When selecting the size of the pump, consideration should be given to the temperature conditions under which the pump will operate. To illustrate this, at 212 F the density of water is 59.88 lb per cu ft, whereas at 380 F it has dropped to 54.36. Therefore, as the weight of a gallon of water is considerably less, the pump will have to handle a much larger volume of water. On large installations the pump sizes can be kept down to practical limits by the use of multiple pumps connected in parallel to a common header.

To prevent flashing at the pump suction line, a bypass connection with valve is made between the supply and return lines to allow a small quantity of the cooler return water to mix with the supply water from the expansion drum. Thus the temperature of the water entering the pump suction line is a few degrees lower than the evaporation pressure, yet subjected to the full pressure in the drum. The valve is set manually to pass the minimum quantity of water as required above.

Pipe, Fittings, and Insulation

Steel pipe and fittings are generally used. An effort should be made to avoid the use of non-ferrous materials, since the action of the water at elevated temperatures on these materials is difficult to predict.

Steel pipe should be used throughout, and piping external to the boiler house should be welded. Within the boiler house flanges are recommended to facilitate inspection and provide ready access. Branches should take off with easy sweeps and full radius bends be used for all changes of direction. Provision for expansion is as important as for steam at the same temperatures. Piping should be insulated to the same thickness and standards as for steam at the same temperature.

Valves for high temperature water should be made with cast steel bodies and stainless steel trim since these have proved far more satisfactory than bronze valves. Wedge-type gate valves are recommended for isolating and for use within the boiler house. For general use throughout the system, globe valves are preferred.

Valves combining flow control and regulation are preferable for high temperature water where heat balancing is necessary, since a small quantity of this water contains a large quantity of heat. As high temperature water is more penetrating than low temperature water, leakage due partly to capillary action should not be ignored because even a small amount of leakage evaporates immediately. This slight leakage becomes noticeable only on the outside of the gland and spindle of the valve where thin deposits of salts are left after evaporation.

Control

The control of temperature is usually obtained by conventional means although it is common practice to place control valves on the outlet line of the heat absorbing equipment where the temperatures are lower. In larger distribution systems means of controlling differential pressures between the flow and return mains are advisable.

With space and process heating, temperatures can be controlled within close limits by the use of two- and three-way mixing valves modulating or by-passing some of the high temperature water. Such controls are essential at heat exchangers or converters.

Boilers or Hot Water Generators

Almost any high presssure boiler can be used for high temperature water systems, but certain types as, for example, the water tube boiler, are more advantageous than others. Boiler selection is important and such problems as frictional head loss, available water space, flue outlet, type of firing etc., need careful consideration. The larger the system, involving heat distribution circuits of three, four, five miles or more, the greater will be the frictional head on the pumps, so every care should be taken to reduce the head loss in the boiler to a minimum and thus reduce the pump horsepower. Frictional loss through a boiler operating with entrained steam and air in the tubes and headers, can be a serious factor.

Balancing is another problem which can be made simple when the system is well designed. During the spring and autumn months and in mild weather at any time, the heat load will be low and only one boiler will be required. To put a boiler on the line or take one off is simplified if all boiler supply lines are connected into a common expansion drum. Boilers are then controlled from the pressure developed in the drum and the high temperature water supply taken through a dip pipe below the water level.

Since the heat storage in the system is very high (Table 6 illustrates this in Btu per cubic foot) advantage of this high temperature water characteristic can be taken when considering the number and output of the boilers. The output of the central boiler plant can be greatly reduced and the initial cost of the system lowered accordingly if the thermal storage of the system is taken into account.

TABLE 6. PROPERTIES OF WATER (212 F TO 400 F)

Temperature F	Pressure* psia	Density Lb/Cu Ft	Specific Heat Btu/(lb)(°F)	Total Heat Above 32 F	
				Btu/Lb*	Btu/Cu Ft
212	14.70	59.88	1.0055	180.00	10.760
220	17.19	59.66	1.0068	188.06	11.222
230	20.78	59.37	1.0087	198.15	11.764
240	24.97	59.17	1.0104	208.26	12.327
250	29.82	58.84	1.0126	218.39	12.856
260	35.43	58.62	1.0148	228.55	13.403
270	41.85	58.25	1.0174	238.74	13.912
280	49.20	58.04	1.0200	248.95	14.555
290	57.55	57.65	1.0230	259.20	14.942
300	67.01	57.41	1.0260	269.48	15.476
310	77.68	57.00	1.0296	279.80	15.955
320	89.65	56.65	1.0332	290.17	16.444
330	103.03	56.31	1.0368	300.59	16.931
340	117.99	55.95	1.0404	311.05	17.407
350	134.62	55.65	1.0440	321.55	17.899
360	153.01	55.19	1.0486	332.10	18.333
370	173.33	54.78	1.0532	342.71	18.778
380	195.70	54.36	1.0578	353.39	19.213
390	220.19	53.96	1.0624	364.14	19.644
400	247.25	53.62	1.0670	374.96	20.106

* Reprinted by permission from *Thermodynamic Properties of Steam*, by J. H. Keenan and F. G. Keyes published by John Wiley and Sons, Inc., 1936 edition.

Storage

High temperature water systems offer the opportunity of storing heat to even out the peak loads and low loads within the 24-hour cycles.