Table 9 .... Pipe Sizes for Cooling Towers[a]

Rated Tons of Refrig.	Cooling Water Gpm	Pipe Sizes (Nominal Inches)	
		Inlet to Tower	Outlet from Tower
3 to 5	10 to 18	1½	1½
7 to 15	20 to 45	2	2
20	65	2½	3
25	86	2½	4
35	115	3	4
50	170	3	4
75	225	5	6
100	300	5	6
150	450	5	8
200	600	6	8
250	750	8	8

piping. Velocities exceeding 10 fps cause undesirable noise in the piping system. This will usually govern the size of the larger pipes in the system while, in the small pipe sizes the friction loss will usually govern the selection because the velocity is low compared with friction loss. Velocity is the governing factor in down-feed systems, where friction loss is usually neglected. Velocity in branches leading to pump suctions should not exceed 5 fps.

Table 10 .... Maximum Daily (24-Hr) Requirements for Hot Water in Gallons

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

Hotels	Room with basin	10
	Room with bath—transient	50
	Room with bath—resident	60
	2 Rooms with bath	80
	3 Rooms with bath	100
	Public shower	200
	Public basins	150
	Slop sink	30
Office Buildings	White-collar worker (per person)[a]	2-3
	Other workers (per person)	4.0
	Cleaning per 10,000 sq ft	80.0
Hospitals	Per bed	80-100

[a] The value for white-collar workers is for office occupancy only, not including allowance for employees' lunch rooms, dining rooms, etc. Requirements for these areas should be calculated separately.

Table 11 .... Estimated Hot Water Demand Characteristics for Various Types of Buildings

Type of Building	Hot Water Required Per Person	Max. Hourly Demand in Relation to Day's Use	Duration of Peak Load Hours	Storage Capacity in Relation to Day's Use	Heating Capacity in Relation to Day's Use
Residences, apartments, hotels, etc.[b,c]	20 to 40 gal per day[a]	1/7	4	1/5	1/7
Office buildings	2-3 gal per day[a]	1/5	2	1/5	1/6
Factory buildings	5 gal per day[a]	1/3	1	2/5	1/8
Restaurants				1/10	1/10
Restaurants 3 meals/day		1/10	8	1/5	1/10
Restaurants 1 meal/day		1/5	2	2/5	1/6

[a] At 140 F.

[b] Daily hot water requirements and demand characteristics vary with the type of hotel. The better class hotel has a relatively high daily consumption with a low peak load. The commercial hotel has a lower daily consumption but a high peak load.

[c] The increasing use of dishwashers and laundry washing machines in residences and apartments requires additional allowances of 15 gal per dishwasher and 40 gal per laundry washer.

If the street pressure is too low to adequately supply upper floor fixtures, means must be provided to increase the pressure. A gravity tank on top of the building, a hydropneumatic tank in the basement, or a booster pump may be used.

Flow control valves are available for installation at the individual fixtures which, under conditions of varying pressure, automatically adjust the flow at the fixture to a predetermined quantity. By using these valves the designer may (1) limit the flow at the individual outlet to the minimum suitable for the purpose, (2) hold the total demand for the system more closely to the required minimum, and (3) be able to design the piping system as accurately as is practicable for the requirements.

COOLING WATER PIPING

Water is very frequently used in refrigeration systems, cooling towers, and other similar installations. In designing the piping system of such installations, the principles of hydraulics, as already outlined, are employed. Nevertheless, there are several practical items having particular application to cooling installations which are outlined in the following paragraphs. It is important that the designer be familiar with them.

In choosing pipe material, the problem of corrosion should be kept in mind to prevent failure of the system. If the water is not severely corrosive, wrought-iron or steel piping may be used; otherwise, galvanized-steel piping may be preferred. If sea water is used as the circulating medium, it is advisable to use alloys such as admiralty metal in pipe and tubing. In refrigeration condensers where water is the cooling medium, iron pipe is commonly employed.

Water treatment is commonly used, especially in recirculating systems. See Chapter 15 of the 1961 Guide And Data Book for more detailed discussion of this subject.

In regard to assembly, cast-iron flanges or welded joints are to be preferred to screwed joints wherever possible.

Valves used in circulating systems may be of the globe, gate, or angle types. If water is the circulating medium, brass valves are usually used. However, if the circulating medium is an electrolyte, such as brine, then it is preferable to use valves made of the same material as the piping itself.

The friction loss in the piping may be determined from Fig. 4 for fairly rough pipe. If the coolant is brine, a correction for the proper density must be made. Experience indicates that in sizing piping for cooling systems, a pressure drop of the order of 2 to 3 psi per 100 ft of pipe length, and a fluid velocity of 3 to 8 fps, are within good practice.

In the case of cooling towers, the amount of circulating water is about 3 gpm per ton of refrigeration, when based on a design wet-bulb temperature of about 75 to 78 F. Table 9 gives pipe sizes frequently used for various sizes of cooling towers, assuming a hot water temperature of 95 F and a cold water temperature of 85 F.[a] These conditions are typical of refrigeration plants, electrically driven. Systems operated by condensing-steam turbines, or steam-operated absorption systems, require more water or produce a higher water temperature, or both. See also Chapter 40.

ESTIMATING HEATING LOAD AND STORAGE CAPACITY

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

For residential dwellings, a design value of about 20 to 30 gal per (person) (day) may be assumed, but it should be remembered that the hot water used will depend primarily on the number of persons in any house or apartment.

Table 10 gives estimates of the maximum hot water requirements in 24 hr in various types of buildings. These may be used for the number of rooms and bathrooms if the person count is not available. The values in Table 10 are not suitable for large buildings. For these the person count as a basis is better.

In estimating the size of hot water storage tank required, and the heating capacity to be provided, either from the boiler or from an independent domestic hot water heater, it is necessary to know the total quantity of water to be

Table 12 .... Hot Water Demand per Fixtures for Various Types of Buildings

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

	Apartment House	Club	Gymnasium	Hospital	Hotel	Industrial Plant	Office Building	Private Residence	School	Y.M.C.A.
1. Basins, private lavatory	2	2	2	2	2	2	2	2	2	2
2. Basins, public lavatory	4	6	8	6	8	12	6	....	15	8
3. Bathtubs	20	20	30	20	20	....	....	20	.....	30
4. Dishwashers[a]	15	50-150	....	50-150	50-200	20-100	....	15	20-100	20-100
5. Foot basins	3	3	12	3	3	12	....	3	3	12
6. Kitchen sink	10	20	....	20	30	20	20	10	20	20
7. Laundry, stationary tubs	20	28	....	28	28	....	....	20	....	28
8. Pantry sink	5	10	....	10	10	....	10	5	10	10
9. Showers	30	150	225	75	75	225	30	30	225	225
10. Slop sink	20	20	....	20	30	20	20	15	20	20
11. Hydro-therapeutic showers				400						
12. Hubbard baths				600						
13. Leg baths				100						
14. Arm baths				35						
15. Sits baths				30						
16. Continuous-flow baths				165						
17. Circular wash sinks				20	20	30	20		30	
18. Semi-circular wash sinks				10	10	15	10		15	
19. Demand factor	0.30	0.30	0.40	0.25	0.25	0.40	0.30	0.30	0.40	0.40
20. Storage capacity factor[b]	1.25	0.90	1.00	0.60	0.80	1.00	2.00	0.70	1.00	1.00

[a] Dishwasher requirements should be taken from Table 14 or from manufacturers' data for the model to be used, if this is known.

[b] Ratio of storage tank capacity to probable maximum demand per hour. Storage capacity may be reduced where an unlimited supply of steam is available from a central street steam system or large boiler plant.