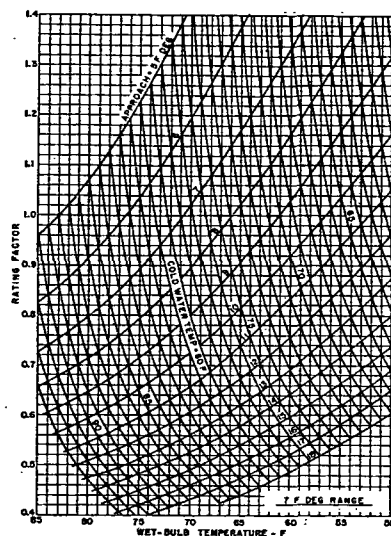


Fig. 14 Rating Chart for 7 Deg Range¹⁰

distribution system have a significant effect on the characteristic. Air channeling is caused by the cell structure and this is most significant in a counterflow tower, due to the restricted air inlet and the changes in the direct of air flow.

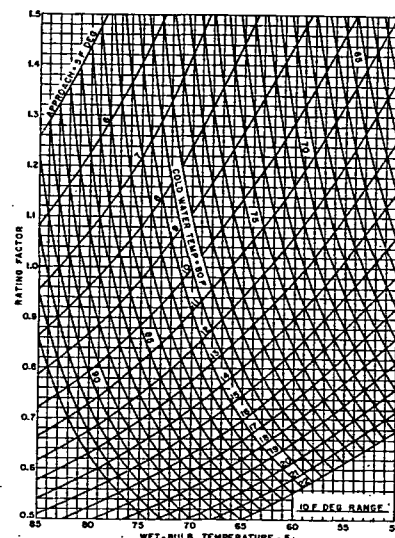
A portion of the cooling occurs in the spray chamber above the filling and also in the open space below the filling. All of the cooling is credited to the filled volume. The indicated available coefficient reflects the overall performance of the entire assembly. The characteristic of a fill pattern varies widely, and the variations are greater in counterflow towers. A true tower characteristic must be developed from full scale tests of the actual assembly.

DESIGN CONDITIONS

A cooling tower is selected to operate at a given set of design conditions, but these conditions must first be selected by considering the function of the tower within the overall operation. The cooling tower is one component of the system, all parts of which must operate in equilibrium.

As shown schematically in Fig. 13, the heat load may be transferred from the process at a constant or variable temperature. The heat flows from the process to the circulating water in the heat exchanger, and the heat is then rejected to the atmosphere by the cooling tower.

A vapor condenses at a constant temperature corresponding to the saturation pressure. A temperature rise occurs where the heat is transferred to the circulating water. The condensing temperature must be above the hot-water temperature to provide a potential difference. The temperature rise, for a given heat load, is determined by the circulating water rate.

Fig. 15 Rating Chart for 10 Deg Range¹⁰

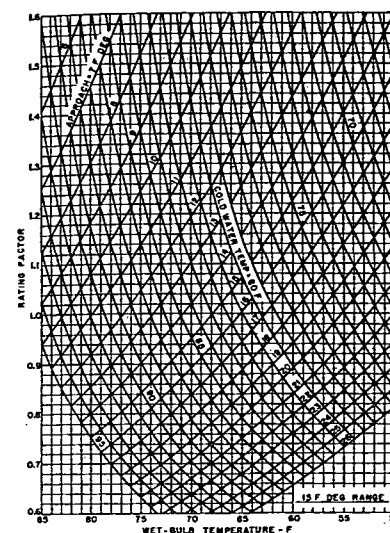
The cooling range of the tower will equal this temperature rise at equilibrium conditions.

The degree of elevation of the process temperature above the ambient conditions is composed of the sum of the approach of the cold-water to the wet-bulb temperature in the tower, the cooling range which equals the temperature rise in the heat exchanger, and the terminal difference in the exchanger. A reduction in operating temperature, always desirable for economic reasons, may be obtained by increasing the capability of either the cooling tower or heat exchanger.

An increase in the circulating water rate, at constant heat load, reduces the temperature rise and cooling range. The characteristics of a cooling tower are such that this results in an increase in approach, but the increase in cold-water temperature is less than the decrease in hot-water temperature. The heat exchanger operates at a constant log-mean temperature difference so the effect of the change in water temperatures is to reduce the condensing temperature. The overall effect of an increase in water rate is to reduce the condensing temperature, but at the expense of higher pumping costs.

Similar conditions exist when a fluid is cooled although the heat is removed from the process at a varying temperature. A temperature differential must exist throughout the heat exchanger, therefore the cooled fluid must be above the cold-water temperature and the hot fluid must be above the hot-water temperature.

The designer selects the water rate and the optimum combination of cooling tower and condenser. The temperature levels throughout the system are dependent on the entering wet-bulb temperature, so the design of the system is based on a variable weather pattern. The wet-bulb temperature fol-

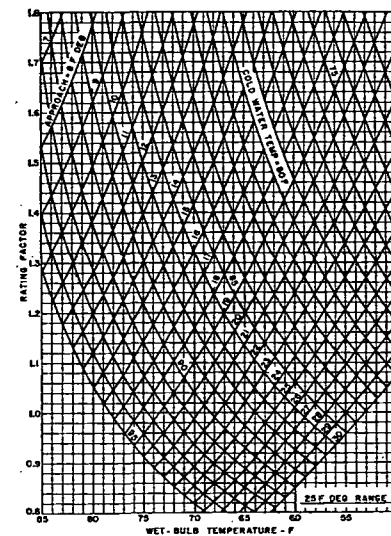
Fig. 16 Rating Chart for 15 Deg Range¹⁰

lows daily cycles that peak around noon. The daily cycles vary with the seasons, and the average conditions vary from year to year, so the design must be based on an average weather pattern for the locality.

A refrigerating system has a maximum condensing temperature, above which it either ceases to function, or must be shut down because of high head pressure. Similar conditions prevail in all processes. A system must be capable of functioning at all times when needed; therefore, the minimum size cooling tower must be capable of maintaining the operation within acceptable limits at the peak wet-bulb temperature.

Operating economy is of no importance during peak conditions because such periods are rare and of short duration. Operating economy improves as the wet-bulb temperature decreases so the optimum cooling tower is selected on the basis of an evaluation that considers the local average weather pattern which is obtainable from the Weather Bureau or from various other sources.¹¹ The analysis considers the tower characteristics which relate water temperatures to the wet-bulb temperature, and the weather pattern which considers the frequency that various wet-bulb temperatures prevail. This means that the cooling tower is selected on the basis of a performance curve that covers a wide range of operating conditions. A single set of conditions must be selected as the design point, and any point on the performance curves may be used for this purpose.

It is seldom possible to conduct an acceptance test at the design point, and guarantees are usually restricted to a narrow range of deviations from the design point. A common practice is to select a design wet-bulb temperature that will prevail or be exceeded 5 percent of the time during the four summer

Fig. 17 Rating Chart for 25 Deg Range¹⁰

months, or about 150 hours per year. A low design point is desirable because it increases the number of hours per year that the tower will operate within the guarantee zone. It should be noted that the size or capability of the tower is determined on the basis of an economic evaluation. Once this is done, any point on the performance curve may be selected for the design point, and the design wet-bulb temperature is chosen on the basis of convenience of testing.

PERFORMANCE CURVES

Cooling tower performance is specified in terms of range, approach, wet-bulb temperature, and water rate, or in some variation of these terms. The rating of a cooling tower is established by developing a series of charts that relate these variables. Relative capabilities are compared on the basis of the required sq ft/gpm. The ratio varies slightly with operating conditions, therefore comparisons should be made at some standard set of conditions. A convenient standard is 90 F hot-water, 80 F cold-water, and 70 F wet-bulb temperature, referred to hereafter as the 90-80-70 point.

Variations in tower design are reflected as variations in the area required to meet a given set of conditions. The variation between rating charts of different towers may be minimized by introducing the term Tower Unit, which is defined as the area required to cool 1 gpm at 90-80-70. The sq ft/gpm at 90-80-70 becomes unity and all rating charts coincide at that point. The family of curves is quite similar for all towers. The deviations become greater as the conditions become more remote from the 90-80-70 point.

The rating charts¹⁰ shown in Figs. 14, 15, 16, and 17 are constructed in this manner and represent the average of a