thermostatic control. It is advantageous to direct only return air through the bypass rather than a mixture of return and outdoor air in order to hold the humidity ratio under thermostatic control.

Although both heating and cooling coils are made of sufficient strength to take up expansion and contraction arising within themselves, care should be taken to avoid imposing strains from the piping on the coil connections. (See Chapter 26.)

COIL SELECTION

In the selection of a coil it is necessary to consider various factors:

1. The duty required: heating, cooling, dehumidifying, and the capacity required to maintain balance with other system components such as compressor equipment in the case of direct expansion coils.
2. Temperature of entering air—dry-bulb only if there is no dehumidification; dry- and wet-bulb if moisture is to be removed.
3. Available heating and cooling media.
4. Space and dimensional limitations.
5. Air quantity limitations.

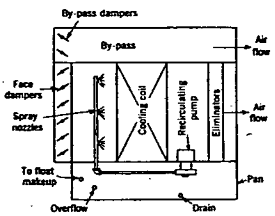

Fig. 11 .... Recirculating Spray System for Cleaning Coils

6. Allowable resistances in air circuit and through tubes.
7. Allowable resistance between the inlet and the outlet of the tube circuits of the coil.
8. Characteristics of individual coil designs.
9. Individual installation requirements, such as, for example, the type of automatic control to be used.

The duties required may be determined from information in Chapter 9, 11, 12, 13, and 19. There may, or may not, be a choice of cooling and heating media, as well as operating temperatures, depending upon whether the installation is new or is in combination with present sources of heating or cooling. Space limitations are dictated by the requirements of individual cases. The air quantity is influenced by a number of considerations. The air quantity through heating coils is often made the same as that necessary to handle the summer cooling load. The air handled may be limited by the use of installed ventilating ducts for air distribution or may be determined by requirements for satisfactory air distribution or ventilation. The resistance through the air circuit influences the fan horsepower and speed. This resistance may be limited to allow the use of a given size of fan motor, or to keep the operating expense low, or it may be limited because of sound-level requirements. The allowable friction through the water or brine circuit may be dictated by the head available from a given size of pump and pump motor. The performance of a surface heating or cooling coil depends upon correct choice of the original equipment, and upon proper application and maintenance.

Coil ratings are based on a uniform *face* velocity. Interference with uniform air flow through the coil will affect performance. Such air flow interference may be caused by air entrance at odd angles or by inadvertent blocking of a portion of the coil face. To obtain rated performance it is necessary that the air quantity be adjusted on the job to that used when selecting the coil, and that it be kept at this value. The most common cause of a reduction of air quantity are the fouling of the filters and collection of dirt on the coils. These difficulties can be avoided by proper design and regular servicing. There are a number of ways in which coils may be cleaned. A common method is to wash them with water. They can sometimes be brushed and cleaned with a vacuum cleaner. In bad cases of neglect, especially on restaurant jobs where grease and dirt have accumulated, it is sometimes necessary to remove the coils and wash off the accumulation with steam, compressed air and water, or hot water. The best practice, however, is to keep the filters serviced, and to inspect and wash the coils at regular intervals.

The proper selection of coils requires an understanding of the requirements of each case, and should be based on an economic analysis of the plant design as a whole. While no general rule can be established for the selection of heating or cooling coils, it is possible, nevertheless, to point out the limits of usual practice and to indicate the influence of the variables involved in the coil selection.

Heating Coils

Steam and *hot water heating coils* are usually *rated* within these limits:

Air Face Velocity—200 to 1200 fpm, sometimes up to 1500 fpm.
Steam Pressure—2 to 200 psig, sometimes up to 350 psig.
Hot Water Temperature—150 to 225 F.
Water Velocity—2 to 6 fps.

Individual cases may deviate widely, but the tabulation given herewith will serve as a guide to usual *heating installation practice*:

Air Face Velocity—500 to 800 fpm face, 500 being a common figure.
Delivered Air Temperature—varies from about 72 F for ventilation only, to about 150 F for complete heating.
Steam Pressure—2 to 10 psig, 5 psig being common.
Hot Water Temperature—150 to 225 F.
Water Velocity—2 to 6 fps.
Water Quantity—Based on about 20 deg temperature drop through a hot-water coil.
Air Resistance—The total resistance through heating coils is usually limited to from 3/8 to 5/8 in. of water for public buildings, to about 1 in. for factories.

The selection of heating coils is relatively simple as it involves dry-bulb temperatures and sensible heat only, without the complication of simultaneous latent heat loads, as in cooling coils. For a given duty, entering air temperature, and steam pressure, it is possible to select several arrangements of the same design of coil depending upon the relative importance of space, cross-sectional area, and air resistance.

Cooling Coils

Cooling and *dehumidifying coils* are usually *rated* within these limits:

Entering Air Dry-Bulb—60 to 100 F.
Entering Air Wet-Bulb—50 to 80 F.
Air Face Velocities—300 to 800 fpm (sometimes as low as 200 and as high as 1200).
Volatile Refrigerant Temperatures—25 to 55 F, at coil suction outlet.
Water Temperatures—40 to 65 F.
Water Quantities—2 to 6 gpm per ton, or equivalent to a water temperature rise of from 4 to 12 deg.
Water Velocity—2 to 6 fps.

The ratio of total to sensible heat removed varies in practice from 1.00 to about 1.65, i.e., sensible heat is from 60 to 100 percent of total, depending on the application. (See Chapter 19.) Since required ratios may demand wide variations in air velocities, refrigerant temperatures, and coil depth, general rules as to their values may be misleading. On most comfort installations air face velocities between 400 and 600 fpm are frequent, 500 being a common value. Refrigerant temperatures ordinarily vary between 35 and 50 F where cooling is accompanied by dehumidification. Water velocities range from 2 to about 6 fps.

When no dehumidification is desired, for which condition the dew point of the entering air is equal to or lower than the cooling coil surface temperature, the coil selection is made on the basis of dry-bulb temperatures and sensible-heat transfer only, the same as with heating coils. It is possible also to choose various arrangements of face area, depth, air velocity, etc., for the same duty.

Dehumidifying Coils

The performance of coils accomplishing both cooling and dehumidification is determined by a series of tests carried on under laboratory conditions. Coil ratings can be prepared from such laboratory test data to facilitate the selection of coils for cooling and dehumidifying duty. The coil capacity should be in balance with the capacity of related equipment, such as compressors, and the temperature of the circulating medium.

The selection of cooling coils for factory-assembled self-contained air conditioners is generally accomplished in conjunction with laboratory testing. The current industry standards call for ratings at 33.4 cfm per thousand Btu of cooling capacity and this is approximately 400 cfm per ton of refrigeration. The use of an entering air condition of 80 F dry-bulb and 67 F wet-bulb is representative of the entering air conditions actually encountered in many comfort operations because, while the indoor conditions are usually lower than 67 wet-bulb, the introduction of outdoor air will usually bring the mixture of air to the cooling coil up to an approximation of the 67 wet-bulb entering air condition at design conditions.

The selection of cooling coils for field assembled projects is usually accomplished by the use of coil rating tables. The practice of selecting coils from the load division indicated by the load calculation has worked out satisfactorily for the usual human comfort applications. Additional design precautions and refinements are being used for more exacting industrial applications and for improved results on all types of air conditioning in the more humid areas. One of these refinements is the use of a separate cooling coil to cool and dehumidify the ventilation air before admixture with recirculated air. This procedure takes care of one of the main sources of moisture in the usual application. Provision for reheat is required for some industrial applications, and is used for better results on very special commercial applications.

In checking the operating results obtained from cooling coils in various air-conditioning installations, it is necessary to keep in mind the influence of the climatic conditions of the various areas encountered. The majority of problems are encountered at *light-load* conditions when the cooling requirement is considerably less than at design conditions. In the hot, dry climates, where the outdoor dew points are so constantly low that dehumidifying is not generally a problem, the *light-load* condition does not pose any special problems. In the hot, humid climates, where the outdoor dew points are generally high and close to the dry-bulb temperatures, the *light-load* condition has a higher proportion of moisture and a correspondingly lower proportion of sensible heat. These climatic conditions result in higher dew points in the conditioned spaces during the *light-load* conditions unless some of the special means for controlling the inside dew points are used. In the geographic locations where warm weather occurs with both high and low dew points, such as around the Great Lakes, the *light-load* operating conditions with the higher percentage of moisture loading will be encountered less frequently and consistently than in the south coastal areas.

Care should be taken to avoid freezing at light loads. In general, freezing occurs when the coil surface temperature falls to 32 F. With usual coils for comfort installations, this does not occur unless the evaporating temperature at the coil outlet is about 20 to 25 F. The exact value depends on the design of the coil and the amount of loading. Although it is not customary to choose coil and condensing units to balance at low temperatures at peak loads, there is danger of this occurring when the load decreases. This is further aggravated if a bypass is used so that less air is passed through the coil at light loads.

HEAT TRANSFER AND AIR FLOW RESISTANCE

The transfer of heat between the heating or cooling medium and the air stream is influenced by several variables:

1. The temperature difference.
2. The design and surface arrangement of the coil.
3. The velocity and character of the air stream.
4. The velocity and character of the medium in the tubes.

The driving force is usually taken as the logarithmic mean temperature difference for heating or cooling without dehumidification. The rating of cooling coils for combined cooling and dehumidification is discussed later in this chapter. With volatile refrigerants there is often an appreciable pressure drop and corresponding change in evaporating temperature through the refrigerant circuit. The problem is further complicated by the fact that the refrigerant is evaporating in part of the circuit, and superheating in the remainder. In the case of volatile refrigerants, a cooling coil is tested and rated in conjunction with a specific distributing and liquid-metering device, and the capacities are stated for a given superheat condition of leaving vapor.

The design and surface arrangement of the coil include