A.O. SMITH

RESIDENTIAL SIZING

INTRODUCTION

A.O. Smith residential water heaters are produced in a large variety of tank sizes and heat inputs to permit the selection of the one best suited to do the job. Ideally this heater would have a combination of storage and heat input equal to the usage.

In addition to the design factors and the sizing examples which follow, a glossary section provides detailed explanations of selected terminology. This is done to avoid expanding the content of the sizing procedure.

STORAGE + HEAT INPUT = WATER AVAILABLE TO MEET USAGE

DESIGN FACTORS

These design factors are the result of combining A.O. Smith engineering test data and practical experience to form a usable guide for the selection of minimum water heater tank sizes and heat inputs. As stated previously, the factors may be adjusted to suit individual needs.

1. Two hour peak usage period.

Residential peak usage, based on accepted practice, is the two hour period during the day when the heaviest draw of hot water will occur.

For example, from 7:00 to 9:00 A.M.

2. Gallons of 140°F hot water required:

- 20 gallons per person for the first two persons.
- 5 gallons per person for each person over the first two.
- 10 gallons for each full bath over the first bath.
- 10 gallons for an automatic dishwasher.
- 20 gallons for an automatic clothes washer.

3. Storage tank size selection:

NOTE: The draw efficiency of a gas or electric water storage tank is considered to be 70%.

- 30 gallon size (21 gallon draw) for one bath residence.
- 40 gallon size (28 gallon draw) for two bath residence -or- one bath with an automatic clothes washer.
- 50 gallon size (35 gallon draw) for three bath residence -or- two baths with an automatic clothes washer.
- When a whirlpool tub is part of the home equipment, it is suggested that the heater storage tank capacity, or the sum total of an additional auxiliary storage tank and heater, be sized in accordance with the following table. This method of tank sizing, will in most cases, cancel all previous statements as noted above concerning tank sizing.

4. Heat input VS recovery capacity.

Gas water heater recovery table (calculated at 75% recovery efficiency).

GALLONS

Tub Capacity To Overflow Outlet	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**
(@ 140°F Water) Min. Stored Water Capacity	65	71	80	89	98	108	117	125
(@ 160°F Water*) Min. Stored Water Capacity	54	59	66	74	82	90	97	104

* A mixing valve is recommended to be installed in heater or auxiliary tank hot water outlet piping.

Based on a tub water temperature of 105°F.

Gas Water Heater Recovery Table (Calculated at 75% Recovery Efficiency)

Input Rating Btuh	GPH Recovery At Indicated Temperature Rise				
	60°	70°	80°	90°	100°
30,000	45.5	39.0	34.1	30.3	27.3
33,000	50.0	42.9	37.5	33.3	30.0
35,000	53.0	45.5	39.8	35.4	31.8
40,000	60.6	51.9	45.5	40.4	36.4
43,000	65.2	55.8	48.9	43.4	39.1
50,000	75.8	64.9	56.8	50.5	45.5
60,000	90.9	77.9	68.2	60.6	54.5
70,000	106.1	90.9	79.5	70.7	63.6
80,000	121.2	103.9	90.9	80.8	72.7
90,000	136.4	116.9	102.3	90.9	81.8
100,000	151.51	129.9	113.6	101.0	90.9

Electric Water Heater Recovery Table (Calculated at 100% Recovery Efficiency)

Heating Element Wattage	GPH Recovery At Indicated Temperature Rise				
	60°	70°	80°	90°	100°
750	5.1	4.4	3.8	3.4	3.1
1000	6.8	5.8	5.1	4.6	4.1
1250	8.5	7.3	6.4	5.7	5.1
1500	10.2	8.8	7.7	6.8	6.1
2000	13.7	11.7	10.2	9.1	8.2
2250	15.4	13.2	11.5	10.2	9.2
2500	17.1	14.6	12.8	11.4	10.2
3000	20.5	17.5	15.4	13.6	12.3
3500	23.9	20.5	17.9	15.9	14.3
4000	27.3	23.4	20.5	18.2	16.4
4500	30.7	26.3	23.0	20.5	18.4
5000	34.1	29.2	25.6	22.7	20.5
5500	37.6	32.2	28.2	25.0	22.5
6000	41.0	35.1	30.7	27.3	24.6

Notes on element operation:

(a) Two element water heaters, simultaneous element operation; figure the upper element recovery at 1/3* the GPH shown for wattage, figure lower element at the GPH shown.

* The bottom element contributes to the heat at the top of the tank. This tends to shut off the top element. Metered tests indicate the upper element operates about 1/3 of the time.

(b) Two element water heaters, non-simultaneous (interlocking) element operation; figure the largest wattage element recovery only – at the GPH shown.

(c) Single element water heaters; figure the recovery at the GPH shown.

5. Storage VS input.

Water heater selection is best made on the basis of hot water usage. However, calculations may lead to a combination of tank size and heat input which doesn't exist. In this case, the tank size and/or heat input must be balanced to achieve the desired result.

Therefore, it is necessary to understand that heat input provides hot water, at the hourly recovery rate, hour after hour. The storage tank represents instant hot water at greater-than-heater recovery.

The supply of hot water in the storage tank cannot be replenished until the peak usage period has ended and heater recovery is available for this purpose.

Having enough storage tank capacity is important when large quantities of hot water are required in a short period of time. If the peak usage period is for an extended period of time (more than two hours), the heater recovery capacity assumes major importance.

DESIGN EXAMPLES

GIVEN: Family of four persons
Two full baths
Automatic dishwasher
Automatic clothes washer

HOT WATER REQUIRED:

Two persons @ 20 gallons/person 40 gallons
Two persons @ 5 gallons/person ..... 10 gallons
Second full bath ..... 10 gallons
Automatic dishwasher ..... 10 gallons
Automatic clothes washer ..... 20 gallons
Total two hour peak hot water usage ..... 90 gallons

*This means 45 gallons of hot water per hour, for two hours, must be provided by the A. O. Smith water heater through storage and heat input.

Storage Tank Size:

According to design factor 3, the storage tank size is 50 gallons.

The draw efficiency of the storage tank is considered to be 70%. Therefore, 35 gallons of "usable" hot water is available from the tank.

Storage VS Input:

90 gallons two hour peak hot water usage
-35 gallons of hot water from storage tank
55 gallons of hot water to be produced by heat input during two hour peak.

This means 27.5 gallons of hot water per hour must be provided by heat input at the accepted temperature rise used in the locale.

GAS WATER HEATER SELECTION

From the gas water heater recovery table it is found that, at 90° temperature rise, 27,225 Btuh will produce 27.5 GPH.

An A. O. Smith gas water heater with at least a 50 gallon storage tank and at least 27,225 Btuh input is required to meet the peak usage requirements. Consult A. O. Smith water heater specification sheets to determine model needed.

ELECTRIC WATER HEATER SELECTION

NOTE: In the following example the fuel used is electricity instead of gas. This does not change the amount of hot water required by the family of four. It may mean a change in the ratio of tank storage versus heat input to reflect the availability or amount of electricity which is obtainable during the peak usage period.

Two element, non-simultaneous operation:

Upper element – 4500 watts
Lower element – 4500 watts

90 gallons two hour peak hot water usage
-35 gallons of hot water from storage tank
55 gallons of hot water to be produced by heat input during two hour peak.

Figure recovery of one element ... the one with largest wattage. In this example both elements are of same wattage.

20.5 GPH recovery x 2 hours = 41.0 gallons available from element recovery. This is less than the amount of recovery needed.

55.0 gallons of hot water needed from heat input (using 50 gallon storage tank)
-41.0 from two hour recovery of (1) 4500 watt element
*11.0 gallons of hot water "short" two hour peak

It is necessary to increase the size of the storage tank and/or element wattages to satisfy the calculated peak usage. Check your local utility for maximum allowable wattage permitted for water heating. They may also have a minimum storage tank size requirement. Consult A. O. Smith water heater specification sheets to determine model needed.

* To allow for draw efficiency, divide the "shortage" by .7 when increasing tank size.

FOR GLOSSARY REFER TO FOLLOWING PAGE B 204.0

GLOSSARY

The following provides detailed explanations of selected terminology used in the sizing procedure. This is to promote a greater understanding of water heating terms, formula and theory.

- **BTU...**abbreviation for the British thermal unit, which is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Stated another way, 8.25 Btu will raise the temperature of one gallon of water one degree.

A Btu may be sensed and visualized as about the amount of heat produced by burning one wooden match. One watt-hour of electricity produces 3.413 Btu.

This is the formula for determining the Btu required to heat a given quantity of water a certain number of degrees:

Gallons x 8.25 x 1.0 x temp. rise = Btu

Where..gallons =Total gallons of hot water required
8.25 = Weight of one gallon of water
1.0 = Specific heat of water (See Specific heat)
Temp. Rise = Difference in degrees between lowest incoming water temperature and desired hot water temperature.
Btu = **Gas water heaters;** divide answer by .75 (recovery efficiency) to obtain equivalent gas input in Btu.
Electric water heaters; multiply by 0.293 to obtain element wattage equivalent.
In actual practice a combination of storage and input is used to assure the availability of hot water.

- **Draw efficiency** is considered to be 70% in this report. When using storage type heaters it is common practice to assume 70% of the storage capacity of the heater tank may be drawn before dilution by incoming cold water lowers the hot water temperature below an acceptable level under normal draw conditions. For example, a 40 gallon storage tank would deliver about 28 gallons of usable hot water.

- **Input rating...**The amount of fuel in British thermal units (Btu) consumed by a gas or oil water heater in an hour. In an electric water heater input is usually expressed in watts or kilowatts. Consuming one watt-hour of electricity produces 3.413 Btu.

- **Interlocking...**(See **Non-Simultaneous**)

- **Non-Simultaneous (Interlocking)** element operation is where both of the heating elements in an electric water heater are not permitted to operate at the same time. The electrical circuit is interlocked through the upper thermostat to prevent simultaneous operation.

- **Recovery (capacity)**, the amount of water in gallons per hour, raised at a given recovery efficiency and Btuh input. Refer to Recovery Table.

This is the formula for determining recovery capacity:

Input x efficiency = Recovery in GPH (See Btu)
8.25 x temp. rise

Efficiency = .75 for gas-fired water heaters
1.0 for electric water heaters
(also see **Recovery efficiency**)

- **Recovery efficiency...**The ratio of the heat in the water delivered at the heater outlet to the heat input of the heating unit. Also see **Btu.**

Gas-fired residential water heaters are generally considered to have a 75% recovery efficiency. This means 75% of the total heat produced by the burner is absorbed into the water in the tank. The remaining 25% of the heat is used to move the products of combustion through the flue to the outdoors.

Electric residential water heaters are generally considered to have a 100% recovery efficiency. This is because immersion style elements place all the heat into the water and there is no flue.

- **Simultaneous** element operation is where both of the heating elements in an electric water heater are permitted to operate at the same time if necessary. The actual operation of each element is individually controlled by its own thermostat.

- **Specific heat,** the amount of heat required to raise the temperature of a given weight of a substance one degree as compared with the amount of heat required to raise the temperature of the same weight of water 1° at some specified temperature.

- **Storage tank,** used for storing hot water in advance of needs. Properly sized, the tank permits large volumes of hot water to be drawn from the system at flow rates exceeding the recovery capacity of the heater. Also see **Draw efficiency.**

- **Temperature rise,** the amount of temperature difference (between incoming and outgoing water) in degrees Fahrenheit.

- **Draw efficiency,** the amount of water that can be drawn from a storage tank, at a 3 gpm flow rate, before the temperature drops 30°F. Heater outlet water temperatures below 110°F is generally not considered as satisfactory or usable.

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SCHOOLS

See page B 421.0 for Bradley wash sinks data.
See page B 115.0 for shower head water usage.

REQUIREMENTS

The modern school will usually require a large supply of both general purpose 140°F water and 180°F sanitizing water. Generally speaking, a system should have 140°F water in storage for a direct supply to the cafeteria sinks and slop sinks. Gymnasium showers and lavatory sinks should be supplied water at a temperature of approximately 110°F through a mixing valve from this 140°F tank. This 110°F temperature is mandatory in some states, particularly for use in elementary schools.

Schools that maintain swimming pools should provide for pool heating. This is best accomplished by separate direct-fired pool heaters.

The 180°F water for the cafeteria can be supplied by a booster heater selected from models shown for the desired fuel. The two-temperature Booster-Recovery System for gas-fired copper type equipment is also recommended. This system permits storage at the 140°F general purpose temperature and recirculates through the same heater for boosting to 180°F. Pumps are generally required to recirculate the sanitizing rinse water because of the distances usually involved. This recirculation of 180°F water is ideally handled by the patented A. O. Smith Shure-Temp Booster-Recovery System. Separate pump should be used to recirculate 140°F and 120°F water.

Supplying heat and hot water for all types of buildings should be accomplished through separate systems to obtain greater economy and flexibility and better performance for both needs. However, where the hot water supply is taken from the central heating system in the winter, the use of an A.O. Smith commercial water heater with the same storage tank will provide definite benefits. The water heater(s) can be used to augment the capacity of the system and to permit shutdown of heating system for repairs or during mild weather. Again, the patented Shure-Temp Booster-Recovery system will have a dual advantage. When the heating system is in operation, the A.O. Smith equipment will serve mainly as a recirculating booster system. But, when there is no space heating requirement, the system will automatically supply both the general purpose and sanitizing rinse water. With year-round programming at many schools, it is necessary to have a hot water supply available during the summer months.

CAFETERIA

Hot water requirements in school cafeterias are generally 30 percent less per pupil than the per person average of a restaurant. By reducing the figure used for the total number of students by 30 percent, it is possible to use the A. O. Smith restaurant sizing tables given in the food service sizing section, to establish the two-temperature hot water requirements for a school cafeteria. When sizing for booster water heaters only, consult the food service sizing section. Most A. O. Smith commercial water heaters are approved by the NSF; see submittal sheets.

In large schools having two-period or three-period lunch programs, the possibility that peak shower and kitchen demands might occur simultaneously should be considered when sizing water heating equipment.

GYMNASIUM SHOWER LOAD

Using a flow restricting device, the average shower head delivers 3 GPM of 105°F hot water. This requires 2 GPM of 140°F water. All shower heads, multiple-use wash fountains, and lavatory basins, should be considered to be in operation for 10 minute period after each gym class. In a co-educational school, the girls and boys gymnasium showers are assumed to be in use simultaneously. If the system is for gymnasium shower usage, it will normally supply the hot water for the visiting and home teams. This shower load is essentially a dump load and should be provided by the storage tank, with sufficient heater recovery capacity to replenish the tank between classes, usually a period of three-quarters to one hour's time.

MAINTENANCE HOT WATER

The building cleaning load occurs at a time when the showers are cafeteria are not normally in use. This hot water demand is less than either of these loads, so it is not considered in sizing.

OFFICE BUILDINGS
COUNTRY CLUBS
LUNCH COUNTERS

OFFICE BUILDINGS

Hot water requirements in office buildings are usually to supply lavatories during the day and for cleanup during the evening. Tests have shown that 3 peak usage periods normally exist each day with each being approximately 30 minutes in duration. Usage demand will be about 0.4 gallons per person maximum per hour. When expected number of persons is not known, some designers will presume 1 person per 100 sq. ft. areas. Ample storage capacity must be provided to meet these relatively short demand periods. Recovery capacity of the equipment to replenish the storage tanks can be based on a 2 to 3 hour period.

Additional loads around the building such as restaurants, showers, and beauty parlors should be determined from section of this manual that pertain to that usage, and added to the basic load.

Size and type of water heating system recommended, must relate to the total load. Type of fuel generally must relate to overall planning of the building. In all cases, the water heating equipment should be separate from the space heating boilers since heat is not required on a year round basis. In some cases, separate water heaters are installed on each floor and would best be served with a self-contained type water heater.

COUNTRY CLUBS

There are generally three types of water heating applications in a country club: dining room, swimming pool, and the locker room showers.

The restaurant hot water sizing should be done in accordance with the data given in section B 101, food service sizing.

The swimming pool heater sizing should be considered separately.

The heaviest hot water usage in a country club occurs in the locker room showers. The heaviest usage of the showers will be encountered during a tournament. The recovery capacity of the water heating equipment should be equal to 75 percent of the total possible hot water hourly usage of the shower heads. The storage tank capacity should be equal to approximately one quarter of the maximum hourly usage. The flow rate of the individual shower heads may be obtained from the manufacturer's data sheet, or by specifying a flow restricting device to obtain a specific GPM flow rate. Shower water is calculated at 105°F and should in most cases be limited to a maximum of 3 GPM. This is equivalent to 2 GPM of 140°F water from the hot water heating system. Hot water is usually stored at 140°F and mixed down at the shower head. Hot water for lavatory use should be added to the shower load.

The restaurant and shower demands may be concurrent. If one system is used to supply both needs, the equipment must be sized accordingly. In many cases, it is advantageous to provide separate systems for these two major usages. As with most commercial water heating applications, these demands are best supplied when not incorporated as part of the space heating system.

Normally a country club has its heaviest demand during the summertime when the incoming cold water temperature is at least 50°F. This factory should be considered when sizing heaters.

LUNCH COUNTERS AND SODA FOUNTAINS

As a restaurant, general purpose hot water and sanitizing rinse are needed. The hot water needs of these similar applications may be obtained by using charts in food service sizing section. A factor of 0.7 is generally applied to the number of people served since a lesser number of dishes is used per meal.

The sizing may also be done on a fixture basis. To determine the total demand, additional lavatories and hot water outlets must be added if used at the same time as the fountain.

General purpose hot water is sometimes supplied by the central heating system of the building. If this is the case, only a booster heater is needed for the sanitizing rinse. See equipment section for selection of booster. Where the heater cannot be located in close proximity of dish and glass washing equipment, the water must be recirculated.

Most A. O. Smith commercial heaters are approved by the NSF; see submittal sheets.

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HOT WATER REQUIREMENTS APARTMENTS

TABLE A
THREE HOUR PEAK PERIOD
USE WITH TABLES 3 hr. A THRU 3 hr. G.

APARTMENTS

This table has been prepared to serve as a guide for estimating the Three Hour hot water demand for various sized apartment buildings. Minimum storage capacities are also shown. The table assumes an average occupancy of 2 1/2 persons per apartment and 5 minute showers.

NOTE: Estimated Three Hour demands shown include shower load and other minor uses such as lavatories and residential dishwashers. Other major hot water consuming appliances such as clothes washers will increase the total demand. Consult manufacturers specifications for hot water consumption and increase generating and storage capacity accordingly.

IMPORTANT: IF APARTMENT BUILDING HOUSES STUDENTS, USE SIZING CHART ON PAGE B 107.0 (HOT WATER REQUIREMENTS FOR DORMITORIES). IF THE MAJORITY OF APARTMENT RESIDENTS NEED TO BE SOMEWHERE IN THE MORNING (WORKING COUPLES, FAMILIES WITH SCHOOL AGED CHILDREN, ETC.) USE THE INFORMATION BELOW AND SELECT PRODUCTS FROM THE TWO HOUR AVAILABILITY TABLES.

TABLE A: HOT WATER REQUIREMENTS - APARTMENT BUILDINGS

(1) Number of Apartments (2 1/2 Persons)	(2) Actual No. of Persons	(3) Gal. Required 3 HR Period 140°F Water				(4) Minimum* Storage Cap.
		2 GPM Shower HD Flow		3 GPM Shower HD Flow		
		40°F Inlet	60°F Inlet	40°F Inlet	60°F Inlet	
1-3	7	57	44	85	66	50
4	10	73	59	110	88	60
5-6	15	109	87	164	131	72
7-8	20	147	117	220	176	85
9-10	25	183	147	275	220	100
11-15	37	250	200	375	300	113
16-20	50	334	267	500	400	130
21-25	62	414	331	620	496	148
26-30	75	500	400	750	600	162
31-35	87	580	464	870	696	175
36-40	100	667	534	1000	800	188
41-45	112	695	556	1042	834	200
46-50	125	734	587	1100	880	210
51-75	187	1035	828	1552	1242	255
76-100	250	1317	1054	1975	1580	300
101-125	312	1581	1265	2370	1896	325
126-150	375	1851	1481	2775	2220	360
151-175	437	2098	1679	3146	2517	395
176-200	500	2335	1868	3500	2800	410
301-250	625	2751	2201	4125	3300	500
251-300	750	3002	2401	4500	3600	600
301-350	875	3502	2801	5250	4200	700

For conditions other than those stated above, consult your A.O. Smith supplier.

*Storage capacities shown are theoretical minimums. See page A 401.0 for storage tank sizes carried in stock and page A 413.0 for insulated tanks.

Diversity factors as previously mentioned have been used in calculating expected hot water requirements.

TO USE TABLE A

1. Determine number of apartments from Column (1).
2. Determine number of occupants from Column (1). NOTE: If average occupancy differs from 2 1/2 persons per unit, disregard Column (1) and use Column (2) "Actual Number of Persons" for estimating Three Hour demand and minimum storage capacity.
3. Read expected Three Hour demand from Column (3) for either 40° or 60°F inlet temperature.
4. Read minimum system storage capacity from Column (4).
5. Consult appropriate availability table for equipment selection. (Be sure storage capacity of system selected is no less than shown in Column (4).)

See reverse side for examples.

APARTMENT BUILDING EXAMPLE

Problem: What A.O. Smith equipment will provide enough hot water for a 30-unit apartment building with 75 occupants at 40°F inlet temperature?

This is known

Number of Apartments	Actual Number of Persons
30	75

Find this on TABLE A : APARTMENTS (pg. B 103.0)

Gal. of 140°F water required in 3 hr. period, 40°F Inlet	Minimum Storage Capacity
750	162

Equipment must have: Minimum Storage Capacity of: 162 gallons
and in a 3 hr. period, heat to 140°F: 750 gallons

Next, choose the type of fuel most suited to your installation: gas, oil or electricity. Use the THREE HOUR AVAILABILITY TABLES on pages B 109.0 and 110.0 to complete the equipment selection. Space limitations, installation costs and difference in cost of various heater and tank combinations that meet minimum storage and recovery requirements will naturally influence the final selection of equipment.

GAS

COPPER HEAT EXCHANGER TYPE WATER HEATER W/AUXILIARY STORAGE TANK

Table 3 hr. A on page B 109.0 shows the next larger storage tank above 162 gallons is T-200. Read down the column to find the next larger gallons provided above 750 is 775 gallons. Read left to find HW-225M as the correct model.

Recommended equipment: One HW-225M and one T-200 storage tank.

GAS-FIRED TANK-TYPE WATER HEATERS — MANIFOLDED

Table 3 hr. B on page B 109.0 shows the next larger gallons storage above 162 is 200, found under the "Two Heaters" column for models BT-100. However, since the gallons available is only 568, it is undersize for the 30-unit apartment building. The line, 954 gallons available, is the correct size.

Recommended equipment: Two BTP-139 heaters manifolded in parallel.

GAS-FIRED TANK-TYPE WATER HEATERS W/AUXILIARY STORAGE TANKS

Table 3 hr. C on page B 109.0 shows that the next highest availability above 750 is 843 gallons. This figure is located in the columns for model BTR-250 having 100 gallon tank size, and the T-80 auxiliary storage tank. The 100 + 80 = 180 gallons which meets the minimum storage capacity of 162 in the problem.

Recommended equipment: One BTR-250 heater and one T-80 storage tank. Forced circulation, between heater and tank is recommended.

OIL

OIL-FIRED TANK-TYPE WATER HEATERS — MANIFOLDED

Table 3 hr. D on page B 110.0 indicates 2 COF-199, 245 & 315 heaters will have the necessary 162 gallons storage. Two COF-199 heaters will supply 1206 gallons, thereby meeting the 750 requirements.

Recommended equipment: Two COF-199 heater manifolded in parallel.

OIL-FIRED TANK-TYPE WATER HEATERS W/AUXILIARY STORAGE TANKS

Table 3 hr. E on page B 110.0 shows the combined 86 gallons storage of a COF-245 with an 80 gallon auxiliary storage tank will meet minimum storage requirements of 162 (86 + 80 = 166). This combination will supply 792 gallons to cover the 750 requirement.

Recommended equipment: One COF-245 heater and one T-80 storage tank. Forced circulation between heater and tank is recommended.

ELECTRIC

ELECTRIC BOOSTER W/AUXILIARY STORAGE TANK

Table 3 hr. F on page B 110.0 shows one CMC-54 heater with 54 KW connected to a T-200 storage tank can supply 824 gallons to meet the requirements of 162 storage and 750 availability.

Recommended equipment: One CMC-54 and one T-200 storage tank.

COMMERCIAL ELECTRIC STORAGE-TYPE WATER HEATERS

Table 3 hr. G on the inside of B 109.0 shows 2 DRE-120 or 2 DVE-120 manifolded heaters with 24 KW each will have 238 gallons combined storage to meet the 162 gallon requirement and either combination can supply 782 gallons for the 750 requirement.

Recommended equipment: 2 DRE-120 or 2 DVE-120 heaters. (24 KW each).

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BEAUTY SHOPS AND BARBER SHOPS

The primary need for hot water in a beauty parlor is for the hair-washing operation. (Sterilization of equipment is most commonly accomplished by either chemical means or small self-contained steam sterilizers.) Hot water requirements for this type of application are generally based on the number of hair-washings that are accomplished in any 1-hour period. Since a busy day may require continuous usage for a 6- to 8-hour period, the recovery capacity of the system should be based on the amount of water used per hour. Water used for cleaning the shop is consumed at an off-peak hour and is not considered in the calculations.

REQUIREMENTS

Hot water for beauty parlor use should be both stored and delivered to the hair-washing sinks at 140°F. There, it is mixed with cold water in the spray head to suit the individual. The mixed water temperature most commonly used is approximately 100°F. Assume that the average shampoo takes approximately 7 minutes and consumes 16 gallons of 100°F water with a maximum of eight shampoos given at each basin in any 1-hour period. In most beauty parlors, one to three wash basins are devoted to hair washing. Each of these should be calculated for full-flow operation. This sizing allows for the small amount of hot water used in the hair-setting operation. Due to the intermittent, high GPM flow rates that can be encountered, a storage tank should be employed to give this system the required degree of temperature stability.

The hot water load in a barber shop is calculated in much the same way as in a beauty parlor. Although less water is used to wash a man's hair than a woman's hair, more high-temperature hot water is consumed for hot towel applications and one approximately offsets the other. Therefore, the hot water needs of a barber shop may be estimated to be 16 gallons of 100°F water per shampoo.

The 16 gallons of 100°F water used per hair wash represents about 9.6 gallons of 140°F water. It is possible under periods of peak operation for each sink employed in hair washing to use approximately 75 gallons of 140°F water per hour. Recirculation of hot water, except in unusual conditions, is seldom used in this type of application. During the time of operation, there is enough hot water usage to keep the lines warm.

COMBUSTION AIR

In today's modern beauty parlors, it is necessary to give some thought to the location of heating and water heating equipment. The propellants used in hair sprays and the chlorine-base bleaches used in hair dyeing can very easily contaminate the combustion air supplied to the heating or water heating equipment. These contaminants have a very corrosive effect on the heat exchanger surfaces of any heating equipment. Because of the extensive use of air conditioning and recirculation of air within this type of establishment, it would be wise to supply outside fresh air to the room containing the heating and water heating equipment.

PHOTO PROCESSING LABORATORIES AND MEAT PROCESSING PLANTS

PHOTO PROCESSING LABORATORIES

The photoprocessing industry uses large quantities of warm water in its film and print development equipment. These water temperatures are low, but are very critical. To insure that there are no interruptions in production, adequate hot water equipment must be provided. Since each photoprocessing plant has its own individual requirements, it will be necessary to discuss these thoroughly with the operating personnel or to contact the equipment manufacturer.

Black and White processors use warm water usually ranging from 68°F to 78°F. Generally, a tolerance of two degrees plus or minus is acceptable. Color processing is done at many different temperatures from 68°F to 94°F, depending upon the film and the processing machine. A one-half degree plus or minus is the tolerance generally required for color work. Normally, each of these processing machines is equipped with a very sensitive mixing valve in order to maintain these close temperature tolerances. Photoprocessing applications are best served by a system having recovery capacity equal to the total hourly demand of all the processing equipment operating simultaneously, and a storage tank to act as a stabilizing medium in order to insure these mixing valves of a constant temperature at their hot water connection. Hot water is usually stored at 120°F. This industry cannot tolerate even minute rust particles or foreign matter in the process water. Therefore, it is a must that an A. O. Smith glass-lined storage tank be used in the system.

Each processing machine in the plant will require water at its own individual temperature. Therefore, to determine the total demand, it will be necessary to reduce each of these loads to a common denominator such as equivalent to 120°F water or to Btu's required. By adding all the processors together, we can determine the recovery capacity of the water heating equipment necessary to produce sufficient hot water for this application. A nominal size storage tank should be selected as a stabilizing medium. Each of the automatic processors used in this industry is a standard piece of machinery for which the manufacturer publishes water and temperature requirements. This information can be obtained from the manufacturer's catalog or your nearest A. O. Smith office. Individually designed process machines must be checked out to determine their demand.

In northern climates, the design temperature of the cold water should be 35°F for this industry.

MEAT PROCESSING PLANTS

Sanitizing of work areas and equipment with 180°F water is a rigidly enforced requirement for meat processing plant. Since time allowed for this function can be critical, two factors must be considered in determining relationship of storage to recovery capacity of the hot water system.

1. Total gallon per minute flow rate that usually develops from some starting flow rate.

2. Length of time alloted to the clean-up.

Multiple hoses, generally used for washing down these areas, collectively create high draw rates when all are in use. The operation normally continues over a long period of time too long to be considered for a dump draw. With no interruptions occurring to permit stabilization of tank temperatures, a draw through condition will develop in the tank. The normal drop in outlet temperature that is expected with general applications is not acceptable here. These installations, as with other sanitizing systems, have a designated minimum temperature of 180°F.

As covered previously for Industrial Plants, systems with high draw rate potential over extended periods should not be equipped with large storage tanks. This is true even though long recovery periods may exist between system usage. Most of these applications must function with a starting flow rate considerably less than that required for full operation. A small tank is applied to stabilize the system during time of minimum flow rates and recovery capacity must be available to heat water through the required temperature rise at times of full flow rate.

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CHURCHES

Churches and other religious organization which maintain a place of assembly generally need hot water. Dinners and banquets will require both general purpose hot water and sanitizing rinse. In a few cases, there will be showers. Where there is a gymnasium, separate hot water load determinations should be made. Hot water needs for the baptistries are covered below.

KITCHENS

Hot water for a kitchen may be estimated on the same basis as for a restaurant, i.e., two gallons per person per meal. Determine the maximum number of persons per meal and the dish washing period, and refer to the food service section B 101.

Hot water needs for the kitchen may also be estimated from the hot water outlets and the dish washing machine used. Refer to section B 101.

BAPTISTRIES

A baptistry tank will range in size from 500 to 1200 gallons. The application is similar to that of a swimming pool, except that the warm-up period is shorter and there is no pool filter or filter pump. The tank is usually drained between baptismal services. The desired temperature varies from one church to another, but is usually between 80°F and 100°F.

There are two methods of heating a baptistry tank or pool. One is the instantaneous method where water is heated as the tank is being filled. The water flow rate is adjusted to obtain a final discharge temperature about 10°F higher than that desired, so that the water temperature at the time of service will be in the desired range. When a type of heater is selected for the chosen fuel, consideration that is bound to occur with extended periods of operation with cold inlet temperature.

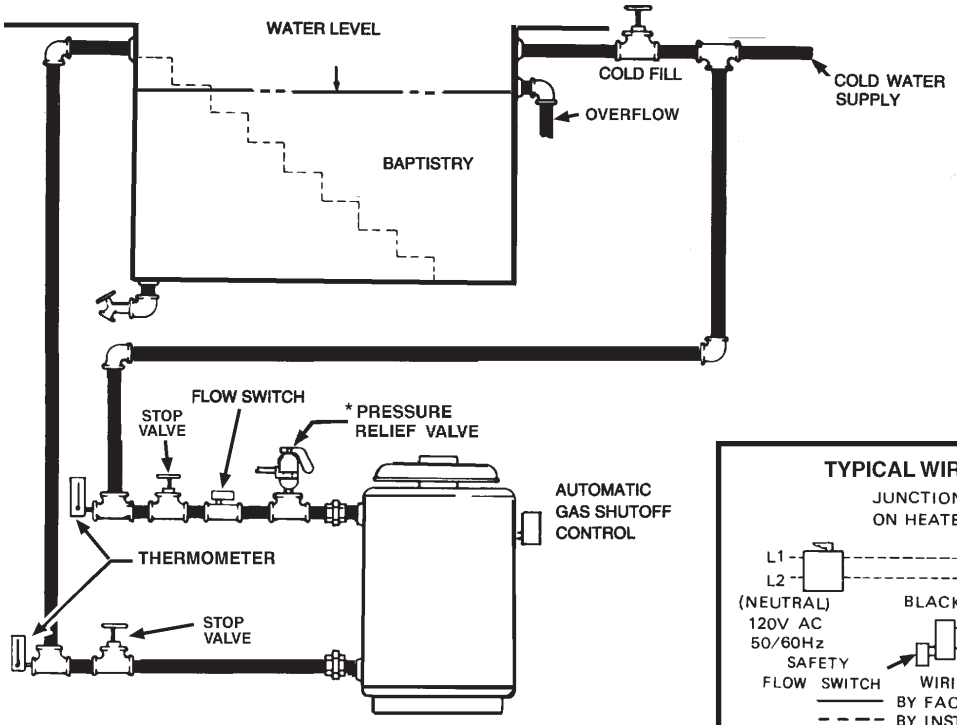
Some churches prefer to fill the baptistry pool and generally to permit the water to rise to room temperature before applying heat. This requires a simple recovery system in which the water is pumped from the pool. A temperature control is located in the baptistry or in the piping to the heater. Size of heater can be adjusted to minimize condensation. Gas and electric booster type heaters are usually selected for these applications and the self-contained type pool heaters are also applicable.

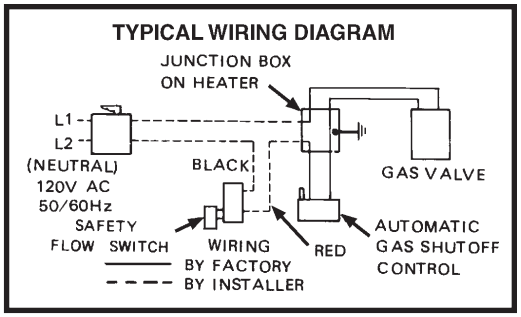
In order to reduce the noise level within the church caused by running water, it is preferable to fill the baptistry tank and heat it to the desired temperature before the service begins.

When the water for the tank is drawn from the potable water supply, safeguards should be installed to prevent possible contamination.

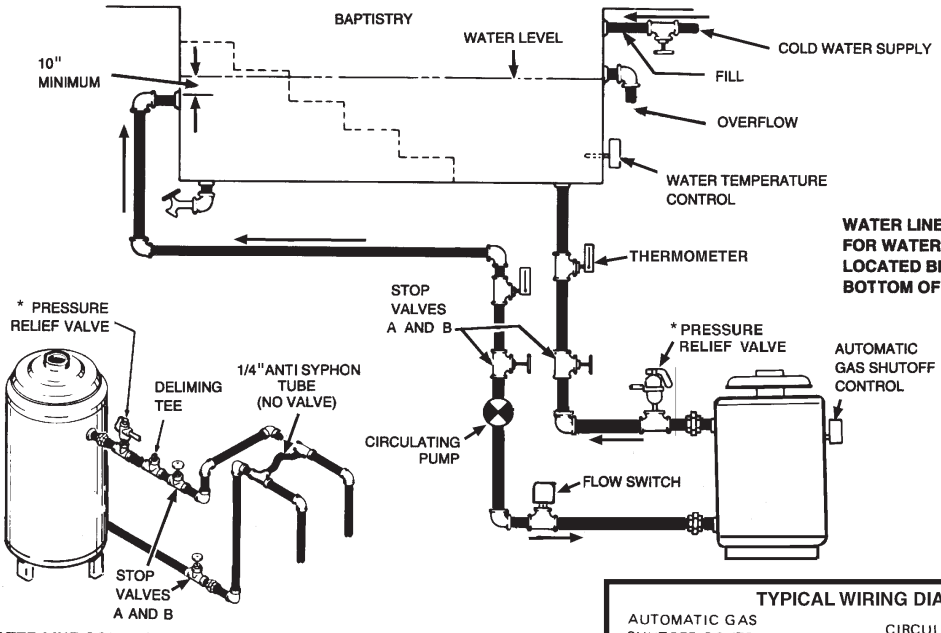
BAPTISTRY WATER HEATING SYSTEMS USING COPPER HEAT ECHANGER HEATERS

INSTANTANEOUS INSTALLATION



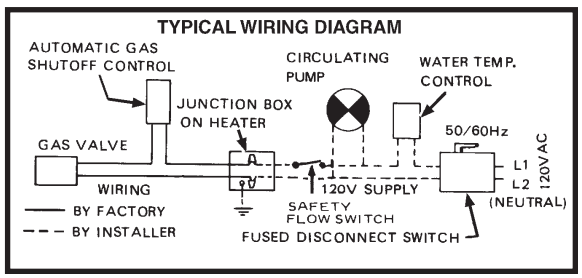


RECIRCULATING INSTALLATION



WATER LINE CONNECTIONS FOR WATER HEATER LOCATED BELOW LEVEL OF BOTTOM OF BAPTISTRY

WATER LINE CONNECTIONS FOR WATER HEATER LOCATED ABOVE LEVEL OF BOTTOM OF BAPTISTRY



PIPING BETWEEN GATE VALVES A AND B AND THE HEATER SHOULD BE BRASS OR COPPER.

* PIPE TO OPEN DRAIN.

INSTALL IN ACCORDANCE WITH LOCAL CODES.

A.O.SMITH

HOT WATER REQUIREMENTS DORMITORIES

TABLE C
ONE HOUR PEAK PERIOD
USE WITH TABLES 1 hr. A THRU 1 hr. G

DORMITORIES

This table may be used as a guide for estimating the One Hour hot water demand for dormitories. Estimated One Hour usages are taken from the EEI Studies which showed a peak hourly load of 5 gallons of hot water per person for dormitories.

TABLE C: HOT WATER REQUIREMENTS-DORMITORIES

(1) Number of Persons	(2) Gal. Required 1 Hour Period - 140°F Water				(3) Minimum* Storage Capacities
	3 GPM		5 GPM - Shower HD		
	40°F Inlet 100° TR	60°F Inlet 80° TR	40°F Inlet 100° TR	60°F Inlet 80° TR	
1-10	125	100	200	160	100
11-15	187	150	299	239	150
16-20	250	200	400	320	200
21-25	277	220	443	354	225
26-30	300	240	480	384	240
31-40	320	264	512	410	280
41-50	350	280	560	448	310
51-75	412	330	659	527	400
76-100	500	400	800	640	430
101-125	625	500	1000	800	475
126-150	750	600	1200	960	510
151-175	875	700	1400	1120	560
176-200	1000	800	1600	1280	600
201-250	1250	1000	2000	1600	650
251-300	1500	1200	2400	1920	720
301-350	1750	1400	2800	2240	800

* Storage capacities shown are theoretical minimums. See page A 401.0 for storage tank sizes carried in stock and page A 413.0 for insulated tanks.

TO USE TABLE C

1. Determine number of persons from Column (1).
2. Read gallons of 140°F water required from section (2) for dormitories at 40° or 60°F inlet temperature.
3. Read minimum storage capacity required from Column (3).
4. Consult appropriate availability table for equipment selection. (Be sure storage capacity of system selected is no less than shown in Column (3).

DORMITORY EXAMPLES

Problem: What A.O. Smith equipment will provide enough hot water for a dormitory to house 180 students and 5 administrative personnel with an inlet temperature of 40°F?

This is known

Number of Persons
100

Find this on TABLE C: DORMITORIES (pg. B 107.0)

Gal of 140°F water required in 1hr. period, 40°F Inlet	Minimum Storage Capacity
1000	600

Equipment must have: Minimum Storage Capacity of : 600 gallons
and in a 1 hr. period, heat to 140°F: 1000 gallons

Next, choose the type of fuel most suited to your installation: gas, oil, or electricity. Use the ONE HOUR AVAILABILITY TABLES on pages B 113.0 and 114.0 to complete the equipment selection. Space limitations, installation costs and difference in cost of various heater and tank combinations that meet minimum storage and recovery requirements will naturally influence the final selection of equipment.

GAS

COPPER HEAT EXCHANGER TYPE WATER HEATER W/AUXILIARY STORAGE TANK

Table 1 hr. A on page B 113.0 shows that a T-750 storage tank and a HW-670 heater will provide 750 gallons storage and 1250 gallons in the one hour peak demand period to meet the 600/1000 requirements.

Recommended equipment: One HW-670 & one T-750 storage tank.

GAS FIRED TANK-TYPE WATER HEATERS-MANIFOLDED

Table 1 hr. B on page B 113.0 shows the largest practical bank of heaters, four units, provides only 400 gallons of storage as the maximum. For a minimum storage requirement of 600 gallons in this example, manifolded heaters are not practical.

GAS-FIRED TANK-TYPE WATER HEATERS W/ AUXILIARY STORAGE TANKS

Table 1 hr. C on page B 113.0 shows that a BTC-500 heater with a T-750 storage tank will provide 1133 gallons to meet the example.

Recommended equipment: One BTC-500 and one T-750 storage tank. Forced circulation between heater and tank is recommended.

OIL

OIL-FIRED TANK-TYPE WATER HEATERS-MANIFOLDED

Table 1 hr. D on page B 114.0 indicates the largest available storage volume from a practical installation of manifolded COF heaters, four units, is 344 gallons. For a minimum storage requirement of 600 gallons in this example, manifolded heaters are not practical.

OIL-FIRED TANK-TYPE WATER HEATERS W/AUXILIARY STORAGE TANKS

Table 1 hr. E on page B 114.0 shows that a COF-455 with a T-750 storage tank will supply 1066 gallons in the one hour peak demand period, to meet the 600/1000 gallon requirements.

Recommended equipment: One COF-455 and one T-750 storage tank. Forced circulation between heater and tank is recommended.

ELECTRIC

ELECTRIC BOOSTER W/ AUXILIARY STORAGE TANK

Table 1 hr. F on page B 114.0 shows 2 CMC-54 booster heaters with 108 KW and a T-750 storage tank will provide 1043 gallons to satisfy the 600 gallon minimum storage and 1000 gallons availability.

Recommended equipment: 2 CMC-54 heaters w/54 KW each and one T-750 storage tank.
Note: A 1 1/2 hr. period for complete recovery of the auxiliary tank is needed.

COMMERCIAL ELECTRIC STORAGE-TYPE WATER HEATERS

Table 1 hr. G on the inside of B 113.0 shows that a DVE-600 or DHE-600 heater with an input of 150 KW will produce 1095 gallons for the one hour peak demand load. Other combinations of tank capacities and generating capacities may be used to meet this example.

A. O. SMITH

LAUNDRIES

REQUIREMENTS

The need for an adequate supply of clean hot water in the laundry industry is obvious. The type of load is a steady 8-10 hour per day usage with very high intermittent flow rates. Adequate storage is required in order to supply this intermittent high demand. Because of their high resistance to corrosion, the A. O. Smith Large Volume Storage Tanks are ideal for this type of application.

The laundry industry may be divided into two major segments, the large commercial or power laundry and the laundry store with individual machines for each customer. The sizing for these two types of usage is somewhat different.

THE POWER LAUNDRY

The barrel type laundry wheel is programmed for the individual needs by the operator of the plant. The water consumption characteristics, even on the same model machine, will vary from plant to plant with respect to the hot water consumed and the temperature at which it is used. For instance, a wheel in a hospital doing bed linen could use the first 20 minutes of the cycle as a cold water rinse and the last 20 minutes of the cycle as a 180°F rinse water, depending upon the type of bleach used. The same machine, when washing uniforms, could be using an entirely different program. The manufacturer of the machine should be consulted when possible. The most accurate information for sizing of a laundry of this type is usually obtained from the operator. However, when the information is not available, an accepted method of sizing is based on three gallons of water to wash one pound of clothing; half of this water is hot. Lacking better information, consider this hot water to be 160°F.

LAUNDRY STORE (Small Automatic Machines)

Laundry stores require adequate hot water storage plus recovery capacity equal to the hourly demand of the machines. The length of one cycle, plus 10 minutes (for loading and unloading), divided into 60 minutes will give you the number of cycles per hour that machine is capable of doing. This is usually one and a fraction to two cycles per hour. The number of cycles per hour multiplied by the number of machines, multiplied by the gallons of hot water used per machine will determine the hot water consumed per hour. This, plus the temperature of the hot water required will determine the recovery capacity of the water heating equipment. The information on the time cycle, temperature required, etc. can be obtained from the individual manufacturers of the clothes washing machinery, or your nearest A. O. Smith office. These machines have a set program of operation and are normally not re-programmed by the individual operators.

Storage tank selection is based on the number of machines that could be drawing hot water for their wash fill simultaneously. The table below gives a diversification factor that is applicable in this type of laundry.

DIVERSIFICATION TABLE

Stores with 1-11 machines	100% of possible draw
Stores with 12-24 machines	80% of possible draw
Stores with 25-35 machines	60% of possible draw
Stores with 36-45 machines	50% of possible draw

The amount of hot water used in the wash fill multiplied by the number of machines and corrected with a diversification factor from the table above, will assist in determining the amount of hot water that must be available from the storage tank. The A. O. Smith CER-TEMP 80® Recovery System was developed to provide maximum draw from storage tanks. Any A. O. Smith commercial water heaters can be installed with forced circulation to a storage tank in this fashion. It is possible to draw 80 percent of the storage tank without encountering an appreciable drop in temperature. Therefore, divide the maximum possible dump draw by 0.8 to determine the actual gallonage of the storage tank. This will indicate minimum size storage tank necessary.

Recirculation of hot water should be provided in laundry installations because of the wash produced depends on an adequate supply of hot water at the washing machine. In order to provide this, the best insurance is a recirculating system. Consult piping layouts for the proper system. Do not use the circulating pump of the water heating system for recirculating water to the laundry machines. Use a separate pump.

COMBUSTION AIR

In recent years, the increased use of combination dry cleaning and laundry stores, spot cleaning facilities, liquid bleaches with chlorine base, and pressure cans with Freon propellants has raised the problem of contaminants in the combustion air supplied to the equipment. As little as two to three parts per million can cause serious deterioration of the heat exchanger surfaces regardless of the type of heating equipment used. This condition adversely affects dryers, space heating and water heating equipment. Provisions should be made to protect the equipment by supplying combustion air from an uncontaminated source. Very often it is necessary to obtain air from outside the building and to maintain a slight positive pressure in the heater room in order to overcome this problem. It is also possible to develop contaminants in stores that have laundry only.

Many state building codes have very stringent regulations regarding ventilation in customer operated dry cleaning stores. These should be consulted when dry cleaning is involved in a laundry store.

CAR WASH

Warm water is necessary in a car-washing operation to materially speed up the washing process and reduce the amount of drying labor required. In addition, hot water is required for automatic machines used for towel washing. Use of hot water under high pressure with detergent pick-up by means of venturi action is fast replacing the steam cleaning of automobile wheels and white-wall tires. Scrubbing action of hot soapy water molecules produces a better job faster than the use of steam. Any system designed to mix a detergent with hot water by venturi action must be designed so that detergent is not circulated through the heater.

Use of reclaimed water has increased in these applications and circulation of filtered water through heater(s) from a settling tank is acceptable.

In northern climates, where ice accumulates under fenders, the car washing process is greatly accelerated by using warm water.

REQUIREMENTS

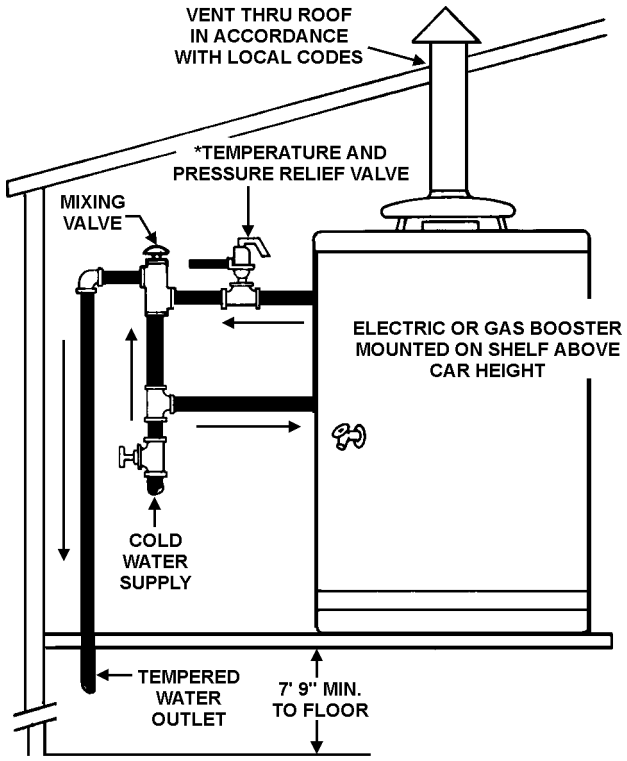
A temperature of approximately 110°F is ideal for use in a car-washing operation. Water at this temperature will not damage the wax finish of an automobile. However, water at up to 180°F may be used through a pressure nozzle to clean wheels and whitewall tires. (Some pressure-nozzle cleaning employs low-temperature warm water.) Water at 140°F to 150°F is required in washing machines to wash the towels. In car wash applications, the hot water storage tank capacity should usually be from 80 to 300 gallons. Water should be stored in this tank at the highest temperature required for the application. Where wheels are washed with water power, storage temperature might be from 160°F to 180°F and then mixed with cold water for both the washing machine and car-rinsing operations. Where wheel washing does not require hot water, the storage tank should be held at 140°F and mixed with cold water for the car-washing operation.

The water heating equipment should be sized to meet the hourly demands of the spray nozzle as rated by the manufacturer. The spray rinse at 110°F will consume approximately 45 GPM with approximately a half-minute spray period allocated to each car. A wheel-washing operation using water at 160°F to 180°F will require water at a flow rate of about 5 GPM and will consume approximately 2 1/2 gallons per car. Consult the car-washing equipment manufacturer's specifications to determine the specific requirements for each application.

Heaters used with filtered reclaimed water should be operated closer to the 110°F requirement and have controls set to approximately 115°F or 120°F. This excludes the use of this water source for wheel washing temperatures.

For a service station or any other one-at-a-time hose type car washing, a small tank electric or gas-fired booster heater will serve. Water should be stored at 180°F and mixed down to approximately 100°F through a mixing valve to extend usage time each cycle. The one or two lavatories usually included at this type of installation can be handled by the same equipment.

TYPICAL SERVICE STATION INSTALLATION



*PIPE TO OPEN DRAIN

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INTRODUCTION

The miscellaneous applications of A. O. Smith commercial water heating equipment are far too many to enumerate here. This equipment is being used for different purposes in various industries, such as raising bean sprouts in the Oriental food industry, pre-warming stand-by diesel engines for fast starting, providing heat through coil grids, curing of concrete, egg washing in the poultry industry, automatic feather-removing equipment in the poultry industry, film development and print washing in the photographic industry, degreasing of steel parts in the metal industry - and many other uses.

HOT WATER FOR EVERY NEED

There is an A. O. Smith commercial water heater or water heating system to fit every need, whether the demand is for 10 GPH or 10,000 GPH. All of this equipment (with the possible exception of the larger A. O. Smith BTP models and glass-lined storage tanks) is designed to go through standard size doorways; thus eliminating the necessity of cutting access ways into existing buildings. The model HW-670 - 670,000 BTU/hr. input with a rated output of 656 GPH at 100°F rise (equivalent to a 16 hp boiler) has a shipping weight of 353 pounds and can be easily carried to the job site through a 36" doorway by two men. These commercial water heaters and also the storage tanks are frequently installed in multiples to meet demands of larger applications.

A. O. Smith commercial water heaters are of two basic designs - finned copper heat exchanger forced flow type and also self-contained tank type:

- COPPER HEAT EXCHANGER MODELS are available as gas-fired units and offer the maximum in operating efficiency along with the greatest flexibility of application. Forced flow installations permit the selection of any heater and tank size combination to meet job requirements without stack loss from the hot water generator during stand-by periods.

  A. O. Smith patented piping systems have been developed to provide for most efficient use of single heater - tank combinations or with multiples of either component. A choice of either single or dual temperature systems is offered with the added feature of minimum storage tank temperature - Aqua-Hot piping kits are available for one and two temperature application using single or multiple heaters. Factory assembled skid-mount systems are also available.

- SELF-CONTAINED TANK TYPE MODELS are offered for either gas, electric, or oil sources of energy in a variety of input and storage capacities. Some BTP models are available with dual fuel. These models are also used as single heaters or in multiples to meet larger requirements. Dual temperature applications are handled by the use of thermostatically controlled mixing valves.

  Manifold kits for 2, 3 or 4 heater applications of this type of equipment are offered to assist installations and also to assure equal draw for all units.

The designer of hot water supply systems for the miscellaneous applications covered in this Section is referred to Section A (Equipment Selection) for a choice of equipment to meet his specific requirements.

INDUSTRIAL PLANTS

See page B 421.0 for Bradley wash sinks data.
See page B 115.0 for shower head water usage.

REQUIREMENTS

Hot water needs in an industrial plant can be categorized as follows: cafeteria, washrooms and manufacturing processes. A fourth category, heating of sprinkler tanks to avoid freezing (although not truly a hot water supply consideration) is also covered in this section. There is no system available that can economically provide both space heating and hot water from the same unit. New design and replacement trends are toward individual water heating systems located at the point of usage and smaller compact boilers for space heating. This improves operating efficiencies by reducing the stand-by losses encountered in large centralized heating plants and the low efficiencies associated with low firing rates.

CAFETERIA

Cafeteria needs of an industrial plant are similar to those of any restaurant. The sizing information for cafeterias can be found in Section B, food service sizing. This sizing is based on the maximum number of persons fed at the industrial plant and the length of time allowed for lunch. If the executive dining room is located a considerable distance from the main cafeteria, it should be handled as a separate system.

MANUFACTURING PROCESSES

The use of hot water in manufacturing processes varies so widely that it is impossible to develop suitable sizing tables. Each application must therefore, be handled as an individual case. This information may be obtained from the production manager of the particular plant involved. To determine the correct sizing, it is necessary to know the required hot water temperature, peak demand (in gallons), and the characteristics of usage. For example, a dump load for batch mixing that has a relatively high GPM flow rate of short duration would require a storage tank sufficient in size to meet that demand. The recovery capacity of the water heating equipment would in this case be based on the length of time before the next draw off.

In an application requiring a steady GPM flow rate use a system employing a relatively small storage tank. In a system requiring critical temperature control (even when sensitive water-mixing valves are used) never use a purely instantaneous system; instead, use a small storage tank to act as a stabilizer. This small stabilizing tank will assure the hot side of the mixing valve a constant supply of even temperature hot water, rather than the rapid fluctuations that can occur in a purely instantaneous system.

Storage tanks should not be large with any continuous operating system that has any usage characteristic that can lower the tank temperature even for a short while. This is specially true with high temperature requirements. Tanks working under these conditions cannot stabilize temperature unless either (a) recovery capacity is considerably larger than usage, or (b) a waiting period is provided for desired outlet temperature to be reestablished.

Where a purely instantaneous system is applicable, minimum flow rates are also a point of consideration. The effect on water outlet temperatures by any of the system or heater operating characteristics must be rationalized when selecting gas, electric or oil fired equipment for these applications.

SIZING FOR INDUSTRIAL SHOWER ROOMS

The industrial shower room is normally considered a dump load. The average shower head delivers 3 GPM of 105°F hot water, equivalent to 2 GPM of 140°F water mixed with 1 GPM of 40°F water. Since many shower heads deliver more than 3 GPM, the actual flow rate should be determined, if possible. (See table of shower head characteristics on page B 115.0). If the flow rate is greater, reduce it to 3 GPM maximum by inserting a flow regulating device in the shower head. Greater rates of flow are wasteful.

The length of the shower period should also be determined. If the length of showering cannot be determined, a 20-minute period may be assumed. (It is known that a majority of the people leaving a shift will not wait more than 20 minutes to shower.) To determine the peak demand, assume that all showers, multi-station wash fountains, and lavatories, are in operation at full flow during the shower period. In some industries, because of health or safety considerations, it is mandatory that personnel shower before leaving the plant. But even in these cases, facilities are generally adequate for the entire shift to clean up in a 20-minute period.

Because of the characteristics of this type of load, the storage tank should be capable of supplying almost the entire hot water peak demand. The recovery capacity of the heating equipment should be adequate to reheat the storage tank before the next shift. It may be advisable to select a heater capacity that will reheat the tank in less than a 3-hour period, even in a one-shift plant, if other hot water demands are made upon the system.

For applications of this type, it is advisable to never store water in the tank at a temperature exceeding 140°F. The dangers involved in delivering high temperature hot water for showering are obvious.

A.O. SMITH

HOT WATER REQUIREMENTS MOTELS AND HOTELS

TABLE B
TWO HOUR PEAK PERIOD
USE WITH TABLES 2 hr. A THRU 2 HR. G

MOTELS AND HOTELS

This table maybe used as a guide for estimating the two hour hot water demand for various sized Motels and Hotels. Minimum storage capacities are also shown. The table assumes an average occupancy of 1 1/2 persons per unit and 5 minute showers.

NOTE: Hot water load for restaurants, laundry operations or other uses should be considered separately.

Motels and Hotels with convention facilities and / or along busy interstate highways will commonly have a one hour peak period. Use the One Hour Availability Tables for sizing.

IMPORTANT - Calculations below based on 3 GPM shower flow rate of mixed temperature water. If shower flow is up to 5 GPM, multiply gallon requirements in chart (sect.3) by 1.6.

TABLE B: HOT WATER REQUIREMENTS-MOTELS AND HOTELS

(1) Number of Units (1 1/2 Persons/Units)	(2) Actual Number of Persons	(3) Gals. Required 2 Hour Period 140°F Water		(4) *Minimum Storage Capacity
		40°F Inlet 100° TR	60°F Inlet 80°F TR	
1-3	4	50	45	50
4	6	66	56	60
5-6	9	100	85	72
7-8	12	132	112	85
9-10	15	165	140	100
11-15	22	230	196	113
16-20	30	300	255	130
21-25	37	370	315	148
26-30	45	450	382	162
31-35	52	520	442	175
36-40	60	570	485	188
41-45	67	600	510	200
46-50	75	650	552	210
51-75	112	840	714	255
76-100	150	1050	892	300
101-125	187	1272	1080	325
126-150	225	1350	1148	360
151-175	262	1575	1340	395
186-200	300	1800	1530	410
201-250	375	2250	1912	500
251-300	450	2700	2295	600
301-350	525	3150	2678	700

For conditions other than those stated above, consult your A.O. Smith supplier.

*Storage capacities shown are theoretical minimums. See page A 401.0 for storage tank sizes carried in stock and page A 413.0 for insulated tanks.

Diversity factors as previously mentioned have been used in calculating expected hot water requirements.

TO USE TABLE B

1. Determine number of units from Column (1).
2. Determine number of persons from Column (2).
   NOTE: If average occupancy differs from 1 1/2 persons per unit, disregard Column (1) and use Column (2) "Actual Number of persons" for estimating Two Hour demand and minimum storage capacity.
3. Read estimated Two Hour demand from Section (3) for either 40° or 60°F inlet temperature.
4. Read minimum storage capacity from Column (4).
5. Consult appropriate availability table for equipment selection. (Be sure storage capacity of system selected is no less than shown in Column (4).

See reverse side for examples

MOTEL/HOTEL EXAMPLE

Problem: What A.O. Smith equipment will provide enough hot water for the shower water load of a motel or hotel with 100 units with 150 persons at 40°F inlet temperature?

This is known

Number of Units	Actual Number of Persons
100	150

Find this on TABLE B: MOTELS/HOTELS (pg. B 105.0)

Gal of 140°F water required in 2hr. period, 40°F Inlet	Minimum Storage Capacity
1050	300

Equipment must have: Minimum Storage Capacity of : 300 gallons
and in a 2 hr. period, heat to 140°F: 1050 gallons

Next, choose the type of fuel most suited to your installation: gas, oil, or electricity. Use the TWO HOUR AVAILABILITY TABLES on pages B111.0 and 112.0 to complete the equipment selection. Space limitations, installation costs and difference in cost of various heater and tank combinations that meet minimum storage and recovery requirements will naturally influence the final selection of equipment. Use one Hour Availability Tables for convention type motel.

GAS

COPPER HEAT EXCHANGER TYPE WATER HEATER W/AUXILIARY STORAGE TANK

Table 2 hr. A on page B 111.0 shows the next larger storage tank above 300 gallons is 350 gallons. The table indicates that either a T-350 tank with a HW-520 heater or a T-400 tank and a HW-420 heater can supply the required 1050 gallons in two hours.

Recommended equipment: One HW-520 & one T-350 storage tank; or one HW-420 & on T-400 storage tank.

GAS FIRED TANK-TYPE WATER HEATERS-MANIFOLDED

Table 2 hr. B on page B 111.0 shows 3 heaters are needed to supply the 300 gallons required storage. Three BTC-197 heaters will exceed the requirements of 1050 gallons, i.e., 1356 gallons.

Recommended equipment: Three BTC-197 heaters manifolded in parallel.

GAS-FIRED TANK-TYPE WATER HEATERS W/ AUXILIARY STORAGE TANKS

Table 2 hr. C on page B 111.0 indicates a BTC-500 heater with a T-350 storage tank is the first combination to meet the requirements. It shows 1237 gallons available with 419 gallons storage capacity, (350 + 69 = 419).

Recommended equipment: One BTC-500 heater with one T-350 storage tank.

OIL

OIL-FIRED TANK-TYPE WATER HEATERS-MANIFOLDED

Table 2 hr. D on page B 112.0 shows the first group of COF heaters to meet the 300/1050 gallon requirement are four COF-199's. This bank of heaters has 344 gallons storage and can supply 1688 gallons.

Recommended equipment: Four COF-199 heaters manifolded in parallel.

OIL-FIRED TANK-TYPE WATER HEATERS W/ AUXILIARY STORAGE TANKS

Table 2 hr. E on page B 112.0 shows the T-200 storage tank and the storage capacity in any of the COF'S falls short of the 300 gallon requirements. So, a T-350 storage tank is needed, and with a COF-455 it can supply 1160 gallons to meet the 1050 gallon requirement.

Recommended equipment: One COF-455 and one T-350 storage tank.

ELECTRIC

ELECTRIC BOOSTER W/ AUXILIARY STORAGE TANK

Table 2 hr. F on page B 112.0 shows 2 CMC-54 heaters with 108 KW total and a T-350 storage tank can meet the requirements of 300/1050 gallons of the example with 350 gallons storage and 1165 gallons availability.

Recommended equipment: 2 CMC-54 heaters w/54 KW each and one T-350 storage tank.

COMMERCIAL ELECTRIC STORAGE-TYPE WATER HEATERS

Table 2 hr. G on the inside of B 111.0 shows a manifolded bank of three DVE-120 heaters with 36 KW each will have combined storage of 360 gallons and can supply 1173 gallons to meet the 300/1050 requirements.

Recommended equipment: Three DVE-120 heaters w/36 KW each.

HOT WATER FOR MULTIPLE DWELLINGS

INTRODUCTION

An adequate supply of hot water is a must in apartment houses, motels, hotels, dormitories, etc. Users expect hot water in adequate amounts, just as they expect lights at the flick of a switch. Improper sizing and design of hot water supply systems will invariably lead to problems — dissatisfied users of undersized systems — wasteful economics of oversized systems.

Experience has shown that the hot water requirements for multiple dwellings are directly related to: (1) the bathing (shower)load which depends on the building size (no. of units and unit occupancy) (2) the type of shower heads utilized, and (3) the peak demand period over which the bathing load is spread.

Peak demand periods vary with the type of dwelling, apartments having a 3 hour period, hotels and motels a two hour period, dormitories & convention hotels/motels a one hour period.

Hot water generating systems should be sized to adequately supply the needs of the bathing load spread over the peak period.

The A. O. Smith sizing recommendations presented herein, are based on these parameters. The requirements for hot water for other large loads such as clothes washers, have not been considered. Designers should provide additional storage and recovery capacity to satisfy the needs of these additional loads.

A. O. SMITH SYSTEMS FOR MULTIPLE DWELLINGS

A. O. Smith offers a wide range of water heating systems ideally suited for use in multiple dwelling applications. Equipment utilizing gas, electricity or fuel oil is available. A number of distinct advantages are inherent in A. O. Smith water heating systems such as low standby losses, excellent tank draw characteristics and space saving features. See Section A for complete equipment and system information. One and two temperature factory skid mounted systems available (see specification sheet A 015.0 and A 018.1).

SPECIAL CONSIDERATIONS

- The use of a recirculating loop should be considered whenever hot water at point of use is needed quickly. Studies show that continuously recirculating systems are not generally energy efficient. Where recirculating lines are exposed to temperatures substantially lower then the temperature of the recirculated water, the lines should be insulated.

  NOTE: The pump for the building recirculating loop should be separate from the water heating system and provisions should be made for turning off of circulating pump(s) when hot water system is not in operation.

- Ideally, the system should be designed so that it is not necessary to store water above 140°F. The inherent danger of extremely hot water getting into a shower is obvious.

- The volume of storage of a particular system may be partially augmented by the volume of stored water in the building hot water mains only if recirculation is employed. **The volume of storage in the building main if considered as storage must be known and compared with minimum storage recommended.**

  CAUTION: Modern piping designs generally result in a comparatively small storage volume.

- **Increasing the size of the space heating boiler is not the most economical way to furnish domestic hot water,** nor does it provide the best in hot water service. The increase in standby loss due to the additional bulk of a larger space heating boiler greatly reduces the overall efficiency of the system. The same is true with storage tanks. The tank size should be compatible with the hot water demand.

VARIOUS SIZING METHODS

As stated earlier, A. O. Smith recommends the sizing method that considers the bathing load of the dwelling. The tables herein are based on this method. The designer familiar with other methods, such as fixture sizing, may use the tables to compare with his own calculations.

FHA

U. S. Department of Housing and Urban Development Minimum Property Standards 4910.1 (1973) paragraph 615-6 states hot water requirements for multiple dwellings should be based on design criteria shown in the ASHRAE Guide.

A. O. Smith tables may not be applicable to FHA sizing for some apartment categories due to different diversity factors than those applied in the ASHRAE Guide.

BUILDING CODES AND HOUSING AUTHORITIES

The requirements of recovery capacity and storage tank size may, in some areas, be fixed on a per apartment or per person basis by building codes or housing authorities. In these cases, the designer must meet the specified requirements.

DIVERSITY FACTORS

Diversity factors are used as a correction factor for the demand per person to be accommodated. The diversity factors have been derived from extensive hot water usage studies conducted by the Edison Electric Institute. These studies have shown that as building size increases, the peak demand per person decreases. This factor is also reflected in the minimum recommended storage capacity per building.

STORAGE REQUIREMENTS

Minimum storage requirements shown in the tables should be considered as a guide for sizing storage tanks. As mentioned earlier, the designer can cautiously consider the storage in the building main and may deduct this amount from storage tank requirements. Larger than required storage tank size may be selected to provide peak demand availability with lower fuel input. All storage volume is considered to be 140°F.

NOTE: Systems requiring reheat time in excess of 5 hours are not recommended. Applications where semicontinuous water usage can be expected between peak periods are more appropriately handled with 3 hour reheat time for storage tanks.

ESTIMATING SHOWER LOAD

T**able A: APARTMENTS and Table B: MOTELS AND HOTELS in this section are constructed on the following basis:** The most accurate method of estimating the shower load is to establish a known flow rate by the use of flow-regulated shower heads. In the past, a maximum flow rate of 4.5 gallons per minute was used. Currently, in the interest of energy conservation, a maximum flow rate of 3 GPM of approximately 105°F per shower is recommended. This flow rate will require 2 GPM of 140°F water from the storage tank, mixed with 1 GPM of 40°F water. It is also assumed that the average shower time is 5 minutes. The total volume of 140°F water per shower is 10 gallons (2 GPM x 5 min. = 10 gal.). Diversity factors were applied to Tables A and B. If shower flow rates closer to 5 GPM are required, multiply the quantities in these two tables by a factor of 1.6.

If actual shower head flow rate is known, the estimated peak period hot water requirements can be corrected by using the following formula:

$$\text{Gallons required for peak period} = \text{Gallons required (from Table A or B)} \times \frac{\text{Actual Shower Head flow rate}}{3.0}$$

See shower head water consumption data chart on page B 115.0 for more information.

Table C "Dormitories" is constructed from data taken from the Edison Electric Institute studies. These studies have shown that in dormitories the maximum peak hourly hot water load is 5.0 gallons per hour per person for women, and 3.8 gallons per hour per person for men. Diversity factors were used in this table for groups less than 100 persons.

Estimated peak period requirements for areas subject to severe winters (40°F inlet water) and those that have milder climates (60°F inlet water) are also shown in the tables.

INDUSTRIAL WASHROOMS AND SHOWER ROOMS

This type of load has a very high hot water peak demand and the tank and heater capacities must be sized accordingly. Usually, large storage volume is required.

Determine actual flow rates of the shower heads from the manufacturers' data on page B 115.0. In the interest of conservation, flow restrictors should be specified for shower heads with excessive flow rates. When a known flow rate of 105° water is established, 65% of that quantity is required from the 140°F stored water assuming 40°F inlet water temperature.

In addition, there are usually lavatory basins, Bradley wash sinks, and possible other hot water fixtures. These must be considered as drawing concurrently with the showers.

No sizing charts are given for this type of usage because of the many variables. When the flow rates of the showers and other fixtures are known, a determination of time usage must be made. Five minutes for a shower is considered average. Multiply the number of people to shower by 5 minutes each and divide by the number of shower heads – obtaining the shower time required. Add the hot water requirements of the other fixtures for that time period to the hot water shower usage, to get total hot water usage.

If it is not possible to obtain a reasonable estimate of the shower time, it is general practice to assume a 20-minute shower period. One-third of the hourly capacity of the heaters would then be available; the remainder must be supplied by the storage tank.

SIZING FOR LIMITED KW DEMANDS

The optimum hot water supply system normally will consist of either self contained heaters of the storage type or booster heaters coupled to auxiliary storage tanks. The ratio or storage capacity to recovery capacity is dictated by the peak hot water demand requirements for any given installation. Systems utilizing gas or fuel oil (where peak fuel demand is not restricted) often result in a high ratio of recovery capacity to storage capacity.

When electricity is used as fuel, the cost of providing the peak KW load can be economically prohibitive due to "demand charges" assessed by utility companies. This extra charge is based on the highest demand for energy during a given time period. It is therefore, important to the operating economy of the system, where demand charges exist, that short duration high energy demand be avoided. In these cases the common remedy is to provide larger storage capacity so that peak hot water demands can be met with lower energy demands.

The availability tables in this section demonstrate how larger storage tanks and lower KW input can be selected to satisfy the hot water for a particular estimated peak demand. CAUTION – Very large storage capacity and low KW input can cause excessive system reheat time.

A. O. SMITH offers a wide range of commercial electric water heating equipment including special control systems, to provide the flexibility of design required for sizing electric water heating systems. Consult your local utility company for information regarding power availability and rate structures.

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MISCELLANEOUS WATER USAGE DATA

Wash sink water consumption rate

Bradley Wash Sinks	GPM @ 105°F	GPM @ 140°F
54" circular sink	5	3.25
36" circular sink	2	1.3
54" semi-circular sink	3	1.95
36" semi-circular sink	1-1/4 to 3.0	.81 to 1.95
Duo	1.5	1
Counter type	1.5	1
Bradley shower heads	2.5 to 3.0	1.6 to 1.95

Temperature factors - hot water

If Temperature Required Is	Multiply Hot Water Load By
70°	0.30
80°	0.40
90°	0.50
100°	0.60
110°	0.70
120°	0.80
130°	0.90
140°	1.00
150°	1.10
160°	1.20
170°	1.30
180°	1.40

General purpose hot water consumption guide for various kitchen usages

Application	Consumption (GPH)
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
Mop/slop sink	20

The above table is based on 40° incoming water temperature and a temperature rise of 100° (temperature usage 140°) --- when the delivered water temperature is other than 140°, multiply the volume of water required by the temperature usage factor shown above.

Temperature factors - cold water

When Incoming Cold Water Is	Multiply Hot Water Load By
50°	0.90
60°	0.80
70°	0.70

Rinse water (180°F) requirements for typical dishwasher ✚ flow pressure at dishwashers assumed to be 20 psi

Dishwasher / Type And Size			Flow Rate/GPM	Consumption/GPH
door type	16 x 16 inches rack		6.94	69
	18 x 18 inches rack		8.67	87
	20 x 20 inches rack		10.4	104
	undercounter type		5	70
conveyor type	single tank		6.94	416
	multiple tank	dishes flat	5.78	347
		dishes inclined	4.62	277
silver washers			7	45
utensil washers			8	75
make-up water requirements/180°F on certain conveyor types			2.31	139

✚ NSF standard no. 5 - 100% mechanical capacity

MISCELLANEOUS WATER USAGE DATA

Proper Flow and Pressure Required During Flow For Different Fixtures

Fixture	Flow Pressure*	Flow GPM
Ordinary basin faucet	8	3.0
Self-closing basin faucet	12	2.5
Sink faucet - 3/8 inch	10	4.5
Sink faucet - 1/2 inch	5	4.5
Bathtub Faucet	5	6.0
Laundry tub cock - 1/4 inch	5	5.0
Shower water saver	12	2.5
Ball-cock for closet	15	3.0
Flush valve for closet	10-20	15-40†
Flush valve for urinal	15	15.0
Garden hose, 50 ft., and still cock	30	5.0

* Flow pressure is the pressure psig in the pipe at the entrance to the particular fixture considered.

† Wide range due to variation in design and type of flush-valve closets.

Water Capacities Of Copper Tubes

Tube Size	1/4"	3/8"	1/2"	7/8"	1"	1 1/4"
Gallon/Ft.						
Type K	.004	.006	.011	.023	.040	.063
Type L	.004	.006	.012	.025	.044	.065
Tube Size	**1 1/2"**	**2"**	**2 1/2"**	**3"**	**4"**	**5"**
Gallon/Ft.						
Type K	.089	.157	.242	.345	.607	.940
Type L	.092	.161	.247	.354	.623	.971

Water Capacities Per Foot Of Pipe

Pipe Size	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
Gallons Per Foot	.016	.023	.040	.063	.102	.17
Pipe Size	**2 1/2"**	**3"**	**3 1/2"**	**4"**	**5"**	**6"**
Gallons Per Foot	.275	.39	.53	.69	1.1	1.5

Formula For Mixing Hot and Cold Water

$$\frac{M-C}{H-C} = \text{\% of hot water required to produce desired mixed temperature}$$

Where M = Mixed water temperature
C = Cold water temperature
H = Hot water temperature

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