Table 15 .... General Purpose Hot Water (140 F) Requirement for Various Kitchen Uses[a,b]

Equipment	Gallons per Hour
Vegetable sink	45
Single pot sink	30
Double pot sink	60
Triple pot sink	90
Pre-scrapper (open type)	180
Pre-flush (hand operated)	45
Pre-flush (closed type)	240
Recirculating pre-flush	40
Bar sink	30
Lavatories (each)	5

Values extracted from Reference 3.
[a] Supply water pressure at equipment is assumed to be 20 psig.
[b] Dishwasher operation at 100 percent of mechanical capacity.

tive peak demand must be determined. This peak demand period will usually coincide with the dishwashing period during and after the main meal and may last for 3 hr or more. Any hour in which the dishwasher is used at 70 percent of mechanical capacity, or more, should be considered as a peak hour. If the peak demand period lasts 4 hr or more, the value of a storage tank is small, unless extremely large sizes are used. In such cases instantaneous heaters should be used.

Automatic storage water heaters with storage capacities up to 100 gal should be sized on the basis of the maximum hourly demand, with the storage capacity being used as an extra capacity factor in the heater.

The following method of making allowances for the water in storage, should be used only when sizing heaters and systems with more than 100 gal storage capacities.

Usable hot water from storage is calculated from the following equation:

$$Q_s = \frac{0.7S}{d} \qquad (2)$$

where

Q_s = quantity of usable hot water from storage, gallons per hour.
S = storage capacity of tank, gallons.
d = duration of peak hot water demand, hours.

The 0.7 factor in Equation 2 has been determined experimentally to be the maximum usable general purpose hot water available from a storage tank after allowance for dilution with cold inlet water, assuming the inlet and outlet connections have been properly designed and located.

If a storage tank is used, the required quantity of 180 or 140 F water which must be supplied by the water heater is determined from Equation 3.

$$Q_n = Q_t - Q_s \qquad (3)$$

where

Q_n = *net* quantity of hot water required from the heater, gallons per hour.
Q_t = total quantity of hot water required, gallons per hour.

The required gas input to the heater is found from Table 13, using the value of Q_n from Equation 3.

The *National Sanitation Foundation Standard* No. 5 recommendations for hot water rinse demand are based on 100 percent mechanical operating capacity of the machines. The data provided in Table 14 are also based on 100 percent operating capacity. *NSF Standard* No. 5 states that 70 percent of operating rinse capacity is all that is normally attained except for rackless-type conveyor machines.

Examples 6, 7, and *8* demonstrate the use of Tables 13, 14, and 15.

Example 6: Determine the hot water demand for a new water heating system in a cafeteria kitchen with one vegetable sink, 5 lavatories, one pre-scrapper, one utensil washer, and one two-tank conveyor dishwasher (dishes inclined) with make-up device. The initial fill requirement for the tank of the utensil washer is 85 gph at 140 F. The initial fill requirement for the dishwasher is 20 gph for each tank, or a total of 40 gph, at 140 F. The maximum period of consecutive operation of the dishwasher at or above 70 percent capacity is assumed to be 2 hr. The supply water temperature is 60 F.

Solution: The required quantities of general purpose (140 F) and rinse (180 F) water for the equipment, from Tables 14 and 15, are shown in the following tabulation:

Item	Quantity Required[a] at 140 F, gph	Quantity Required[b] at 180 F, gph
Vegetable sink	45	—
Lavatories (5)	25	—
Pre-scrapper	180	—
Dishwasher	—	277
Initial tank fill	40	—
Make-up water	—	139
Utensil washer	—	75
Initial tank fill	85	—
Total requirements	375	491

[a] General purpose hot water consumption, from Table 15.
[b] Water consumption when dishwasher is operated at 100 percent of mechanical capacity, from Table 14.

The total consumption of 140 F water is 375 gph. The total consumption 180 F depends upon the type of heater to be used. For a heater having sufficient internal storage capacity to meet the *flow demand*, in *gallons per minute*, the total consumption, based on the recommendation of The National Sanitation Foundation, is 70 percent of the total calculated from Table 15, or approximately 350 gph ($0.70 \times 491 = 344$ gph). For an instantaneous-type heater, having no internal storage capacity, the total quantity of 180 F water consumed must be based on the flow demand, *gallons per minute*. From Table 14, the quantity required for the dishwasher is 277 gph; for the makeup, 139 gph; and for the utensil washer, 480 gph. The total consumption of 180 F water is $277 + 139 + 480 = 896$ gph, or approximately 900 gph.

Example 7: Determine the gas input requirements for heating water in the cafeteria kitchen described in *Example 6*, by means of the following types of systems, which are among the many possible solutions:

a. Separate self-contained storage-type heaters.
b. Single instantaneous-type heater, having no internal storage to supply both 180 F and 140 F water through a mixing valve.
c. Separate instantaneous-type heaters, having no internal storage.
d. Combination of heater and external storage tank for 140 F water, plus a booster heater for 180 F water. The heater and external storage are to supply 140 F water for both the general purpose requirement and the booster heater. The booster heater is to have sufficient storage capacity to meet the *gallon per minute* flow demand of 180 F rinse water.

Solution a: The temperature rise for 140 F water is $140 - 60 = 80$ deg. From Table 13, the gas input required to produce 375 gph of 140 F water with an 80 deg temperature rise is 360,000 Btu per hr. One or more heaters with this total Btuh may be selected.

From Table 13, the gas input required to produce 350 gph of 180 F water with a temperature rise of 120 deg ($180 - 60$) is 504,000 Btuh. One or more heaters with this total Btuh requirement may be selected from manufacturers' catalogs.

Solution b: The correct sizing of instantaneous-type heaters is dependent upon the *gallon per minute* flow rate of the 180 F rinse water. From *Example 6*, the hourly consumption of 180 F water based on the *gallons per minute* flow rate is 900 gph. The hourly consumption of 140 F water is 375 gph.

From Table 13, the gas input required to produce 900 gph of 180 F water with a 120 deg temperature *rise* is 1,296,000 Btuh. The gas input to produce 375 gph of 140 F water with a temperature rise of 80 deg is 360,000 Btuh. The total heater requirement is $1,296,000 + 360,000 = 1,656,000$ Btuh. One or more heaters meeting this total Btuh requirement may be selected from manufacturers' catalogs.

Solution c: The gas input required to produce 140 F water is the same as for *Solution b*, 360,000 Btuh. One or more heaters meeting this total Btuh requirement may be selected.

The gas input required to produce 180 F water is also the same as in *Solution b*, 1,296,000 Btuh. One or more heaters meeting this total requirement may be selected.

Solution d: The *net* hourly hot water requirement must be determined in order to size the heater required to supply 140 F water. From Equation 2, the quantity of usable hot water in storage Q_s is $(0.70 \times 500) \div 2 = 175$ gph. The total quantity of 140 F water required is $375 + 350 = 725$ gph. From Equation 3, the *net* hot water required Q_n, is $725 - 175 = 550$ gph.

From Table 13, the gas input required to produce 550 gph of 140 F water with an 80 deg temperature rise is 528,000 Btuh.

For systems involving storage tanks it is assumed that the water in the storage tanks has been brought up to temperature prior to the peak dishwashing period, and that sufficient time elapses before the next peak period to permit recovery of the water temperature in the storage tank.

The booster heater is sized to heat 350 gph from 140 F to 180 F, a 40 deg rise. From Table 13, the gas-input required is 168,000 Btuh.

Example 8: A luncheonette has purchased a door-type dishwasher which will handle 16 x 16 in. racks. The existing hot water system is capable of supplying the necessary 140 F water to meet all requirements for general purpose use, plus supply to a booster heater which is to be installed. Determine the size of booster heater required to heat 140 F water to provide sufficient 180 F rinse water for the dishwasher, using:

a. Booster heater with no storage capacity.
b. Booster heater with sufficient storage capacity to meet the *gallons per minute* flow demand.

Solution a: Since the heater is of the instantaneous type, it must be sized to meet the 180 F water demand at a rated flow. From Table 14, this rated flow is 6.94 gpm, or 416 gph. From Table 13, the required gas input, with a 40 deg temperature rise, is 204,000 Btuh. A heater meeting this input requirement may be selected from manufacturers' catalogs.

Solution b: In designing a system with a booster heater having storage capacity, the *hourly* flow demand of the dishwasher may be used instead of the *gallons per minute* flow demand used in *Solution a*. The flow demand from Table 14 is 69 gph when the dishwasher is operating at 100 percent mechanical capacity. However, The National Sanitation Foundation states that 70 percent of operating rinse capacity is all that is normally attained for this type of dishwasher. Therefore, the *hourly* flow demand is $0.70 \times 69 = 48$ gph. From Table 13, with a 40 deg temperature rise, the gas input required is 24,000 Btuh. A booster heater with this input may be selected from manufacturers' catalogs.

Hot water requirements for kitchens sometimes are also estimated on the basis of the number of meals served (assuming 8 dishes per meal) as follows:

1. 180 F water for single tank dishwasher
gph = 0.8 (number of meals served) ÷ (hours of service)
2. 180 F water for two-tank dishwasher
gph = 0.5 (number of meals served) ÷ (hours of service)
3. Hand washing, sink with gas burners
gph = 3 × capacity of sink (15-in. depth)
4. 140 F general purpose water (add to above)

$$\text{gph} = \frac{1.2 \text{ (number of meals served)}}{\text{(hours of service)} + 2}$$

5. Soda fountains and luncheonettes—Use 75 percent of Items 1, 2, 3, and 4.
6. Hotel meals, or other elaborate meals—Use 125 percent of Items 1, 2, 3, and 4.

METHODS OF HEATING WATER

Hot water may be heated either by the direct combustion of fuel, by an intermediate carrier such as steam or hot water, or by electrically heated surfaces. The simplest method is to have the fire on one side of a metal barrier and water on the other. In such a method, if the surfaces for transferring heat are small, and if the water carries a heavy proportion of precipitable salts, the water passages may soon become clogged with resultant cracking or burning of the surface. A familiar example of such trouble is the water back in the kitchen stove, or the pipe coil inserted into the firebox of a warm air furnace or small boiler. The critical water temperature at which the lime, magnesia, etc., collect on hot surfaces, varies with the character and proportions of the solids, but generally such deposits are not serious below 140 F.

Direct-Fired Water Heaters

Coal-burning, direct-fired water heaters may be constructed of cored cast-iron sections, or of steel. In some cases the external appearance of the cast-iron sections is the same as in heating boilers, but internally the cores are changed to enable the sections to withstand the city water pressure. In small capacity water heaters, efficiency is not considered so important as low first cost and ability to maintain a fire at a low rate of combustion, and consequently, such heaters are generally built with a *dry* section or firebrick lining at the base of the firepot to prevent too much chilling of the fuel. While mud and scale will eventually clog the waterways of any direct-fired heater, increased life may be obtained by providing a three-way cock in the return line between the heater and the bottom of the storage tank, so that water can be blown through the heater or the tank separately, at full line pressure, to clean out loose sediment. Cleanout openings in the bottom of the heater are advantageous, if used by operators for periodic cleaning out of sediment.

Oil-burning, direct-fired water heaters usually are of steel, and operate with higher flame temperature and better efficiency than commensurate sized coal-burning heaters. As they have the same tendency as coal boilers to accumulate lime deposits, the water passages should be large in cross-section and accessible for periodic cleaning.

The most common types of gas-fired water heaters are: (1) automatic storage heaters, (2) circulating tank heaters, (3) multi-coil heaters, (4) multi-flue or booster heaters, and (5) instantaneous heaters.

Automatic Storage Type. In this type, the heater, the storage tank, the insulation and the controls are all combined in a single unit.

Heaters of this type are available with storage tank capacities from 10 to 100 gal. Recovery capacity ranges from 3.8 to over 150 gal per hour based on a 100 deg rise in temperature. The smaller sizes, with storage capacities of 20 to 40 gal and inputs up to 50,000 Btuh, are commonly used for private residences, while larger sizes are used in many small and medium-sized commercial applications. When used in multiple, they are also satisfactory for restaurant installations.

Automatic storage heaters are usually encased in an outer