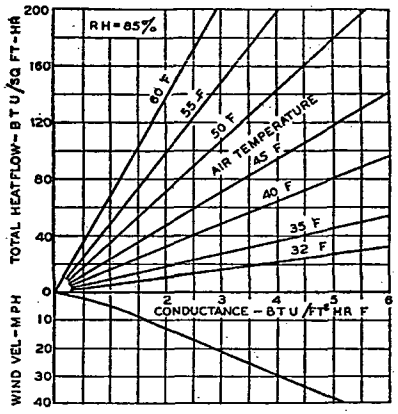

Fig. 1 .... Heat Transfer from Air to Ice Surface as Affected by Air Velocity and Temperature

to the many variable factors which enter into the calculation. Empirical values needed for calculation of the refrigeration requirements are based on data obtained from a test of 50 ice rink installations used for a wide variety of purposes, in Toronto, Canada, and its environs. It was found that some rinks, such as private clubs and figure skating, have very light usage, except for a few hours daily and on weekends. However, they may be in use during shows or bonspiels for

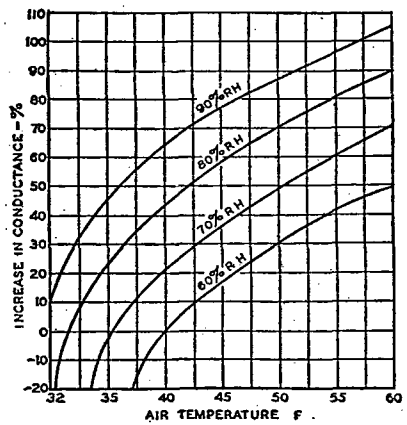

Fig. 2 .... Effect of Relative Humidity on Heat Transfer from Air to Ice Surface

Table 1 .... Average Maximum Wet-Bulb Temperature in Toronto Area, Season 1950–1951

September	October	November	December	January
56.3	45.3	35.5	27	26.7
February	March	April	May	June
22	28	38.2	48.3	58.2

18 hr per day during one week of a season. Community rinks have been used for hockey practice, free children skating, figure skating, and public skating all in the same day, almost around the clock, or as much as 20 to 22 hours per day. On such rinks the service factor is much heavier than on rinks used only a few hours per day.

Since, in many cases, it was impossible to foretell in advance the service factor to apply when a new rink was contemplated, data were obtained from a number of rinks under average conditions. Tables and curves were drawn for the actual performance of the machinery, based on acceptable conditions of the ice for the intended purpose.

The average wet-bulb temperature for each month of the skating season as shown in Table 1 was obtained from the Toronto weather bureau station. The total heat flow in Btuh per square foot was calculated and is shown graphically in Fig. 3 which was derived from Figs. 1 and 2. This heat flow will apply to all rinks at various average maximum monthly outdoor wet-bulb temperatures. The internal wet-bulb temperatures will follow those outdoors but with a lag due to the heat capacity of the building.

No attempt was made to take actual readings of the wet-bulb temperature inside and outside the building, since it was felt that to make these readings representative, would require considerable time and would not help the purpose, which was to arrive at average service or load factors for the various types of rink usage. These were determined and are listed in Table 2.

By knowing the tonnage of the compressor at operating conditions, and having previously calculated the heat flow, it was only necessary to add the curve at the bottom of Fig. 3 so that the refrigerating requirements could be calculated for any locality or any application. Tests have been made to check the reliability of the curves.

Example: Assume a rink for use for hockey and light public skating; size 85 × 185 ft or 15,725 sq ft. The skating season is to be from October to April, the average maximum monthly wet-bulb temperature from Table 1 in the month of October is 45.3 F and in April 38.2 F. Therefore, 45 F may be used as the design wet-bulb temperature.

From Table 2, the service factor for hockey and light public skating is 7.5. Then using Fig. 3, at 7.5 service factor and 45 F average wet-bulb temperature, the heat flow per sq ft per hr is found to be 37.5. The cooling load is

$$\frac{(37.5)(15{,}725 \text{ sq ft})}{12{,}000} = 49.14 \text{ tons refrigeration.}$$

ICE SEASON

The length of the ice season for a hockey or public skating rink depends upon location of the rink. In a metropolitan area it may be financially justified to operate all year. The usual operating season for an indoor rink is from six to seven months.

Open air rinks have not only been installed in localities in moderate climates and below the Mason-Dixon line but in cities where the winter temperature may at times drop to

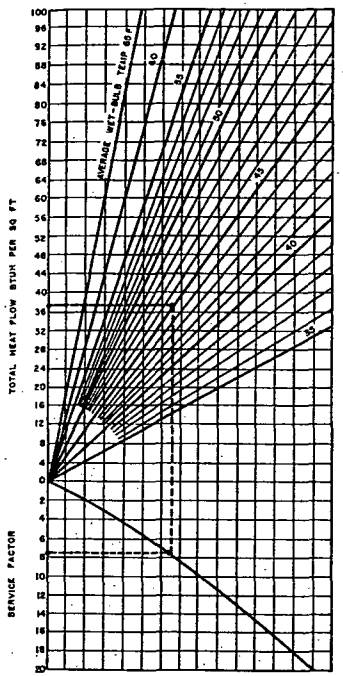

Fig. 3 .... Total Heat Flow and Service Factors

−40 F as in Calgary, Alberta and Ampere, Finland, the latter being almost within the Arctic Circle.

If sufficient refrigeration capacity is provided—ice can be maintained even though the sun is shining and warm winds are blowing or even during a rain.

TYPE OF ENCLOSURE

Almost every type of building material has been used to enclose skating rinks, including galvanized iron, frame, brick and concrete. The latest material to be used is translucent fiber glass panels, which also afford some protection against the sun.

The type of construction to be used will depend on the funds available, on local and climatic conditions and the expected maintenance of proper ice and spectators' comfort.

When heating during winter is provided, it should be of sufficient capacity to bring the space temperature up to 50 F. When the house is filled, the temperature will rise, and ventilation must be provided for the spectators' comfort.

SELECTION OF EQUIPMENT

For an ice thickness not exceeding 1½ in. to be maintained at an average temperature of 26 to 28 F when the average

Table 2 .... Service Factors

Hockey rinks and light public skating	7.5
Heavy public skating	10.0
Curling rinks	5.0
All-year figure skating	2.5
Sports arenas	7.5[a]
Open air rinks (shaded)	15–20.0

[a] Does not take into consideration the actual freezing of the ice surface (½ in. thickness in 12 hr at 200 Btu per lb).

maximum ambient wet-bulb temperature is 45 F, the following brine temperatures are sufficiently low at: 16 F for hockey, 18 F for public skating, and 20 F for curling.

As wet-bulb temperature increases the temperature of the ice must be lowered one or more deg to maintain the same condition of ice given for 45 F wet-bulb.

The compressor should be selected to operate at a suction pressure not exceeding 10 F mean temperature difference between brine in the rink surface and the primary refrigerant. A suction temperature of 5 to 10 F is satisfactory.

The refrigeration tonnage may be calculated on a basis of average wet-bulb temperature, using Fig. 3. Since there are seasonal extremes in temperature, as well as service, protection should be provided against occasional extremes and against possible compressor breakdown at a critical time when ice must be supplied by installation of spare compressor.

For sport arenas and open air rinks, three compressors are favored. One compressor usually maintains the surface, the second is usually required when the rink is in use, and the third is used for a fast freeze or as a spare. Many installations have been made without a spare compressor.

The evaporator should be of modern conventional design. The liquid feed control should be the most efficient and suitable for the refrigerant used. It should match the compressor capacity under design conditions.

The brine pump should be of sufficient capacity to circulate enough brine so that the temperature difference between incoming and outgoing brine does not exceed 1.75 F deg under design conditions. One brine pump is satisfactory for small rinks. A spare pump is always recommended, but if used both should be of full capacity to maintain constant velocity through the piping system and thereby prevent the brine from short circuiting some of the floor pipes. A spare pump will minimize operating troubles.

The quantity of brine should be no less than 10 and preferably 15 gpm per ton for any application.

The condensing system and liquid receiver selection will depend on local water supply conditions and type of evaporator used. When selecting evaporative condensers consideration should be given not only to the maximum expected outdoor wet-bulb temperature during the skating season but also to suitable operating controls and to provide protection against freezing during cold weather in northern areas.

Skating Surface Temperature

Skaters prefer hard, dry or damp ice surfaces, depending on the use. With proper design and operation these ice conditions can be obtained within a degree of the desired ice temperature. Hockey players and curlers prefer hard ice; figure skaters dry ice; and public skaters damp ice.

Since it is not practicable to measure the surface temperature, it is customary to control the ice sheet condition either from the predetermined brine temperature or from the ice temperature determined from a thermostat bulb embedded in the ice.

It has been found that with approximately 45 F wb