Table 8.... Maximum Daily (24-Hr) Requirements for Hot Water in Gallons

	No. of Rooms	Number of Bathrooms 1	2	3	4	5
Apartments and Private Homes	1	60	—	—	—	—
	2	70	—	—	—	—
	3	80	—	—	—	—
	4	90	120	—	—	—
	5	100	140	—	—	—
	6	120	160	200	—	—
	7	140	180	220	—	—
	8	160	200	240	250	—
	9	180	220	260	275	—
	10	200	240	280	300	—
	11	—	260	300	340	—
	12	—	280	325	380	450
	13	—	300	350	420	500
	14	—	—	375	460	550
	15	—	—	400	500	600
	16	—	—	—	540	650
	17	—	—	—	580	700
	18	—	—	—	620	750
	19	—	—	—	—	800
	20	—	—	—	—	850

Hotels	Room with basin	10
	Room with bath—transient	50
	Room with bath—resident	60
	2 Rooms with bath	80
	3 Rooms with bath	100
	Public shower	200
	Public basins	150
	Slop sink	30
Office Buildings	White-collar worker (per person)	2.0
	Other workers (per person)	4.0
	Cleaning per 10,000 sq ft	30.0
Hospitals	Per bed	80–100

ESTIMATING HEATING LOAD AND STORAGE CAPACITY

The maximum daily and the maximum hourly hot water demand form the basis for the selection of the heater and the storage tank.

In general, two-thirds of the total daily water consumption is hot water. For residential dwellings, a design value of about 20 to 30 gal per (person) (day) may be assumed, but it should be remembered that the hot water used will depend on the number of rooms and the number of bathrooms in any house or apartment. Table 8 gives estimates of the maximum hot water requirements in 24 hr in various types of buildings.

In estimating the size of hot water storage tank required, and the heating capacity to be provided, either from the boiler or from an independent domestic hot water heater, it is necessary to know the total quantity of water to be heated per day, and the maximum amount which will be used in any one hour, as well as the duration of the peak load.

In cases where the requirements for hot water are reasonably uniform, as in residences, apartment buildings, hotels, and the like, smaller storage capacity is required than in the case of factories, schools, and office buildings, where practically the entire day's usage of hot water occurs during a very short period. Correspondingly, the heating capacity must be proportionately greater with uniform usage of hot water than with intermittent usage, where there may be several hours between peak demands during which the water in the storage tank can be brought up to temperature. As a general rule, it is desirable to have a large storage capacity in order that the heating capacity, and consequently the size of the heater, or the load on the heating boiler, may be as small as possible.

Table 9.... Estimated Hot Water Demand Characteristics for Various Types of Buildings

Type of Building	Hot Water Required Per Person	Max. Hourly Demand in Relation to Day's Use	Duration of Peak Load Hours	Storage Capacity in Relation to Day's Use	Heating Capacity in Relation to Day's Use
Residences, apartments, hotels, etc.	40 gal per day[a]	1/7	4	1/5	1/7
Office buildings	2 gal per day[a]	1/5	2	1/5	1/6
Factory buildings	5 gal per day[a]	1/3	1	2/5	1/8
Restaurants				1/10	1/10
Restaurants 3 meals/day		1/10	8	1/5	1/10
Restaurants 1 meal/day		1/5	2	2/5	1/6

[a] At 140 F.

In estimating the hot water which can be drawn from a storage tank, it should be borne in mind that only about 75 percent of the volume of the tank is available, since, by the time this quantity has been drawn off, the incoming cold water has cooled the remainder down to a point where it can no longer be considered hot water.

Where steam from the heating boiler is used to heat domestic hot water, the computed load on the boiler should be increased by 4 sq ft EDR (equivalent direct radiation) for every gallon of water per hour heated through a 100 deg rise. The actual requirement is $(100 \times 8.33)/240 = 3.48$ sq ft per gal heated 100 deg. The value of 4 allows for transmission losses.

There are two methods in common use for estimating the hot water requirements of a building: (1) by the number of people, and (2) by the number of plumbing fixtures installed. Where the number of people to be served can be reasonably estimated, the data in Table 9 may be used.

Example 3: Determine the heater size and storage tank capacity for a residence housing five people.

Solution: From Table 9, a residence housing five people would have a daily requirement of $5 \times 40 = 200$ gal per day, and a maximum hourly demand of $200 \times 1/7 = 28.5$ gal. The heater should have a storage capacity of $200 \times 1/5 = 40$ gal, and a heating capacity of $200 \times 1/7 = 28.5$ gal per hr.

The conditions given in *Example 3* may be cited as average. It is possible to vary the storage and heating capacity by increasing and decreasing one over the other. Such a condition is illustrated in *Example 4*.

Example 4: Determine the required heater capacity for an apartment housing 200 people, if the storage tank has a capacity of 1000 gal. What heater capacity will be required if the storage tank is changed to 2500 gal capacity?

Solution: Assume an apartment house housing 200 people. From the data in Table 9: Daily requirements $= 200 \times 40 = 8000$ gal. Maximum hours demand $= 8000 \times 1/7 = 1140$ gal.

Duration of peak load = 4 hr. Water required for 4-hr peak $= 4 \times 1140 = 4560$.

If a 1000-gal storage tank is used, hot water available from the tank $= 1000 \times 0.75 = 750$. Water to be heated in 4 hr $= 4560 - 750 = 3710$ gal. Heating capacity per hour $= 3710/4 = 930$ gal.

If instead of a 1000-gal tank, a 2500-gal tank had been installed, the required heating capacity per hour would be $[4560 - (2500 \times 0.75)]/4 = 671$ gal.

Table 10 may be used to determine the size of water heating equipment from the number of fixtures. To obtain the *probable maximum demand*, multiply the total quantity for the fixtures by the *demand factor* in line 11. The heater or coil should have a water heating capacity equal to this *probable maximum demand*. The storage tank should have a capacity equal to the *probable maximum demand* multiplied by the storage capacity factor in line 12. *Example 5* will illustrate the procedure.

Example 5: Determination of heater and storage tank size for an apartment building from number of fixtures.

60 lavatories	× 2 =	120 gal per hr
30 bathtubs	× 20 =	600 gal per hr
30 showers	× 75 =	2250 gal per hr
60 kitchen sinks	× 10 =	600 gal per hr
15 laundry tubs	× 20 =	300 gal per hr
Possible maximum demand	=	3870 gal per hr
Probable maximum demand	=	3870 × 0.30
	=	1161 gal per hr
Heater or coil capacity	=	1161 gal per hr
Storage tank capacity	=	1161 × 1.25
	=	1450 gal

Although, in private dwellings a water temperature of 140 F is reasonable for dishwashing, in public places sanitation regulations call for 180 F water. Most of the dishwashing machines now available on the market require 180 F water. The amount of 180 F water needed in restaurants per day may be determined according to the method outlined by the American Gas Association,[a] in the following paragraphs:

1. Multiply the number of meals per day by the number of dishes per meal (6 for low-price restaurants, 8 for medium-price restaurants, and 10 for high-price restaurants) to determine the total number of dishes per day.
2. Divide the total number of dishes per day, as determined by method in paragraph 1, by the average number of dishes per rack to find the number of racks per day.
3. Multiply the number of racks per day by the gallons of 180 F water (using 1.5 for single tank machines and 0.75 for two tank machines). This product will give the gallons of 180 F water per day for rinse sprays.
4. Multiply the number of meal periods per day (one, two, or three) by the dishwashing tank capacity in gallons, giving the gallons of 180 F water per day necessary to fill the tanks.
5. Add values from paragraphs 3 and 4 to obtain the total number of gallons of 180 F water required per day.

For purposes other than dishwashing, a considerable amount of 140 F water is also used. To find the daily 140 F water requirement in a restaurant, multiply the total number of meals served per day by the gallons of 140 F water per meal. Low priced restaurants on the average utilize 0.9 gal of 140 F water per meal, while medium- and high-price restaurants use 1.2 and 1.5 gal per meal, respectively.[a]

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 tem-

Table 10.... Hot Water Demand per Fixtures for Various Types of Buildings

Gallons of water per hour per fixture, calculated at a final temperature of 140 F

	Apartment House	Club	Gymnasium	Hospital	Hotel	Industrial Plant	Office Building	Private Residence	School	Y.M.C.A.
1. Basins, private lavatory	2	2	2	2	2	2	2	2	2	2
2. Basins, public lavatory	4	6	8	6	8	12	6	....	15	8
3. Bathtubs	20	20	30	20	20	30	....	20	....	30
4. Dishwashers	15	50–150	....	50–150	50–200	20–100	....	15	20–100	20–100
5. Foot basins	3	3	12	3	3	12	....	3	3	12
6. Kitchen sink	10	20	....	20	20	20	....	10	10	20
7. Laundry, stationary tubs	20	28	....	28	28	....	....	20	....	28
8. Pantry sink	5	10	....	10	10	....	....	5	10	10
9. Showers	75	150	225	75	75	225	....	75	225	225
10. Slop sink	20	20	....	20	30	20	15	15	20	20
11. Demand factor	0.30	0.30	0.40	0.25	0.25	0.40	0.30	0.30	0.40	0.40
12. Storage capacity factor[a]	1.25	0.90	1.00	0.60	0.80	1.00	2.00	0.70	1.00	1.00

[a] Ratio of storage tank capacity to probable maximum demand per hour.