1-36KW	1-80G	1-71PG
SS40B, SS48B, SS62B, SS70B, SS76B, SS84B	426	1-72E	1-45KW	1-80G	1-72PG	2-361E	3-54KW	1-200G-450	2-361PG
SS64B, SS80B, SS86B, SS102B, SS100B, SS116B	300	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	2-54KW	1-165W-370SD	1-361PG
115-20, 165-20, 225-20, 275-20	282	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	2-54KW	1-100W-300SD	2-361PG
HOBART									
UM Series	70	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
WM Series	68	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
AM Series, LM-3T3	122	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	1-45KW	1-80G	1-72PG
C-44, CRS-66, CWS-66, CPW-80, C-54CRS-76, FR-54, FRC-54, CWS-76, CPW-90, FT-400 Series	450	1-72E	1-45KW	1-80G	1-72PG	2-361E	3-54KW	1-200G-450	2-361PG
C-64, CRS-86, FR-64, FRC-64, CPW-100, C-81, CRS-103, FR-81, FRC-81, CWS-103, CPW-117, CS-100, CS-117	282	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	2-54KW	1-100W-300SD	1-361PG
FT-200, 300 and 500 Series	348	1-71E	1-36KW	1-80G	1-71PG	1-361E	3-40KW	1-80W-450SD	-----
INSINGER									
Ensign 40-2, 45SA	61	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
Commodore 15, Commander 18, 50SA	120	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	1-45KW	1-80G	1-72PG
Admiral 120-5, Admiral 120-7, Admiral 60-2, Admiral 66-2	416	1-72E	1-40KW	1-80G	1-72PG	2-361E	3-54KW	1-80W-505SD	2-361PG
MiniFlite S-9 thru S-12, Admiral RC-12 FPW thru RC-20 RPW	480	1-73E	1-54KW	1-115G	1-73PG	2-361E	3-54KW	1-200G-450	2-361PG
Speeder 5, Speeder 86-1, clipper 9, Clipper 96-1, Super 8, Super 106-1, Super F-106-1, Master 165-DA-3, 60-DA, 85-DA, 85-DA7, 115-DA, 135-DA, 165-DA, 185-DA, 225-DA, 250-DA, 275-DA	300	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	2-54KW	1-65W-370SD	----
Clipper RC-16 FPW thru RC-21 FPW, Clipper RC-16 RPW thru RC-21 RPW, Master RC-18 thru RC-33, Master RC-18 FPW thru RC-33 FPW, Master RC-18 RPW thru Master RC-33 RPW	312	1-51E	1-36KW	1-75G-8	1-51PG	1-361E	2-54KW	1-65W-399SD	----
Clipper RC-16-EW-2 thru RC-31 RPW-EW-2, Clipper RC-16 RPW-EW-3 thru RC-31 PRW-EW-3, Master RC-18 RPW-EW-3 thru RC-33 RPW-EW-3, Master HRC-18 RPW-EW-3 thru HRC-33 PRW-EW-3	480	1-73E	1-54KW	1-115G	1-73PG	2-361E	3-54KW	1-65W-625SD	2-361PG
Commander 18-4, Commander 18-4C, Commander 18-4H	65	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
Admiral 44, Admiral 66-3	210	1-51E	1-24KW	1-75G-8	1-51PG	1-361E	2-40KW	1-100G-180	1-361PG
Speeder 65, Speeder 86-3	222	1-51E	1-24KW	1-75G-8	1-51PG	1-361E	2-40KW	1-100G-180	1-361PG
Super 106-2	300	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	2-54KW	1-65W-370SD	-----
Century 14	228	1-51E	1-24KW	1-75G-8	1-51PG	1-361E	2-40KW	1-100W-250SD	1-361PG
Clipper (all)	222	1-51E	1-24KW	1-75G-8	1-51PG	1-361E	2-40KW	1-100G-180SD	1-361PG
Master (all)	360	1-72E	1-40KW	1-80G	1-72PG	2-361E	3-40KW	1-80W-425SD	-----
Defender (all)	306	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	2-54KW	1-65W-370SD	-----
CA-3	70	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
DA-3, Trac 321-2	140	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-40KW	1-75G-8	1-51PG
Trac 321-2 RPW	140	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-40KW	1-75G-8	1-51PG

Dishwashers

TABLE 17

MACHINE DISHWASHING REQUIREMENTS

MAKE & MODEL NUMBER	180ºF WATER REQUIRED GPH	A BOCK WATER HEATER MODEL TO BOOST EXISTING 140ºF WATER TO 180ºF				B BOCK WATER HEATER MODEL TO SUPPLY 180ºF WATER AT 140ºF RISE			
INSINGER, cont.		OIL	ELECT.	GAS	POWER GAS	OIL	ELECT.	GAS	POWER GAS
Ensign 40-2, Ensign 60-2oM-NSU, 85-20M, 135-20M-NSU, 185-20M-NSU	61	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
250-20M-NSU	220	1-51E	1-24KW	1-75G-8	1-51PG	1-361E	2-40KW	1-115G	1-361PG
45SA5-F1, 45SA5-F2	36	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
JACKSON									
10A, 10AB, 10APRB, 10APRB-H, 50APR, 50APRB, JV-24A, JV-24AF, JB-24B, JV-24BF		1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
JL-100A, JL-100G, JL-100, JL-100PRB, JL-100PR		1-51E	1-15KW	1-75G-8	1-51PG	1-72E	1-40KW	1-80G	1-72PG
J-44, SJF-44, 39-C, 44-C		1-72E	1-40KW	1-80G	1-72PG	2-361E	3-54KW	1-80W-505SD	2-361PG
4-A, DJF-48, 4-ARD, 6-A, DJF-60, 6-ARD, ROTO DR JR, DJF-64, 1323 thru 2673 (Suffix 'B' models above have integral booster)		1-51E	1-30KW	1-75G-8	1-51PG	2-73E	2-54KW	1-75G-8	2-73PG
JP-24 Series	26	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
24LT Series	29	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
200 Series	52	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
Temp Star, SDS	52	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
Conserver I	111	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	2-40KW	1-80G	1-72PG
Conserver II	60	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
10 Series	234	1-51E	1-24KW	1-75G-8	1-51PG	1-361E	2-40KW	1-100W-250SD	1-361PG
AJ-44, AJ-66, AJ-80 Vision Series	234	1-51E	1-24KW	1-75G-8	1-51PG	1-361E	2-40KW	1-100W-250SD	1-361PG
MOYER DIEBEL									
501LT, 501HT									
MD-18 Series									
MH6L, MH60									
501HTN	37	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
MH6N	66	1-51E	1-15KW	1-75G-8	1-51PG	1-51E	1-24KW	1-75G-8	1-51PG
STERO									
SF-1RA, SF-2RA, SF-2DRA, SDRA, SD-2RA	103	1-51E	1-15KW	1-75G-8	1-51PG	1-71E	1-36KW	1-80G	1-51PG
SCT-44, SCT-44-10, SCT-76S, SCT-76SC, SC-1-SCT-44, SC-1-SCT-44-10, SC-1-SCT-54, SC-2-4, SC-6-4, SC-1-2-4, SC-1-6-4, SC-5-6-4	417	1-51E	1-40KW	1-80G	1-72PG	2-361E	3-54KW	1-80W-505SD	1-51PG
SCT-64, SCT-76, SCT-80, SCT-94, SCT-94S, SCT-95SC, SCT-108S, SCT-108SC, SCT-108, SCT-120, SCT-120SM, SCT-120S, SCT-120SC, SCT-105SM, SC-1-SCT-64, SC-1, SC-76, SCT-80, SCT-94, SCT-108, SCT-120, SC-5-SCT-64	277	1-51E	1-27KW	1-75G-8	1-51PG	1-241E	3-40KW	1-100W-300SD	2-51PG
SCT-76SM, STPC-15, STPC-18, STPC-19, STPC-19PS, STPC-20, STPC-22, STPC-24, STPC-24D, STPC-26, STPC-26D	330	1-72E	1-36KW	1-75G-8	1-71PG	1-361E	2-54KW	1-65W-399SD	1-361PG
SC-2-3-4, SC-6-3-4, SC-2-7-4, SCT-44, SC-3-4, SCT-44-10SC-3-4, SCT-54SC-3-4, SC-1-2-7-4, SC-1-6-3-4, SC-5-2-3-4, SC1-6-7-4, SC5-6-3-4, SC-5-2-7-4, SCT-76S, SC-3-4, SCT-44, SC-1-3-4, SCT-44-10, SC-1-3-4, SCT-54 SC-1-3-4	295	1-51E	1-30KW	1-75G-8	1-51PG	1-361E	3-54KW	1-65W-370SD	1-361PG
STPC-10, STPC-12HS, STPC-12PS	465	1-73E	1-54KW	1-115G	1-73PG	1-200E-450	4-54KW	1-200G-450	-----
STPCW-10, STPCW-12HS, STPCW-12PS, STPCW-15HS, STPCW-15PS	576	1-241E	2-30KW	----	1-241PG	1-150E-600	4-54KW	1-200G-650	-----
STPCW-15 thru STPCW-26	390	1-72E	1-40KW	1-80G	1-72PG	2-361E	3-40KW	1-80W-505SD	-----
VULCAN-HART									
CU-16BTA, R-16BTA, 3D20T, CD20T	120	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	1-45KW	1-80G	-----
A-44 thru A-54	480	1-73E	1-54KW	1-115G	1-73PG	2-361E	3-54KW	1-65W-625SD	-----
A-64 thru A-98	390	1-72E	1-40KW	1-80G	1-72PG	2-361E	3-40KW	1-80W-505SD	-----
CP-3 Series, HP-3 Series, CP-2 Series	420	1-72E	1-45KW	1-80G	1-72PG	2-361E	3-54KW	1-115G	-----
WELLS									
AD-20 Series	102	1-51E	1-15KW	1-75G-8	1-51PG	1-72E	1-36KW	1-80G	-----
AD-44, PC-12	480	1-73E	1-54KW	1-115G	1-73PG	2-361E	3-54KW	1-65W-625SD	-----
AD-64, AD-80, PC-19, PC-26	300	1-51E	1-30KW	1-75G-8	1-51PG	2-51E	2-45KW	1-65W-370SD	-----

Dishwashers

Water Consumption

	Previous Rinse System			Opti-Rinse System			Water Savings	
	gals/min	gals/hr		gals/min	gals/hr		gals/min	gals/hr
FT 900 10FPM	5.4	324		2.8	168		2.6	156
FT 900 12FPM	5.4	324		3.5	210		1.9	114
FT 900 6" HTS	5.4	324		3.6	216		1.8	108
FT 900S	6.5	390		1.9	114		4.6	276