P. W. Wyckoff: Design search for the foolproof air conditioner (REFRIGERATING ENGINEERING, January 1959, p. 43).

W. K. Lewis: The evaporation of a liquid into a gas (*ASME Transactions*, Vol. 44, 1922, p. 325).

W. H. Carrier: The contact-mixture analogy applied to heat transfer with mixtures of air and water vapor (*ASME Transactions*, Vol. 59, 1937, p. 49).

William Goodman: The evaporative condenser—theory and characteristics (*Heating, Piping and Air Conditioning*, March 1938, p. 165; April 1938, p. 258; May 1938, p. 327).

D. D. Wile: Evaporative condenser performance factors (REFRIGERATING ENGINEERING, January 1950, p. 55).

F. Rasori: Cooling potential vs. specific enthalpy (REFRIGERATING ENGINEERING, November 1953, p. 1207).

CHAPTER 43

EVAPORATORS FOR LIQUID COOLING

Types of Water and Brine Coolers, Design Criteria, Mechanical and Chemical Requirements, Performance Requirements, Fluid Friction, Heat Transfer, Refrigerant and Chilled Liquid Film Coefficients, Separation of Coefficients, Overall Heat Transfer Rates, Water and Brine Properties

EVAPORATORS used for cooling water and brines with the commonly used refrigerants are discussed in this chapter. Evaporators for cooling air are discussed in Chapter 34.

An *evaporator* is that part of a refrigerating system in which the refrigerant is vaporized to produce refrigeration.

A *brine* is any liquid cooled by a refrigerant and used for the transmission of heat without a change in its state, having no flash point, or a flash point above 150 F, as determined by the American Society for Testing Materials Method D93.

Items to be considered in evaporator design and selection are: (a) evaporator surface heat transfer rates, (b) methods of supplying liquid to the evaporator, (c) safety, (d) loss of refrigerant through leakage, (e) liquid carryover, (f) oil return to compressor, (g) fouling of evaporator surface, (h) corrosion, (i) space and weight characteristics, (j) possible freezing of the medium being cooled, (k) circulation pressure losses of the medium being cooled, and (l) cost.

TYPES OF WATER AND BRINE COOLERS

The various types of water and brine coolers are listed in Table 1, which also indicates the refrigerant flow control, capacity range, and refrigerants commonly used with each type.

Flooded Shell-and-Tube Type

The *flooded cooler* is one in which the refrigerant is vaporized on the outside of finned or plain tubes which are within a closed shell. Space is usually provided above the tubes submerged in the boiling liquid for the separation of liquid droplets from the leaving vapor. These coolers utilize straight tubes, U-shaped tubes, or coiled tubes for the evaporator surface through which the water or brine flows. The number and size of tubes per pass determines the velocity of the fluid circulated. This velocity is usually held between the limits of 3 and 10 fps. Fig. 1 shows a cross section of a typical ammonia bare-tube cooler. Fig. 2 shows a cross section of a typical finned-tube cooler designed for use with fluorinated hydrocarbon refrigerants.

Other types of coolers may be operated flooded by providing a suction trap located above the evaporator, of suitable size and arrangement to effectively separate the liquid refrigerant from the vaporized refrigerant flowing to the compressor, and to return the liquid refrigerant to the cooler.

Ammonia flooded coolers are customarily designed with bare steel tube surfaces while flooded coolers using other common refrigerants usually will be designed with non-ferrous tubes having extended surface on the refrigerant side.

Refrigerant feed methods for flooded coolers control in some manner the liquid level in the cooler. This can be accomplished by a low pressure float valve, by a high pressure float valve on single cooler systems, by a constant pressure expansion valve, by a thermostatic expansion valve, by a float switch and solenoid valve combination, or by means of a restrictor.

Spray Type

A spray type cooler is similar to a flooded shell-and-tube cooler except that the refrigerant liquid is recirculated through spray nozzles located above the top tubes. None of the tubes are submerged in liquid. The quantity of refrigerant circulated is usually three to four times the quantity evaporated in order to thoroughly wet the tube surface. The spray cooler is spe-

Table 1 .... Types of Water and Brine Coolers

Type of Cooler	*Usual Refrigerant Feed Device*	*Usual Range of Capacity (Tons)*	*Commonly Used with Refrigerant Nos.*
Flooded Shell-and-Bare-Tube	Low Pressure Float	50–500	717 (Ammonia)
Flooded Shell-and-Finned-Tube	Low Pressure Float	25–2000	11, 12, 22, 113, 114, 500
	High Pressure Float	50–3000	
Spray Type-Shell and-Tube	Low Pressure Float High Pressure Float		11, 12, 113, 114
Dry Expansion Shell-and-Tube	Thermal Expansion Valve	5–150	12, 22, 500, 117
Flooded Baudelot Cooler	Low Pressure Float	10–100	717
Dry Expansion Baudelot Cooler	Thermal Expansion Valve	5–25	12, 22, 717
Flooded Double-Pipe Cooler	Low Pressure Float	10–25	717
Dry Expansion Double-Pipe Cooler	Thermal Expansion Valve	5–25	12, 22, 717
Shell-and-Coil Cooler	Thermal Expansion Valve	2–10	12, 22, 717
Flooded Tank-and-Agitator	Low Pressure Float	50–200	717

The general responsibility for this chapter is assigned to TC 9.2, Liquid Heat Exchangers.