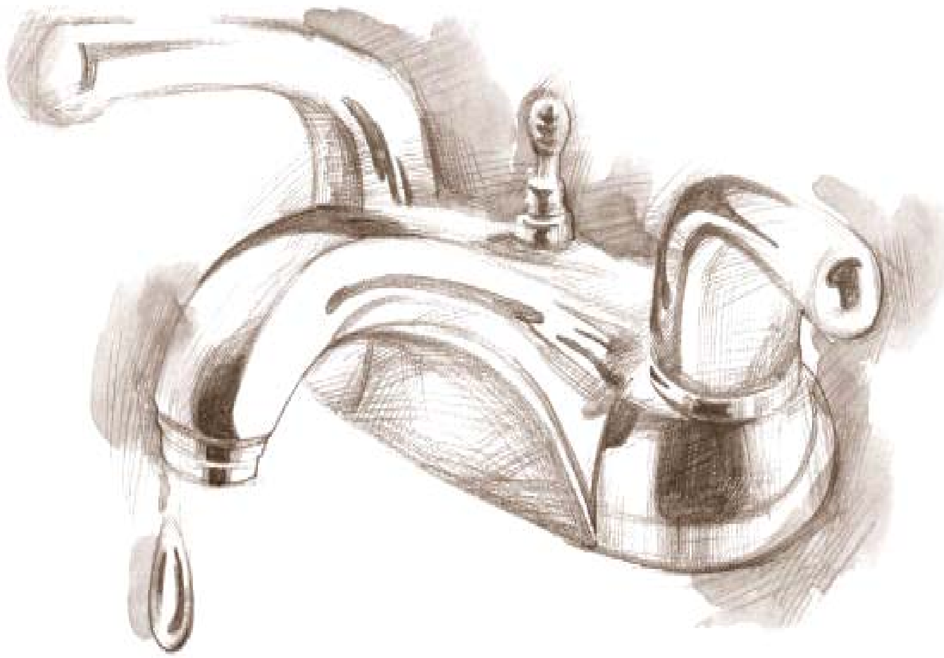
A TECHNICAL GUIDE TO DESIGNING ENERGY-EFFICIENT COMMERCIAL WATER HEATER SYSTEMS



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Foreword

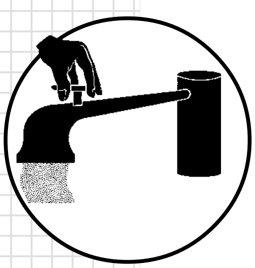
This guide is different than most produced by the water heating industry. Instead of just referring you to prepared sizing information the guide shows you how it's done. Then, when new model heaters are introduced or applications are different, you will have the information necessary to proceed on your own with confidence.

You will learn how to evaluate water characteristics which could affect system life and performance, develop a profile of system operation to establish demand and recovery periods, size energy and storage requirements to meet system demands and, all told, create a successful commercial water heating system.

I. Introduction to Commercial Water heating

Parameters

A water heater is an appliance for supplying hot water for residential or commercial use other than space heating. The maximum outlet water temperature for a water heater is 210°F (98.5°C).



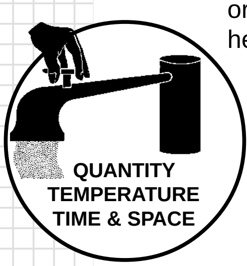
Water heaters are sometimes called boilers and may be so labeled. This is because the gallon capacity of the tank and/or the energy input is above a level for which some codes require ASME (American Society of Mechanical Engineers) construction. Essentially the requirement applies when the water-containing capacity is in excess of 120 gallons or the heat input is above 200,000 Btuh (58.6 kw). Caution, some local inspectors interpret the code to mean including 120 gallons and 200,000 Btuh. The "boiler" requirement can cause cost escalation or system rejection if not taken into consideration by the system designer. One way that more expensive heater costs are often avoided is by combining several "smaller" heaters into a system instead of one large unit.

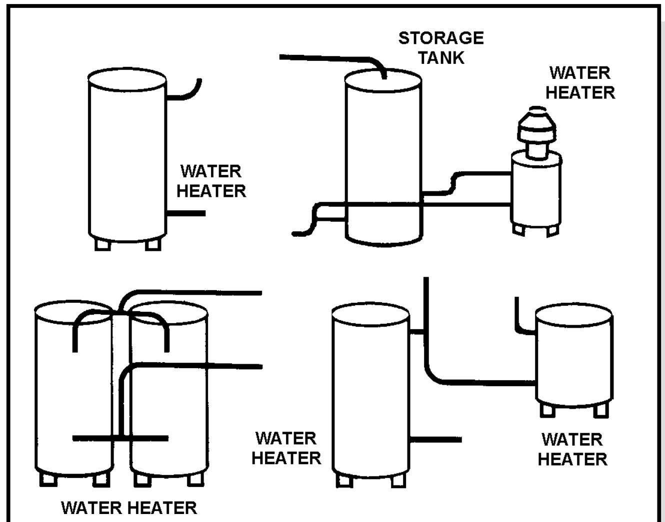
The term water heater and water heating system is used interchangeably in this technical guide. The water heating system may consist of one or more water heaters installed individually at points-of-use or manifolded together to form a central system. Some systems are comprised of water heater(s), with or without storage, hot water storage tanks, circulating pump, related piping and controls.

The major objective of this presentation is to promote the design of energy-efficient commercial water heating systems through proper sizing, equipment recommendations and system selection. Properly designed commercial and industrial water heating systems are essential to the health and well being of the community. Some activities would have to suspend operations or risk serious health and comfort problems if they do not have the quantity of hot water at the temperature needed during the time it is required.

Therefore, the key to proper water heating system design is to identify the quantity, temperature and time characteristics of the hot water requirement. Also, space available for equipment should be noted.

But first, a knowledge of water and its characteristics is necessary in order to effectively design a water heating system.



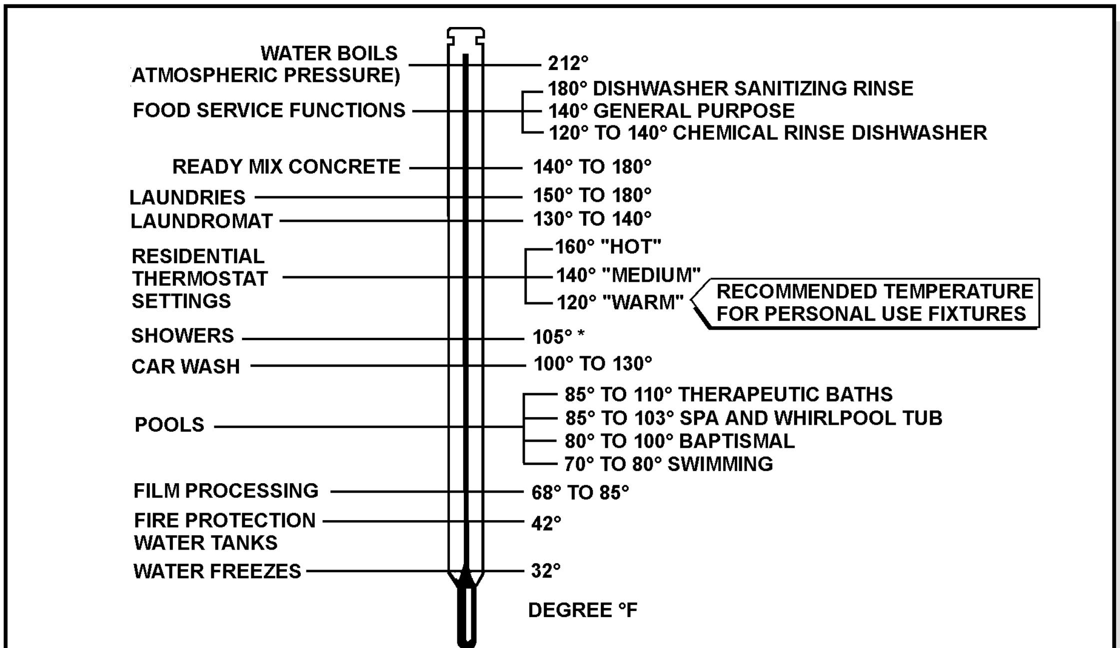


SYSTEM CONCEPTS

What is Hot Water?

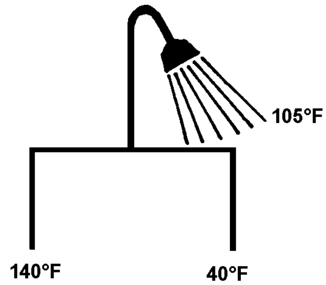
Hot water is water to which heat energy has been added . . .as more heat is added the water becomes hotter. This water temperature guide shows typical water heating system design temperatures.

In practice, the system designer will establish the temperature or temperatures of hot water needed for the various activities through consultation with the user or their representative. It is also necessary for the system designer to know the coldest entering water temperature in order to determine temperature rise.



* The average temperature of the hot and cold water mixture applied to the body.
The hot water being normally obtained from the commercial water heating system at 140°F.

SHOWER HEAD FLOW
RATE AT 105°F



3 GPM SHOWER HEAD FLOW RATE

A) 3 GPM X 81% = 2.43 GPM
B) 2.43 GPM WILL BE HOT WATER AT 120°F
C) .77 GPM WILL BE COLD WATER AT 40°F

3.00 GPM TOTAL FLOW AT 105°F

5 GPM SHOWER HEAD FLOW RATE

A) 5 GPM X .81 = 4.05
B) 4.05 GPM WILL BE HOT WATER AT 120°F
C) .95 GPM WILL BE COLD WATER AT 40°F

5.00 GPM TOTAL FLOW AT 105°F

$$\frac{M - C}{H - C} = \frac{105 - 40}{120 - 40} = \frac{65}{80}$$

THEREFORE 81% OF SHOWER HEAD FLOW RATE WILL BE HOT WATER (120°F)

Evaluating Water

The coldest water inlet temperature experienced during the year should be the base from which the maximum system temperature rise is established. Your water supplier can provide this information. Surface water sources such as lakes and rivers tend to fluctuate as the seasons change. Well water remains relatively constant in temperature year round. A water heating system supplied with varying incoming water temperatures will only provide adequate hot water if the lowest cold water temperature encountered is used in the temperature rise calculation.

Other characteristics of the water supply which should be determined and evaluated by the system designer include supply pressure, water hardness and the presence of silt. These facts may be obtained by contacting your water supplier.

High water supply pressure (above the rated working pressure of the heater) should be reduced by a water pressure reducing valve set to about 50 psig. This will also reduce water consumption but, more important, will bring the water pressure well within the working pressure range of the heater. It is then possible to provide proper relief valve protection on the heater.

It is also necessary to provide water pressure reducing valves on the 180°F rinse lines of dishwashers.

Hardness is the term applied to the compounds of calcium and magnesium present in hard water. So common are these two minerals in water that practically no supply can be found that does not contain at least 1 or 2 grains per gallon. Hardness is also stated in parts per million. One grain of hardness is equal to 17.1 parts per million. Water containing less than 1 grain per gallon of dissolved calcium and magnesium hardness minerals is considered soft water.

The significance of hardness is that the heat transfer surfaces of the water heater will become coated or blocked with the mineral deposits. Depending upon the type of heater, less hot water, noisy operation, increased energy costs and premature equipment failure are some of the problems which may result from “hard” water. The system designer should select water heating equipment which is capable of being delimed or repaired when used in hard water areas.

If the water supply contains silt or sediment, the water heating equipment should be capable of being flushed (and have sediment risers installed in horizontal storage tanks) to extend heater life and minimize energy expense.

The effects of hard water and silt upon the heating equipment can be minimized by lowering water temperature, controlling flow, leakage and waste. For example, fixture and shower head flow controls are a must to minimize hot water consumption and regulate the flow to system design.

Energy saving fixtures benefit the user by reducing water and sewerage charges, energy and maintenance costs. Reducing consumption through flow control is the one way initial cost, operating costs and the space to be occupied by a new water heating system can be dramatically reduced.

II. Principles of Sizing

Hot Water Demand

The major determination in sizing and the basis of all computations is establishing the probable demand for hot water. In addition, any unusual conditions which might relate to hot water consumption must also be recognized and planned for. Unusual conditions will be described under Profiles of Operation.

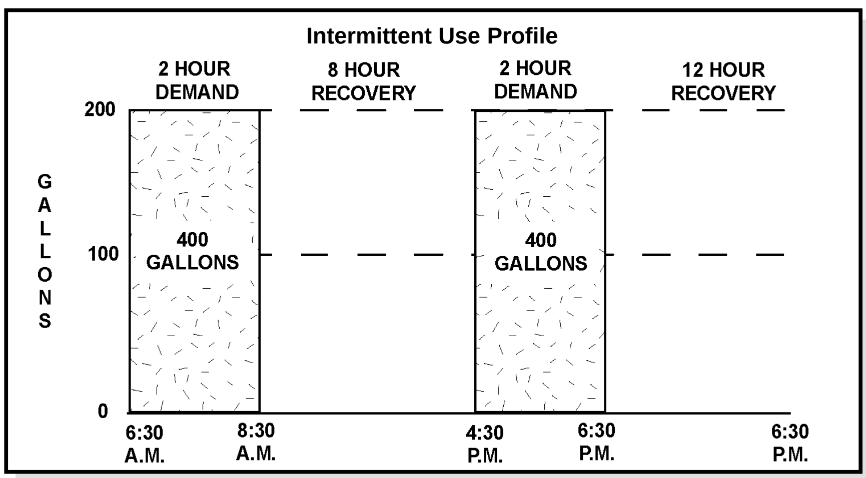
Sources of hot water demand information include the ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) Guide, and hot water using equipment manufacturers such as dishwasher and washing machine makers. Government agencies may also require demand criteria be met.

Profiles of Operation

The system designer should draw a profile of the proposed system hot water usage demand period. The profile will also include the recovery period available before the next demand. Demand and recovery periods can be measured in seconds, minutes or hours.

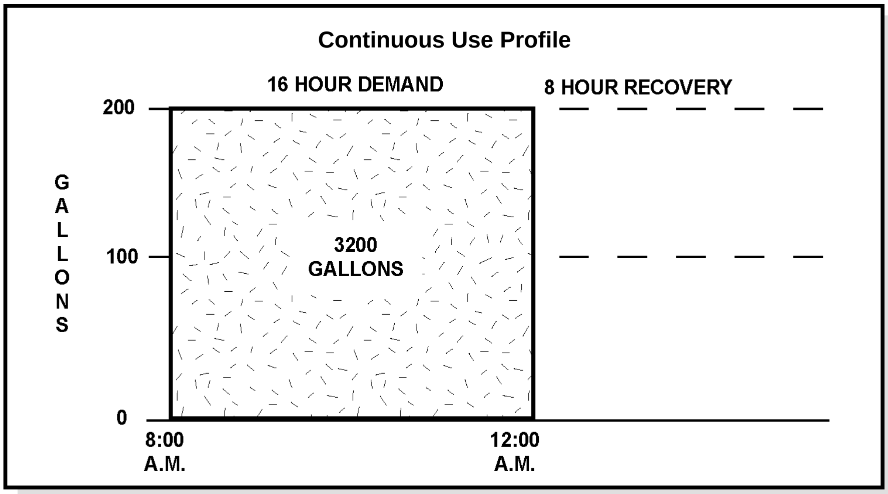
Any unusual needs for hot water during the demand or recovery periods are identified in order to provide additional tank and/or recovery capacity. An unusual need could be a lesser, but significant hot water requirement appearing just after the demand period. For example, a motel could have a laundry operation which begins in mid-morning, after the guest shower load is over. If not taken into consideration there many be no hot water available for the washing machines.

An oversimplification of system design is to say that systems are either for intermittent use or continuous use as shown in the following profiles.



This example shows two demand and recovery periods within a day.

- A combination of heater recovery and hot water storage capacity should be selected to handle the demands.
- The demands are separated by an 8 and a 12 hour recovery period.
- The heater recovery capacity of the shortest recovery period must be sufficient to heat all the water in storage.
- Short demands usually mean placing emphasis on tank size. Heater recovery capacity is emphasized on longer demands.
- The dividing line between long and short demands is about 3 to 4 hours.
- In this example storage is most important.
  -The purpose of the storage tank is to permit relatively low heater recovery capacity while still maintaining adequate hot water supply during the demand period.



- This example could represent an industrial process which is operated for two continuous shifts a day.
- Hot water is used at a maximum rate of 3.3 gpm or 198 gph. (It is important to establish maximum flow rate and water temperature rise in order to select a heater model.)
- In this example heater recovery is most important as the system for all practical purposes is an instantaneous one. That is, it heats the water at the rate it is being used.
- If a tank type water heater is used, the tank size is minimum . . . just large enough to put the heat into the water.

III. Equipment Performance

Recovery Capacity Tables

Recovery capacity tables are the published results of laboratory tests which establish the ability of a heater to raise the temperature of a given volume of water a certain number of degrees within a given time period.

Recovery tables are prepared for all State commercial water heaters regardless of the type fuel used. In each instance the thermal efficiency of the particular type heater has been taken into consideration.

The tables shown here are representative for the types of heaters produced by State using a variety of fuels. In this publication, for electricity, recovery at 1 kW for various temperature rises is shown. The table can then be used without regard to model number as all electric heaters are considered 100% thermal efficient.

Recovery Capacity Calculated at Thermal Efficiency of @ 94%

Recovery Capacities Gas Tank Type

Model	Approx. Gal. Cap.	Input Rating Btu/Hour Nat. & Prop.	TemperatureRise-Degrees F - Gallons Per Hour											
			30	40	50	60	70	80	90	100	110	120	130	140
SUF 100-150	100	150,000	570	427	342	285	244	214	190	171	155	142	131	122

@100%

Recovery Capacities Electric Tank Type

Kilowatts* (kW)	Btu Produce	TemperatureRise-Degrees F - Gallons Per Hour											
		30	40	50	60	70	80	90	100	110	120	130	140
1.0	3,413	13.6	10.3	8.1	6.8	5.8	5.1	4.5	4.1	3.7	3.5	3.3	3.0

*1 KW = 1000 Watts

When used at altitudes of 2000' or more above sea level, gas-fired heater recovery capacities must be derated 4% for each 1000' above sea level in order to reflect actual recovery.

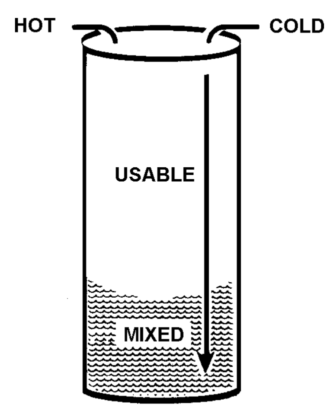
Recovery Capacity means hot water at the heater recovery rate minute after minute, hour after hour. If the hot water demand period is more than 3 or 4 hours, recovery capacity usually becomes more important than storage capacity.

Heater recovery capacity plus usable storage capacity must be sufficient to supply the amount of hot water consumed during the peak demand period.

⚠ **CAUTION:** Many tables refer only to gallons per hour recovery. Be certain that the heater will also meet your gallons per minute requirements.

Storage Capacity and Tank Efficiency

The heater tank provides a source of instant hot water, over and above the heater recovery rate. However, the supply of hot water in the tank cannot be replenished until the recovery capacity of the heater exceeds the demand upon the system. This is usually after the peak hot water demand period has ended.



COLD WATER DILUTES HOT WATER

Tank size is usually more important than recovery capacity when large quantities of hot water are required in a short period of time . . . less than 3 or 4 hours.

All of the stored hot water is not available from the tank at the desired system temperature. This is because hot water is pushed from the system by entering cold water, resulting in temperature dilution of the water in storage.

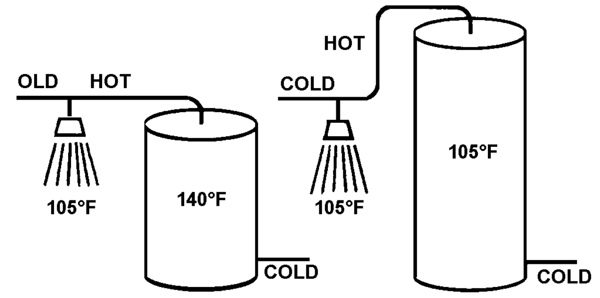
The term usable storage is employed to indicate the quantity of water which must be available from the tank before dilution reduces temperature to an unusable level. Therefore, tank size should be increased by a percentage to cover the expected loss of hot water temperature so enough usable water will be available.

When a specific drop off characteristic for a system is unknown or tank efficiency is not given, 70% availability within a 30° F temperature drop during the demand period may be applied to the tank of a heater or system. For systems requiring precise delivered temperatures, figure 60% availability from the tank.

Obviously the actual availability and temperature drop of any system will depend upon the hot water demand flow rate and piping concept.

The potential for hot water temperature drop during the demand period must be kept in mind by the system designer when establishing the tank temperature. For example, while the hot water temperature guide, page 3, lists showers at 105°F, the system temperature is actually set for 140°F. A mixing valve would limit hot water temperature supplied to person use fixtures to 120°F. In this way the ability to handle a 30°F drop during the demand period is built into a design. The water temperature at the end of the demand would still be above that required by the use . . . about 110°F. Were the system temperature designed to 105°F, the tank size would have to be about half again as large because there would be no "extra" heat in the water to "stretch" the tank contents. The water temperature would also drop below that required by the use. So heating water above the needed temperature in systems employing tanks is common as it reduces tank size through the added heat energy available in the stored water.

STORAGE TEMPERATURE AFFECTS TANK SIZE



105°F TANK IS 1.5x THE 140°F TANK

State commercial tank type water heaters, hot water storage tanks and water heating systems using tanks have assigned tank efficiencies as follows:

Gas and Oil-Fired Tank Type Heaters

- Use 70% tank draw efficiency for all one and two temperature applications. For example, a gas fired Ultra Force® SUF100-150 model has an 100 gallon tank:
- 100 x .70 = 70.0 usable gallons of hot water available within 30°F temperature drop during the demand period.
- Conversely, if 70.0 gallons of usable hot water were needed from the tank over the demand period, the minimum purchased tank size would be:

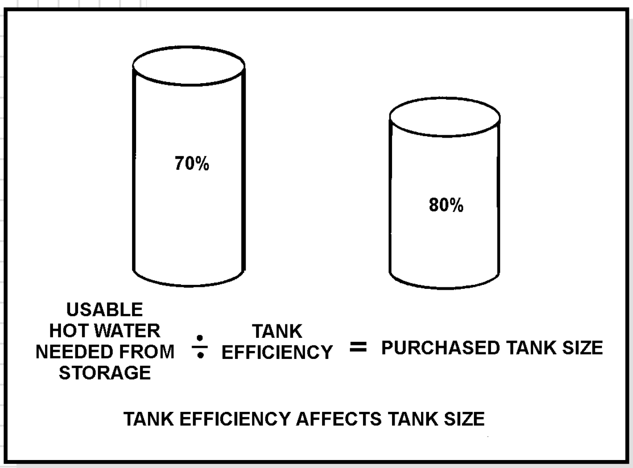
  70.0 ÷ .7 = 100 gallons

Note: Storing water below 140°F may require more storage capacity.

- If the input of the heater is satisfactory for recovery purposes but the tank size is not, an auxiliary hot water storage tank may be piped into the system to increase the amount of available hot water during the demand period. State instruction manuals show the details.

Electric Tank Type Heaters

- Use 70% tank draw efficiency for all two temperature applications. For example, a model CSB - 52 has a 52 gallon tank:



- 52 x .70 = 36.4 usable gallons of hot water available within 30°F temperature drop during the demand period.
- Conversely, if 36.4 gallons of usable hot water were needed from the tank over the demand period, the minimum purchased tank size would be:

  36.4 ÷ .7 = 52 gallons

- Use 80% tank draw efficiency for one temperature systems in the same manner as described for two temperature.
- As in the example of gas and oil-fired tank type heaters, and auxiliary tank can be used to supplement the heater capacity if necessary. However, it should be noted that State commercial electric water heaters are available in tank sizes to 120 gallons. Booster size heaters may also be connected to auxiliary tanks of any size. This would permit fuel conversion at a later date by heater substitution.

Auxiliary Tank (Unfired)

- As explained previously, auxiliary tanks are used to increase the hot water storage potential of gas and oil-fired an electric tank type heaters. Also, auxiliary tanks are used with gas copper heat exchanger type heaters in applications requiring stored hot water.
- Use 70% tank draw efficiency for all two temperature applications.
- Use 80% tank draw efficiency for all one temperature applications piped according to State instruction manuals.

Heater Recovery Plus Storage Tank Equals Demand

As previously explained, select maximum recovery and minimum storage if the hot water demand period is longer than 3 or 4 hours. Storage must be sufficient to handle any peaks within the demand period.

Select minimum recovery and maximum storage if the hot water demand period is less than 3 or 4 hours. Heater recovery must be sufficient to reheat the entire tank contents before the next demand period.

To summarize:

"Short" Demand:	"Long" Demand
• Min. recovery	• Max. recovery
• Max. storage	• Min. storage

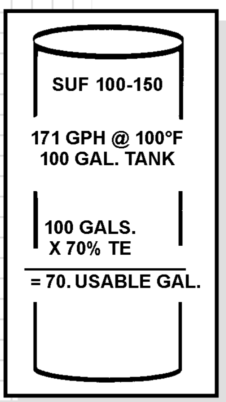
Check for the possibility of any hot water needs occurring during the recovery period which could affect the reheating of the system. Add heater recovery and/or storage tank capacity as necessary to handle unusual conditions.

Equipment sizing calculations may lead to a combination of heater recovery and storage tank which is not made. If so, both factors may be "adjusted" to favor one or the other as desired. Here's how:

1. Where it is important that hot water temperature be maintained (as opposed to "within a 30°F drop" being o.k.) increase recovery capacity in preference to increasing tank size. This will aid in maintaining system temperature. Also, assume 10% less draw efficiency than if the 30°F drop was acceptable.
2. Where it is important to maintain water volume (for demands possibly in excess of heater recovery) increase tank size in order to provide "instant" hot water.

Heater Recovery and Storage Tank Performance Comparison

These examples demonstrate the roles that heater recovery and storage tank capacity play over a demand period. For example, a Model SUF 100 -150 which has an 100 gallon tank, when used for a one or an eight hour demand provides:



One hour demand period

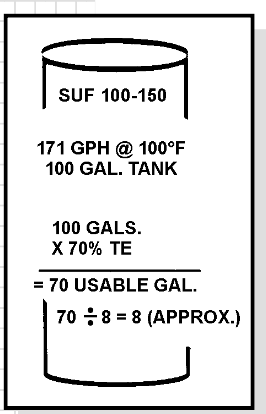
171 gph recovery
+70 gal storage
241 gal/1 hour

Storage provides 30% of demand

Storage:
100 gallon tank
x 70% tank efficiency
= 70.0 usable gallons

Here's how it's figured: 171 gph recovery + 70.0 gallons storage = 241 gallons of hot water available for one hour.

Thereafter, until the tank is reheated, only the heater recovery of 171 gph is available, The heater tank obviously provides a good portion of the hot water in a short, intermittent demand period. Without any use of hot water during the recovery period the tank contents should be reheated within about 25 minutes (20 ÷ 171 = .41)



Eight hour demand period, per hour capacity.

171 gph recovery
+ 8 gal storage
179 gal/8 hour
Recovery provides 96% of demand.

Storage:

100 gallon tank
x 70% tank efficiency
= 70 usable gallons over 8 hours

70.0 – 8 = 7.8 or 8 usable gallons per hour

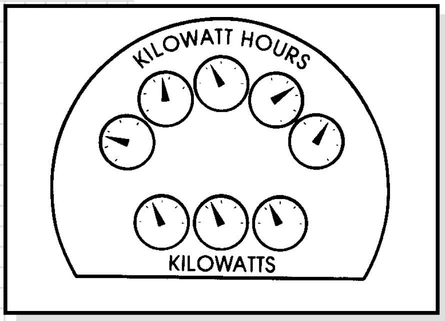
Here's how it's figured: 171 gph recovery + 8 gallons storage per hour = 179 gallons of hot water available per hour for 8 hours.

Thereafter, until the tank is reheated, only the heater recovery of 171 gph is available. The heater recovery obviously provides the hot water in a long, continuous demand period. Without any use of hot water during the recovery period the tank contents should be reheated within about 25 minutes (70.0 ÷ 171 = .41 hour).

When Using Electricity To Heat Water

The system designer may want to modify the preceding heater recovery and storage tank capacity information when using electricity to heat water.

This is because electricity for commercial use, including water heating, is often sold on a demand rate basis. This means, in addition to the energy charge (measured in kWh), there is a charge for the demand (measured in kW) that a customer imposes upon the electrical service. Your power company will provide and explain rate information upon request.



kWh**= ENERGY USED**
(HEATS WATER, COSTS PENNIES)

kW**= DEMAND**
(DOESN'T HEAT WATER, COSTS DOLLARS)

The presence of a demand rate means the system designer should minimize recovery (heater kw rating) and maximize storage capacity (heater tank size.) Demand charges can greatly increase the cost of using electricity to heat water.

Another approach to minimize electric demand is to provide enough hot water storage to allow the elements to be turned off during periods of peak electrical usage. This may be done with a locally obtained time clock or through demand limiting equipment supplied by State or others in the energy control business. Working with the customer, power company, heater supplier and electrician can often result in significant power cost savings by providing control over the electrical demand.

Estimating Water Heating Costs

Occasionally the system designer may want to project energy expense and make fuel cost comparisons as a part of the system design project.

If so, use this formula and the example as a guide.

$$\text{Cost} = \frac{(\text{Gallons per time period}) \times (8.25) \times (\text{temp. rise}) \times (\text{cost of fuel per sale unit})}{(\text{Btu content of fuel per sale unit}) \times (\text{Heater efficiency})}$$

Cost example of heating 50 gallons of water with electricity:

$$\text{Cost} = \frac{(50)x(8.25)x(100)x(.08)}{(3413) \times (1)}$$

$$\text{Cost} = \frac{2062.5}{3413}$$

Cost = 96 cents based on 100% efficiency, plus demand and fuel adjustment charges if applicable.

Notes:

8.25 - Weight of gallon of water

8.00¢ per kwh assumed

1 kW = 3413 Btu/h

Efficiency = 1 (100%)

IV. System Types and Application

Design Objective

The objectives in the design of commercial water heating systems are numerous and varied. The major considerations which the system designer should include in the planning stages are:

1. The heater and related system components and their installation must comply with all applicable codes and requirements.
   - ASME construction and NSF (National Sanitation Foundation) labelling are two examples of requirements which may have to be met.
2. Water heating system performance must promote the health, welfare and safety of the public.
   - Often times exact water temperatures over a long period of time are required in order to provide sanitation. This quality must be built into the system in the design stages.
3. Efficiently utilize energy to achieve the least possible operating costs.
   - Electricity is an example of a fuel which must be applied thoughtfully to avoid unnecessary demand charges.
4. Provide the quality and features needed to attain the desired results at least cost.
   - Least cost means not only initial cost but operating costs as well. Often times higher initial cost can be offset by lower operating costs achieved by using State energy-saving water heater models.

System Types

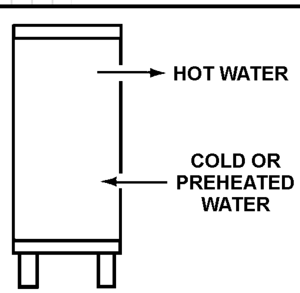
Water heating systems may be divided into two basic types. The types depicted in State instruction manuals are either one temperature or two temperature systems. Of course the customer, through fixture adjustment, may obtain a variety of temperatures to serve their needs.

- One Temperature systems produce only one temperature of hot water to satisfy the demand.
- Two Temperature systems produce two temperatures of hot water and are usually associated with food service functions. The higher temperature water is used for dishwasher sanitizing rinse. Two temperatures may be produced by a single water heater with a mixing valve or by two water heaters set at two different temperatures.

Within each division are numerous system names which should be understood and used by the system designer. It is important to correctly identify a system so the plumber and electrician will follow the proper instructions and diagrams. The following describes the system nomenclature used by State as it applies to the various types of heaters and fuels in use.

Tank Type Water Heater Systems Using Gas, Oil And Electricity.

One Temperature



ONE-TEMPERATURE SYSTEM TANK TYPE HEATER

1. One Temperature and Booster are the names of one temperature water heating system.
   - One Temperature implies that the one temperature hot water produced in the heater is for general purpose use.
   - Traditionally, a Booster system receives hot water (usually at 140°F) and raises it to 180°F for use in the dishwasher final rinse. The Booster is therefore a one temperature water heating system. The tank type heater is the proper choice for a Booster system serving a stationary rack type dishwasher because of their intermittent use of 180°F final rinse water. A combination of heater recovery and storage tank capacity is the rule for a stationary rack type dishwasher.
   - One-temperature
   - Booster.

2. Two Temperature provides two temperature hot water service by means of a water mixing valve or through a pre-heater/booster heater combination. In the first concept the heater storage tank is maintained at the highest system temperature required (usually at 180°F) and the mixing valve externally produces the 140°F hot water requirement.

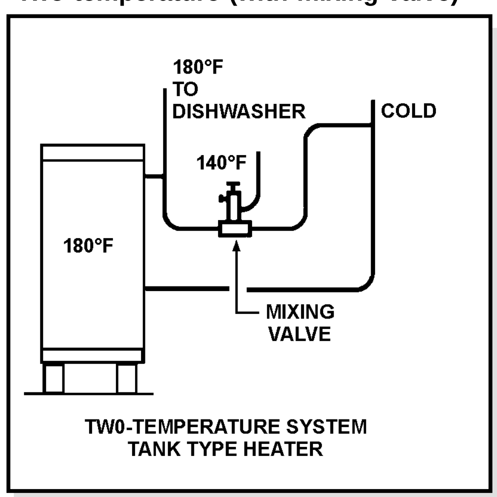
The 180°F water in the tank is therefore piped to the water mixing valve for tempering and also sent directly to the dishwasher final rinse.

The pre-heater/booster heater combination provides two temperatures of hot water without the use of a mixing valve. One heater is operated at 140°F to provide general purpose hot water and provide a source of pre-heated water for the booster heater. The booster heater raises the 140°F water to 180°F for the dishwasher final rinse.

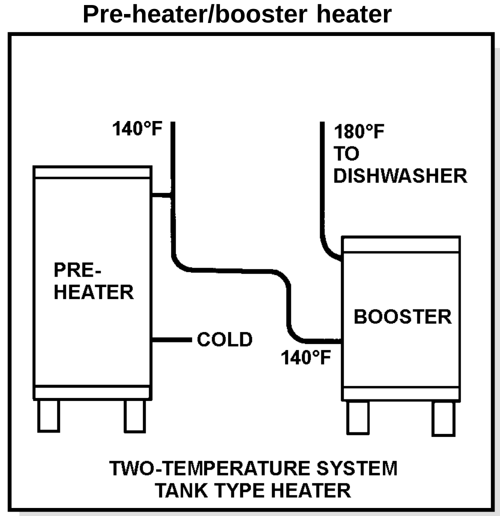
CAUTION

STORING WATER AT HIGHER THAN NECESSARY TEMPERATURES RESULTS IN MORE RAPID LIME BUILD UP, MORE CORROSIVE WATER, AND INCREASES THE POSSIBILITY OF CAUSING INJURY TO ANYONE COMING INTO CONTACT WITH THE HOT WATER.

Two-temperature (with mixing valve)



Pre-heater/booster heater



Creating the Successful System

Creating the successful commercial water heating system is a joint venture involving many persons and skills.

In order to select the right system using either tank type or copper type heaters, one should understand the role that each of the persons concerned with the installation plays.

The following chart summarizes the responsibilities for each of the roles.

Remember, your customer's success or profit may depend upon the continued availability of hot water . . . and you will achieve that goal through proper system selection and sizing.

IDENTITY	RESPONSIBILITY
Customer	Must define his needs
System designer*	Designs a water heating system to satisfy the customer's needs. Acts as an interface between all involved parties.
Water Heater Supplier and/or Manufacturer	Furnishes the equipment to meet the system specifications. May aid the designer in equipment selection or specifications with his knowledge of product performance and availability.
Plumbing and Electrical Installation Contractors	Must understand system concept to provide installation, startup and customer instruction. Also provide maintenance and service for continued satisfaction.
Energy Supplier	Advises characteristics of energy available at job site and how to achieve best use. Particularly important when electricity is the fuel.
Water Supplier	Advises characteristics of water, lowest temperature, maximum pressure and hardness. May influence heater selection and use of a pressure reducing valve.

*The system designer may be the architect, engineer, installing contractor or water heater supplier.

Sizing Without Prepared Information

The following procedures will establish heater recovery and storage tank capacities for intermittent use systems.

Continuous use systems are sized so that heater recovery equals or exceeds demand. Therefore the size of the tank (when proposing a tank type heater system) is unimportant.

The procedures for one and two temperature systems are essentially the same:

1. Establish the hourly 1 / hot water demand in gallons and the maximum temperature rise.

2. Select a trial size heater 2 / .

3. Subtract the hourly heater recovery from the demand.

4. The difference in gallons between demand and recovery must come from the tank.

5. Multiply the difference by the number of demand hours. The result is the "usable" number of gallons which must come from the tank.

6. Divide the "usable" tank gallons by .7 or .8 to obtain minimum tank size needed, see pages 7 thru 10.

7. Compare minimum calculated tank size with that of the "trial size" heater. If the heater tank is equal to or greater than calculated tank size the selection is satisfactory. If not, adjust recovery and storage as necessary, see page 10.

8. Divide the heater tank size by the heater recovery to be certain the tank will be recovered by the time of the next demand. If not, adjust recovery and storage as necessary, see page 10.

1* / The demand could be in minutes or seconds. In either case all references to hours in the procedure would revert to minutes or seconds. For example, a stationary rack type dishwasher may have a 12 second demand period and an 83 second recovery period.

2* / Review PROFILES OF OPERATION, Page 5, as an aid in determining whether to favor recovery or tank capacity in the selection of a "trial size" heater. Normally the hourly heater recovery of the heater selected should not exceed the hourly demand. In this way the hot water content of the tank will be put to use.

One temperature example

1. A two hour demand of 206 gph of 140°F water has been established. The lowest incoming water temperature is 40°F. The shortest time in any day in which the demand will be repeated is 8 hours.

2. A State gas-fired tank type commercial water heater will be selected for the job. (Any fuel or type of heater could be substituted in this example.)

   "Try" a Model SUF 100 -150. This heater has 171 gallons per hour recovery at 100°F water temperature rise and an 100 gallon tank.

3.

Needed:	206 gph for 2 hours
Subtract:	- 171 gph heater recovery at 100°F rise
Equals:	35 gallons needed from tank, first hour
Multiplied by:	x 2 demand hours
Equals:	70 usable gallons needed from tank
Divide:	70 ÷ .7 = 100. gallons minimum tank size
Capacity	100 gallon tank vs.100. gallon tank minimum

Compare tank size vs.recovery:

Used 70 gallon. 8 hours is available to recover tank.
(70 - 171 gph recovery = .41, .41 X 60 minutes = 24.6 minutes needed to recover 70 gallons.

Conclusion: The Model SUF 100 -150 will do the job and should be the heater selected.

CAUTION: A two hour demand of 206 gph means that the 206 gph is spread throughout the entire hour. It does not mean that 206 gallons is dumped in 15 minutes and no additional hot is used in the remaining 45 minutes.

Two temperature example

1. A one hour demand of 75 gallons of 180°F water and 110 gallons of 140°F water has been established. The lowest incoming water temperature is 40°F. The shortest time in any day in which the demand will be repeated is 3 hours.

2. Convert the 180° water requirement into the equivalent of a 140°F water requirement to avoid working with two different temperature rises.

   Converting to a single temperature rise:

   - Multiply the 180°F requirement by 1.4 in 100°F temperature rise applications.

     a) This means 1.4 more water can be raised from 40°F to 140°F than 40°F to 180°F with the same amount of energy.

     b) Multiplier formula:

     $$\frac{\text{Hot - Cold}}{\text{Mixed - Cold}} = \text{multiplier}$$

     Example:

     $$\frac{180 - 40}{140 - 40} = \frac{140}{100} = 1.4$$

     c) 75 gallons 180°F water required
     x 1.4
     105 equivalent gallons of 140°F water

   - Add the converted 180°F water requirement to the 140°F requirement and proceed with heater selection.

     a) 105 + 110 gallons of 140°F water = 215 equivalent gallons of hot water required at 100°F water temperature rise.

3. A State electric tank type commercial water heater will be selected for the job. (Any fuel or type of heater could be substituted in this example.

   Review SYSTEM TYPES AND APPLICATION beginning on page 11.

   "Try" a CSB -120 with 24 kw input. This heater has 98 gallons per hour recovery at 100°F water temperature rise and a 119 gallon tank. The heater will be operated at 180°F and equipped with a water mixing valve set at 140°F.

4. Needed: 215 gallons for one hour
   Subtract: -98 gph heater recovery at 100°F rise
   Equals 117 usable gallons needed from tank

   Compare tank capacity: 119 gallon tank vs. 117 gallon tank minimum

   NOTE: The 119 gallon tank capacity at 70% tank efficiency is equal to 83 gallons of usable hotwater. However, it is 83 gallons of 180°F water and therefore has the heat content equivalent of 83 x 1.4 = 116 gallons of 140°F water. Therefore the tank size is adequate (only 1 gallon short).

   Compare tank size vs recovery: 1.21 hours vs 3 hours available. (119 ÷ 98 = 1.21 hour)

   Conclusion: The model CSB -120 with 24 kw input will do the job and should be the heater selected.

Field Assistance

Please contact your local State distributor, sales representative or the technical information center (See: www.statewaterheaters.com for phone and fax numbers) if you need help designing a water heating system or selecting the proper equipment for the job.

STATE WATER HEATERS
ASHLAND CITY, TENN.

TECHNICAL INFORMATION
800-365-0577