TABLE 1. AVERAGE MAXIMUM WATER MAIN TEMPERATURES[a]

State	City	Temp. F	State	City	Temp. F	State	City	Temp. F
Ala.	Birmingham	84	Mass.	Boston	80		Tulsa	86
	Mobile	80		Cambridge	70	Ore.	Eugene	60
Ark.	Little Rock	83		Fall River	76		Portland	65
Ariz.	Phoenix	82		Lowell	50	Pa.	Altoona	74
	Tucson	80		Lynn	68		Erie	75
Calif.	Anaheim	60		New Bedford	70		Johnstown	74
	Berkeley	69		Salem	68		McKeesport	82
	Fresno	80		Worcester	76		Philadelphia	85
	Fullerton	76	Mich.	Detroit	77		Pittsburgh	86
	Glendale	68		Flint	70	R. I.	Providence	68
	Los Angeles	80		Grand Rapids	84	S. C.	Charleston	83
	Oakland	69		Highland Park	77		Greenville	81
	Ontario	70		Jackson	56		Spartanburg	78
	Pasadena	82		Kalamazoo	53	S. D.	Rapid City	65
	Pomona	75		Lansing	64	Tenn.	Chattanooga	84
	Riverside	78		Saginaw	82		Knoxville	90
	Sacramento	72	Minn.	Duluth	55		Memphis	85
	San Bernardino	65		Minneapolis	85		Nashville	90
	San Diego	84		St. Paul	80	Texas	Amarillo	70
	San Francisco	71	Mo.	Jefferson City	82		Austin	90
	Whittier	75		Kansas City	84		Beaumont	86
Colo.	Denver	75		Springfield	82		Dallas	86
Conn.	Bridgeport	66		St. Joseph	84		El Paso	85
	Hartford	73		St. Louis	85		Fort Worth	85
	New Haven	76		Springfield	74		Galveston	90
	Waterbury	72	Nebr.	Lincoln	70		Houston	83
D. C.	Washington	84		Omaha	85		Port Arthur	83
Del.	Wilmington	83	Nev.	Reno	70		San Antonio	78
Fla.	Jacksonville	86	N. H.	Manchester	76		Wichita Falls	85
	Miami	82	N. J.	Jersey City	63	Utah	Logan	44
	Tampa	77		Newark	75		Salt Lake City	65
Ga.	Atlanta	85		Paterson	78	Va.	Fredericksburg	75
	Macon	80		Trenton	79		Lynchburg	73
Idaho	Boise	60	N. Y.	Albany	68		Norfolk	80
Ill.	Chicago	78		Buffalo	78		Richmond	85
	Cicero	76		Jamaica	56	Wash.	Olympia	58
	Evanston	73		Mt. Vernon	74		Seattle	62
	Moline	83		New Rochelle	75		Spokane	51
	Peoria	67		New York	72		Tacoma	57
	Rockford	59		Rochester	70	W. Va.	Charleston	85
	Springfield	82		Schenectady	60		Huntington	78
Ind.	Evansville	88		Syracuse	74		Wheeling	78
	Gary	75		Utica	69	Wis.	LaCrosse	54
	Indianapolis	84		Yonkers	70		Madison	58
	South Bend	61	N. C.	Asheville	74		Milwaukee	75
	Terre Haute	82		Charlotte	85		Racine	68
Iowa	Cedar Rapids	78		Raleigh	92			
	Des Moines	77		Winston-Salem	82			
	Sioux City	62	N. M.	Albuquerque	65	Province		
Kans.	Concordia	57	Ohio	Akron	76			
	Kansas City	86		Canton	50			
	Topeka	88		Cincinnati	84			
	Wichita	72		Cleveland	77	Alta.	Calgary	64
Ky.	Louisville	85		Columbus	84	B. C.	Vancouver	60
La.	Baton Rouge	85		Dayton	60	Ont.	London	50
	New Orleans	90		Lakewood	82		Toronto	63
	Shreveport	88		Springfield	72	P.E.I.	Charlottetown	48
Me.	Augusta	60		Toledo	83	Que.	Montreal	78
Md.	Baltimore	75	Okla.	Oklahoma City	82		Quebec	68

[a] These averages taken from various city water main locations, with some actual values slightly higher and some lower than values shown. Some values were supplied by H. E. Degler, Marley Company. Some were obtained from City Water Department records. The highest values given by the various authorities are usually those listed.

bulb temperature, but the same humidity ratio, more water can be absorbed per pound of dry air in passing through the washer, assuming that the humidifying effectiveness of the washer is not adversely affected by operation at the higher wet-bulb temperature. The analysis of the process occurring in the washer itself is the same as that explained under *Method 1*. The final desired conditions are secured by adjusting the amount of preheating to give the required wet-bulb temperature at entrance to the washer.

Method 3. Even if heat is added to the spray water, the mixing occurring in the washer itself may still be regarded as adiabatic. The state

point of the mixture should move in a direction determined by the specific enthalpy of the heated spray as explained in Chapter 3. It is possible, by elevating the water temperature, to raise the air temperature, both dry-bulb and wet-bulb, above the dry-bulb temperature of the entering air.

In each of the methods, 1, 2 or 3, the air leaving the air washer may require reheating to produce in the conditioned space the required dry-bulb temperature and relative humidity.

DEHUMIDIFICATION AND COOLING WITH AIR WASHERS

Cooling of the wet-bulb temperature of an air vapor mixture can be accomplished by an air washer if the temperature of the spray water is lower than the wet-bulb temperature of the air. Moisture removal is obtained when the spray water temperature is lower than the dew-point of the entering air. In these cases the final dry-bulb temperature and relative humidity of the leaving air are dependent upon the design factors of the air washer.

Both sensible and latent heat are removed in the process of dehumidification by cold spray water. Abstraction of sensible heat occurs during the entire time that the air is in contact with the spray medium. Latent heat removal takes place as condensation occurs. Therefore, the lower the spray temperature, the greater the amount of moisture removal per pound of dry air, all other conditions remaining the same.

Washers with two or more banks of spray are usually selected for dehumidifying installations, whether for comfort or industrial installations. Generally such air washers cool the air to within one or two degrees (Fahrenheit) of the leaving spray water temperature; this differential will increase somewhat when the difference between the entering wet-bulb and leaving dew-point is relatively large.

Where a limited supply of cold water is available, multiple stage washers may be used to great advantage. In such washers the cool water is pumped through the multiple spray systems in series and counterflow to the air flow. Such an arrangement brings the delivery air in contact with the coldest water, securing a maximum amount of cooling and saving water.

When using cold well water or water from city water mains, care should be used to secure accurate data on the water temperatures. Table 1 lists some approximate water-main averages which may be used as a guide, but they should be verified from local records. This is particularly true with city water main temperatures. In the case of well water temperatures, Fig. 3 shows the approximate temperatures of water to be expected from wells at depths of 30 to 60 ft.

Air washers for dehumidifying and cooling usually have separate recirculating pumps. These pumps deliver a mixture of cold and recirculated water under the control of a three-way valve. The valve may be actuated either by a thermostat in the washer outlet, or by a humidity or other controller in the space being conditioned.

Air washers for dehumidifying are very often furnished with direct expansion or water cooling coils within the washer space, in which case water for the washer sprays is entirely recirculated.

APPARATUS FOR DIRECT HUMIDIFICATION

Humidifiers may be divided into two general types which are, according to the method of operation: (1) indirect, such as the air washer, which