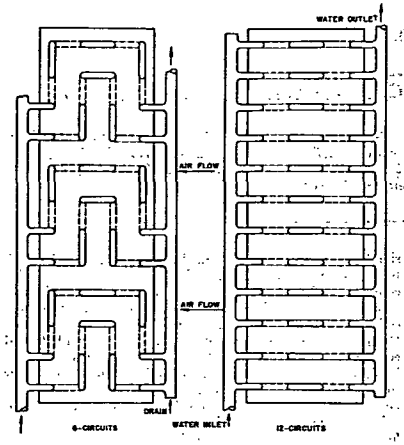


Fig. 2 .... Various Water Circuit Arrangements

fins for each tube. All of these, as well as other less common types, are in use, the selection for a particular installation being based on economic considerations, space requirements, and performance of individual designs of coils. A most important factor in the performance of extended-surface coils is the bond between the fin and the tube. An intimate contact between the tube and the fin must be maintained permanently to ensure unimpeded heat transfer from fin to tube.

In some coils, fins are wound on the tubes under pressure, in order to upset the metal slightly at the fin root, and are then given a coating of solder while the fin and tube are still revolving, for the purpose of assuring a uniform coating of solder. In other types, the spiral fin may be knurled into a shallow groove on the exterior of the tube. The tube may be expanded after the fins are assembled, or the tube-hole flanges of a flat or configurated fin may be made to override those in the preceding fin and so compress them upon the tube. There are also types of construction where the fin is formed out of the material of the tube itself.

Cooling coils for water or for volatile refrigerants most frequently have aluminum fins and copper tubes, although copper fins on copper tubes are also used. There are many makes of cooling coils of the lightweight extended-surface type for both heating and cooling with tubes commonly ¼, ⅜, ½, ⅝, ¾, and 1 in. outside diameter, and with fins spaced three per inch up to fourteen per inch. The tube spacing generally varies from about ¾ to 2½ in. on centers, depending upon the width of individual fins and on other considerations of performance. Fin spacing should be chosen for the duty to be performed, with special attention being paid to air friction, possibility of lint accumulation and, especially at lower temperatures, the consideration of frost accumulation.

Water Coils

The performance of water coils, for heating or cooling, depends on the elimination of air from the system and proper distribution of water. Air elimination is taken care of in the system piping as described in Chapter 10, 1964 Guide And Data Book. To assure a pressure drop sufficient for adequate distribution, but at the same time to provide against excessive pumping head where large water quantities are handled, water coils are provided with various water-circuit arrangements. For instance, a typical coil 18 tubes high and 6 tubes deep in the direction of air flow can be arranged for 6, 9, 18, 24, or 36 parallel water circuits, as conditions may require. Orifices in individual tubes are occasionally employed, but are usually unnecessary as the resistance of individual water circuits is generally sufficient to effect a satisfactory distribution. In precooling coils using well water, where there may be considerable sand and other foreign matter in the water, provision for cleaning of individual tubes is important in order to assure a continuation of rated performance after the cooling units have been in service for a period of time. It is important to arrange water coils for complete drainage (see Fig. 2). The drains are usually provided in the water piping at the coil header.

Direct-Expansion Coils

Coils for volatile refrigerants present more complex problems of fluid distribution than water, brine, or steam coils. It is desirable that the coil be effectively and uniformly cooled throughout, and necessary that the compressor be protected from entrained, unevaporated refrigerant. There are two types, namely, flooded systems, and thermal-expansion-valve systems, as shown in Figs. 3 and 4. In a flooded coil, the circulation is similar to that in a water tube boiler. The liquid is maintained at the proper level by the action of a float regulator, refrigerant pump, or both, as shown in Fig. 3. The thermal-expansion-valve system depends upon the thermal valve to feed automatically just as much liquid to the coils as is required to evaporate all refrigerant entering the coil and maintain the superheat at the coil-suction outlet within predetermined limits, which vary from about 6 to 10 deg. The thermal-valve arrangement is in common use for the type of coils covered by this chapter, while the flooded system is rarely used.

With the flooded system considerably more refrigerant is circulated than in expansion valve systems (up to 5 times rate of evaporation) and liquid refrigerant may leave the coil. The refrigerant distribution through the tubes depends on properly selecting the length of the feeds, and the head of liquid imposed upon the liquid inlets. The flow of refrigerant from the liquid inlets must be horizontal and upward. The possibility of gas trapping must be avoided. No auxiliary distributing devices are required.

The path of each refrigerant feed from the distributor to the suction header is called a circuit. The length of each circuit should be chosen to provide good heat transfer and return of oil, as well as a reasonable pressure drop across the circuit.

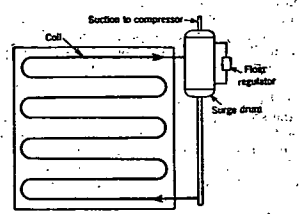


Fig. 3 .... Direct-Expansion Coil with Flooded System

The external loading conditions, the tube size, and other factors, influence the practical length of a circuit. Because of the various factors involved, the practical length and the arrangement of the circuits is developed from laboratory tests and the design of coils for units produced in volume are usually verified by additional tests.

To insure reasonably uniform refrigerant distribution in multicircuit coils, it is common practice to provide a distributing means, between valve and coil liquid inlets, to divide the refrigerant equally among the feeds. Such a distributor must be effective for distributing both liquid and vapor, because the entering refrigerant is a mixture of the two. Fig. 5 shows four typical types of distributors. In distributor *A*, the liquid and gas mixture from the thermal valve is led tangentially into a chamber. The coil feed connections extend outward radially at the top of this chamber. In distributor *B*, the refrigerant is discharged at a high velocity through a central jet against the end plate, forming a uniform mixture of gas and liquid within the distributor, from which individual connections are led as shown. In type *C*, the refrigerant enters at high velocity from the thermal valve and is discharged against the end plug in which the individual liquid feeds are closely arranged. Type *D* shows a typical pressure-drop type distributor. The liquid-vapor mixture flows into the nozzle, which is sized to match the load so that adequate mixing of the two phases is maintained to feed equal portions of the mixture to the individual circuits. Beyond the nozzle, the refrigerant stream is deflected by a conical pin towards the individual circuits which are spaced evenly around the base of the cone. These distributors can be used in either vertical or horizontal position. There are also other types of headers such as the weir type. The individual liquid connections from the distributor to the coil inlet are commonly made of small diameter tubing, and are all of the same length and diameter in order to impose the same friction between the distributor and the coil. Since the thermal valves act in response to the superheat at the coil outlet, this superheat should be produced with the least possible sacrifice of active evaporating surface.

Control of Coils

Chapter 13 discusses methods of controlling air-cooling coils to meet system or space requirements, and factors that should be considered in sizing automatic valves for water coils. Chapter 46 discusses refrigerant flow control devices and factors to be considered in their use with direct expansion coils. It is general practice to obtain superheat by suitable design of the coil rather than by use of external heat exchangers or other auxiliary devices.

The majority of direct expansion coils are equipped with thermal valves. Sometimes a single thermal valve is used per coil while, in other cases, two or more thermal valves are employed by each coil. The function of the thermal valve is to control the refrigerant flow rate through its coil circuit so

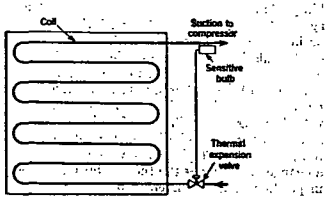


Fig. 4 .... Direct-Expansion Coil with Thermal Valve System

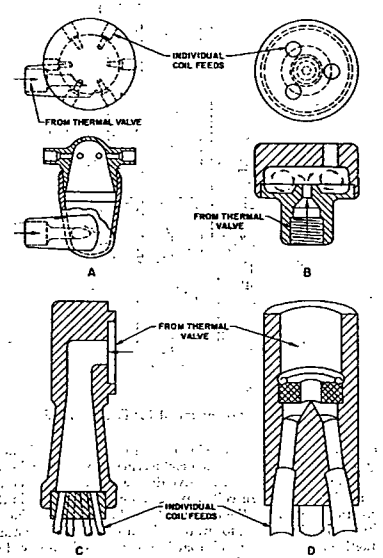


Fig. 5 .... Refrigerant Feed Distributing Heads

that the refrigerant vapor at the coil outlet is properly superheated. By themselves, thermal valves do not provide accurate control of the total system refrigeration capacity under partial load conditions.

For regulating the refrigeration load requirements for the conditioned space, a common method of controlling coil capacity is by use of solenoid operated refrigerant liquid valves located upstream from the thermal valves as shown in Fig. 6 and 7. One or more thermal valves may be operated by a single solenoid valve. The solenoid valves are usually controlled by a thermostat located in the return air or in the conditioned space. For coils with multiple thermal valves, there are two arrangements: (1) face control in which the coil is divided across its face, as shown in Fig. 6, and (2) depth (or row) control as shown in Fig. 7. Face control is used in most cases and provides substantially equal loading on all thermal valve fed circuits within the coil. Face control has the disadvantage of permitting re-evaporation of condensate on the coil and bypassing air into the conditioned space, during partial load conditions when some of the thermal valves are on an *off* cycle. Depth control is seldom available as standard equipment and is usually supplied on special order. Depth control produces unequal loading on the thermal valve circuits, but this is not necessarily a disadvantage if thermal valves are properly sized and designed to overcome this effect. Depth control eliminates air bypassing during partial load operation and minimizes condensate re-evaporation.

Flow Arrangement

In all heat transfer processes, the relative directions of flow of the fluids influence the performance of the heat-