

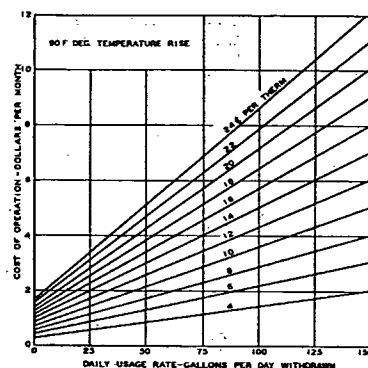


Fig. 8. . . . Monthly Cost of Operation of Gas Water Heaters*

jacket or shell and are designed to be installed directly in modern kitchens, play rooms or utility rooms. Some units are of table top height and may be installed in line with kitchen cabinets, ranges, etc. Those with inputs of 5,000 Btuh, or less, do not require a vent connection.

Domestic automatic laundry washers add severe peak hot water demands to the family hot water needs. To meet the peak demands of three consecutive washing cycles, the American Gas Association recommends the use of a heater capable of supplying 81 gal of hot water during a two hour period. The following automatic storage type heaters will meet this requirement:

Inlet Water Temperature F	Tank Capacity gal	Input Rating Btuh
40	30	45,000
	40	42,000
50	30	40,000
	40	35,000
60	30	35,000
	40	30,000

Fig. 8 shows the monthly operating cost for gas water heaters with various daily usage rates.*

Circulating Tank Heaters. Heaters of this type are commonly referred to as *side-arm* or *tank* heaters where the input rating ranges from about 15,000 to 30,000 Btuh. Larger circulating tank heaters are very frequently used for multi-family, institutional, commercial and industrial applications, and this class of heater is briefly described under *Multi-Coil Heaters*.

The small *side-arm* heater is used for domestic hot water service in conjunction with a 20 to 40 gal storage tank. The heater contains coils of copper tubing $\frac{3}{4}$ in. to 1 in. dia through which the cold water circulates and becomes heated by a gas burner located under the coil. These heaters may be either manually or automatically controlled. The performance

of the latter type is similar to that of the automatic storage type heater, but if the tank is not insulated, the operating costs will be higher.

Multi-Coil Heaters. For the very large homes, apartment houses, institutions, restaurants, clubs and many other applications demanding more water than conventional types of heaters can supply, a so-called large volume water heater is recommended. In this field are found the multi-coil heaters, which externally look like instantaneous heaters, but which are equipped with a series of separate coils connected to manifolds, and are in turn operated by a thermostat inserted in an insulated, horizontal storage tank.

Heaters of this type are practically unlimited in their range of application insofar as delivery of hot water is concerned. They have recovery rates from 15 to 445 gal per hour through a 100 deg temperature rise and, in addition, may be installed in multiple if more capacity is required.

Multi-Flue or Booster Type Heaters. These heaters bridge the gap between a multi-coil heater with a large storage tank and an instantaneous heater having no hot water storage tank.

The multi-flue heater is similar in design to a storage type heater, except that the ratio of gas input or recovery rate to storage tank capacity is much greater, having an input of 5000 or more Btuh per gallon of storage capacity.

As a result of this high input ratio, heaters of this type are designed with multiple flues through the tank in order to provide the necessary heat transfer surface—hence the name *multi-flue* heater.

These heaters are intended for large volume installations and their application is suitable for any job where a multi-coil or instantaneous heater would be considered. While the multi-flue heater can be used as a complete water heating system by itself, it is frequently advisable to use it in conjunction with an auxiliary storage tank. The most economical ratio between storage capacity and recovery capacity will depend upon the particular hot water demand requirements.

Multi-flue heaters can be used successfully in hard water districts where coil-type heaters incur trouble due to severe liming conditions.

Instantaneous Heaters. The automatic instantaneous or continuous flow type of water heater is a self-contained unit including a large copper coil suspended above a battery of burners and all enclosed within a casing, together with necessary valves and thermostats. The principle of operation is simple. The cold water is heated as it flows through the long copper coil. The pressure drop that occurs when a faucet is opened provides the power which moves the flow valve or water motor piston forward, overcoming a normal spring tension and forcing the gas valve open. Gas flows at once to the burners and is ignited by a pilot burner.

Instantaneous-type heaters are recommended for intermittent demand where hot water storage is wasteful; for hot water demands for long periods that would exhaust tank supply; for water conditions that corrode iron tanks where use of non-corrosive tanks is impracticable. They are often used in clubs, fraternity houses, shower baths, industrial washrooms, restaurants, gymnasiums, ball parks, and recreational centers.

Instantaneous heater capacities range up to 7.43 gal per minute at 100 deg rise, or 445 gal per hour.

The American Gas Association tests water heaters for conformance with the American Standard Approval Requirements Z21.10.1 and Z21.10.2. Approved gas water heaters are listed in the *A.G.A. Directory of Approved Appliances*, which also gives the input rates and recovery capacities for

Table 16. . . . Standard Rated Capacities of Electric Water Heaters

Tank Size Gallons		Rated Input, Watts		
		Two-Unit Heater		Single-Unit Heater
Nominal	Range	Primary	Secondary	
30	30 to 35	600	1000	1500
40	35 to 45	750	1250	2000
60	45 to 55	1000	1500	2500
66	55 to 70	1250	2000	3000
80	70 to 90	1500	2500	4000
110	90 to 115	2000	3000	
120	115 to 135	2500	4000	
140	135 to 175	3000	4000	

American Standard C72.1-1949.

each approved model. The proper installation of gas water heaters is covered in the *American Standard Installation of Gas Appliances and Gas Piping*, Z21.30-1959, or the similar Standard No. 54 of the National Fire Protection Association.

Electric Water Heaters

Electric water heaters for hot water service in residences and commercial buildings are predominantly of the automatic storage type. These generally have a cylindrical tank mounted vertically, with a primary electric heating element or resistor near the bottom and a secondary unit located within the upper one-quarter of the tank. Water heaters of single-heating-unit type have an element only at the bottom. The first cost of automatic electric heaters is somewhat higher than that of fuel-fired types, owing to the need for larger tank storage to compensate for the limitation of recovery rate, since for economical electric service the connected load should be kept low. Large tank capacity is necessary also with off-peak operation, where there are low electric rates for this class of service.

Instantaneous heaters are used in special cases only, because of the high electric power input required, for example, 15 kw to deliver 1 gpm with 100 deg temperature rise.

Capacities of household automatic storage-type water heaters, as partially standardized within the electrical industry, range from 30 to 140 gal nominal tank capacity with input 1600 to 7000 watts. Wattage input ratings of two-unit heaters are based on approximately 30 watts per gallon of tank capacity for the secondary unit and 20 watts for the primary unit. Single-unit heaters have tank sizes up to 80 gal with an input of 4000 watts; the ratings being based on 50 watts per gallon. The schedule of heater capacities shown in *American Standard C72.1, Household Automatic Electric Storage Type Water Heaters* is reproduced in Table 16.

The wattages listed in Table 16 are minimum recommended values for continuous service. Some departure from the standardized watts-per-gallon ratios is to be expected, as experience indicates that increased hot water use with automatic laundry machines and dishwashers may call for larger heating units than have heretofore been found desirable. With off-peak operation the watts-per-gallon ratio likewise must be raised.

Rated voltage for water heaters is 240 volts, with a range

220 volts minimum to 248 volts maximum, but specified test performance is required to be met only at the 236 volts taken as normal design voltage. Thermostats controlling the heating units are normally set for 150 F, with upper limit of adjustment range of 170 to 180 F.

Heating units are of three general types, all of which give approximately the same service efficiency if selected to suit the operating conditions, as follows:

1. Immersion element, inserted horizontally through a threaded or flanged opening in side of tank.
2. Strap-on unit, externally mounted directly against the tank shell and held in close contact by a band or strap encircling the tank.
3. Side-arm or outside circulation unit, consisting of a vertical cylindrical housing or heat exchanger which contains an immersion heating element, connected by pipes into top and bottom of the storage tank.

For the third type, which is less commonly used, thermostats separate from the heating units are mounted within the storage tank.

A fourth type of heater, applied only in exceptional cases and for large installations with alternating current, employs the water itself as a resistor in which electrodes are immersed. Close temperature regulation and compensation for the effect of variable amount and composition of solids and gases in the water are difficult to obtain with small unattended heaters of this kind. The electrode type of construction has in the past been used also for generating steam in so-called electric boilers, mainly for industrial plants; however, in only few instances today is electric energy obtainable at cost low enough to make it competitive with fuel-fired boilers for steam production.

Tanks of electric heaters are regularly constructed to withstand a 300 psig hydrostatic test pressure and are rated for a safe working pressure of 127.5 psig. Materials in contact with the water are selected to resist corrosion caused by solid and gaseous impurities occurring in some locations. It may be desirable also to provide *sacrificial metal* anodes of magnesium, zinc, or alloys to protect the tank and its piping connections. A safety relief valve of pressure-actuated type must be included; it may optionally be actuated also by internal temperature. A heat trap at the hot water outlet, if not provided by manufacturer within or outside the tank shell and inside the insulated jacket, may be placed in the external piping. The trap consists of vertical pipe at least 6 in. long having downward flow, to retard circulation of hot water within the distribution piping under standby conditions.

Delivery performance efficiency of heaters meeting the electrical-industry standard 24-hour operation test is 90 percent minimum, which allows 10 percent for thermal loss through the jacket insulation. In service, the quantity of water withdrawn from an automatic storage heater has considerable influence on overall efficiency. With increasing quantities, service efficiency rises and approaches the upper limit fixed solely by the jacket thermal loss; on the other hand, if little or no water is drawn, efficiency approaches zero since no useful work is done. Hence oversizing a water heater by having too large a tank impairs the service efficiency. Excessive heating-unit wattage causes undesirably high electric demand. Undersizing of heaters obviously results in inadequate and unsatisfactory hot water service.

Fig. 9 shows the monthly operating cost for electric automatic storage-type heaters with various daily usage rates.*

Selection of electric heater capacity for residences is made by reference to rating tables which take into account the