= 28.5 gal. The heater should have a storage capacity of 200 × 1/5 = 40 gal and a heating capacity of 200 × 1/7 = 28.5 gal per hour.

The conditions given in *Example 1* 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 2*.

*Example 2.* Assume an apartment house housing 200 people. From the data in Table 1: Daily requirements = 200 × 40 = 8000 gal. Maximum hours demand = 8000 × 1/7 = 1140 gal. Duration of peak load = 4 hours. Water required for 4-hour peak = 4 × 1140 = 4560.

If a 1000 gal storage tank is used, hot water available from the tank = 1000 × 0.75 = 750. Water to be heated in 4 hours = 4560 − 750 = 3710 gal. Heating capacity per hour = $\frac{3710}{4}$ = 930 gal.

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

In cases where only the number of fixtures is known, the data in Table 2 have been found satisfactory.

*Example 3.* An apartment building has a hot water requirement as follows:

| | | |
|---|---|---|
| 60 lavatories | × 2 = | 120 gal per hour |
| 30 bath tubs | × 20 = | 600 gal per hour |
| 30 showers | × 75 = | 2250 gal per hour |
| 60 kitchen sinks | × 10 = | 600 gal per hour |
| 15 laundry tubs | × 20 = | 300 gal per hour |
| Maximum hourly requirement | = | 3870 gal per hour |
| Hourly heating capacity | = 3870 × 0.30 = | 1161 gal per hour |
| Storage capacity | = 1161 × 1.25 = | 1450 gal per hour |

TABLE 2. HOT WATER DEMAND PER FIXTURE 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. |
|---|---|---|---|---|---|---|---|---|---|---|
| Basins, private lavatory | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Basins, public lavatory | 4 | 6 | 8 | 6 | 8 | 12 | 6 | .... | 15 | 8 |
| Bathtubs | 20 | 20 | 30 | 20 | 20 | 30 | .... | 20 | .... | 30 |
| Dishwashers | 15 | 50–150 | .... | 50–150 | 50–200 | 20–100 | .... | 15 | 20–100 | 20–100 |
| Foot basins | 3 | 3 | 12 | 3 | 3 | 12 | .... | 3 | 3 | 12 |
| Kitchen sink | 10 | 20 | .... | 20 | 20 | 20 | .... | 10 | 10 | 20 |
| Laundry, stationary tubs | 20 | 28 | .... | 28 | 28 | .... | .... | 20 | .... | 28 |
| Pantry sink | 5 | 10 | .... | 10 | 10 | .... | .... | 5 | 10 | 10 |
| Showers | 75 | 150 | 225 | 75 | 75 | 225 | .... | 75 | 225 | 225 |
| Slop sink | 20 | 20 | .... | 20 | 30 | 20 | 15 | 15 | 20 | 20 |
| Hourly heating capacity factor | 30% | 30% | 40% | 25% | 25% | 40% | 30% | 30% | 40% | 40% |
| Storage capacity factor | 125% | 90% | 100% | 60% | 80% | 100% | 200% | 70% | 100% | 100% |





## 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 water surfaces of heat transfer are small, and if the water carries a heavy proportion of precipitable salts, the water passages may soon clog and then burn out. A familiar example of such trouble is the water back of the firebox 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 a serious trouble with water temperatures lower than 140 F.

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 fire-brick lining at the base of the fire-pot to prevent too much chilling of the fuel. While mud and scale will eventually clog the water ways 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. Clean-out openings in the bottom of the heater are advantageous if used by operators of water heaters 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 then commensurate sized coal-burning heaters. They have the same tendency as coal boilers to *lime up*, and the water passages should be large in cross-section and accessible for periodic cleaning.

Gas-burning direct-fired water heaters may be of the instantaneous or storage type. Instantaneous heaters are generally constructed of spiral water tubes of copper around which the products of combustion circulate upward from high capacity burners. Storage-type heaters may include in one unit an insulated storage tank, a combustion chamber, flues, burner equipment and controls, or may consist of a separate storage tank and external direct-fired water heater, which may be a so-called *side-arm* heater for small capacity or a gas-fired boiler for larger capacity. Gas boilers used for direct hot water supply must be able to withstand the city water operating pressure. While direct-fired gas heaters are used generally for residences and small installations of 100 gal storage capacity or less, indirect heaters are recommended for larger installations.

In the indirect method either steam or hot water is used for heating the water. With steam the water to be heated is preferably circulated around the outside of the steam tubes which are submerged within a