

# Plate Freezers

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**A**ir blast freezing has been the most common method used for freezing cartons in Australia's meat industry. This practice, however, is being replaced by the development of large capacity, mechanised plate freezers which have overcome their previous disadvantages of limited capacity and relatively high labour requirements.

Plate freezing offers four key advantages over air blast freezing (AMT Meat Research Report 2/96):

1. Faster temperature reduction and freezing time, particularly suited to hot offal and hot-boned meat
2. Flat cartons with minimum bulge allowing the safe stacking in cold stores to greater heights without the necessity for racking
3. Better stowage density in containers
4. Lower refrigeration capacity requirements due to the absence of high capacity fans in the freezer

Figure 1 illustrates the general arrangement of a plate freezer.

A plate freezer consists of hollow, flat plates constructed from aluminium or mild steel.

Aluminium plates are formed from a number of

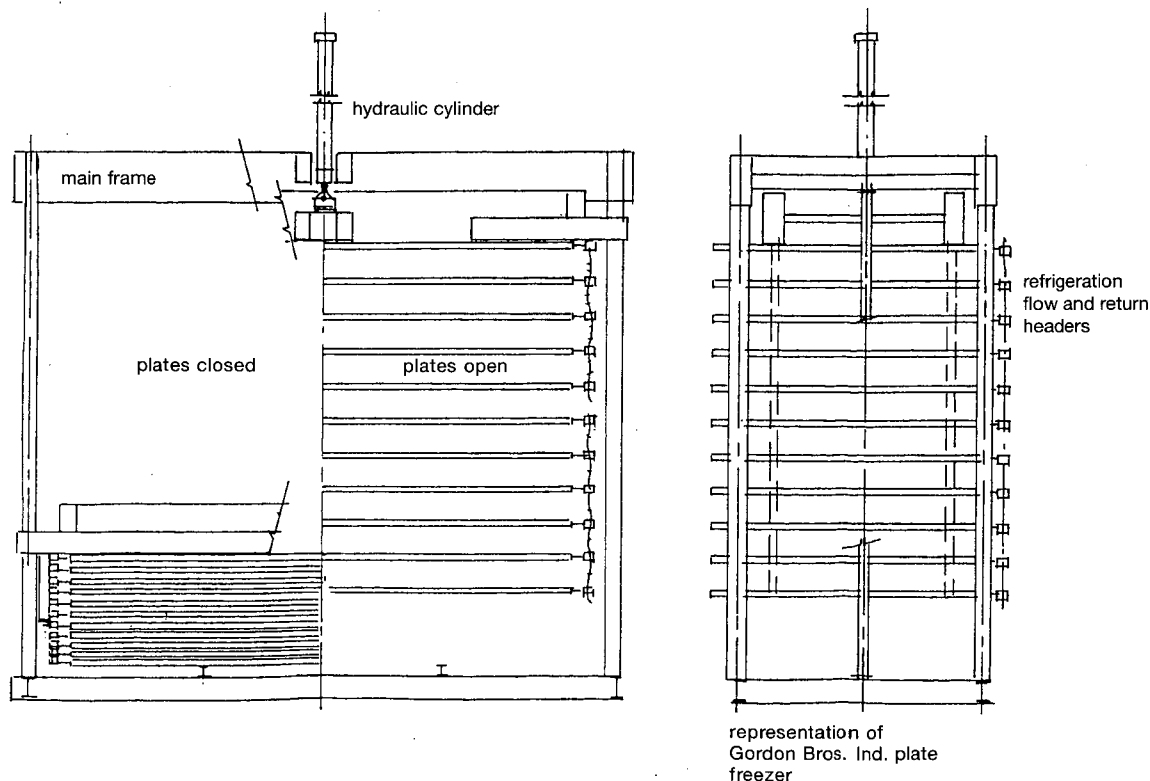
hollow, extruded sections, butt-welded together along their length. The sections are connected at each end to a header, allowing ammonia to flow to and from each section of the plate.

Mild steel plates are formed from hollow, square sections welded between two flat plates. As in the aluminium plates, headers are provided at each end to achieve an even flow of ammonia across the plates.

A complete plate freezer unit is formed by stacking a number of plates horizontally – one on top of the other. The stack of plates is placed inside a steel frame and each plate connected to the adjacent plate, allowing the plates to be moved apart to form a gap for cartons to be placed between two adjacent plates. Hydraulic rams are used both to move the plates and to apply an even pressure on the cartons between the plates during freezing.

Each plate is connected to the refrigeration supply by pairs of flexible hoses, with supply and return lines at opposite ends of the plate. The plate freezer also has an insulated housing around the plate stack. Access to the plate stack for manual loading and unloading operations is through a vertically rising door(s). Automatically loaded plate freezers have in-feed and out-feed conveyers and carton loading mechanisms mounted inside the insulated enclosure.

**FIGURE 1** General arrangement of a Plate Freezer



Because heat is transferred from the carton directly to the plates, high heat transfer rates are achieved. With refrigerant at a temperature of around  $-30^{\circ}\text{C}$ , it usually takes less than 24 hours to freeze cartons of conventionally chilled and boned meat to below  $-10^{\circ}\text{C}$ . There is little variation in freezing times between cartons, provided an even flow of refrigerant is achieved over all sections of the plate and carton heights are sufficiently uniform. The absence of high-powered fans, which contribute significantly to the refrigeration load in air blast freezers, is a major advantage of plate freezers.

Disadvantages of plate freezers include:

- Higher capital cost
- A larger charge of refrigerant is required
- All cartons should be the same height to simplify loading

The heat loads in a plate freezer consist of the product load and heat gains from within the enclosure through the edges of the plates, flexible hoses and refrigerant headers.

### Comparison of Freezing Rates

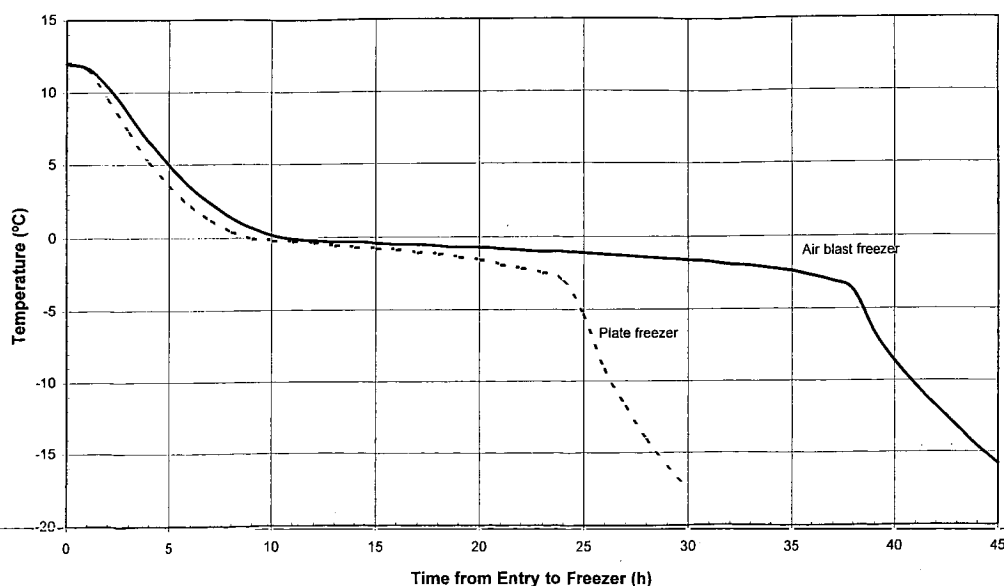
Due to the direct contact between the plates and cartons, cartoned meat freezes faster in plate freezers than in air blast freezers. (Figure 2)

Cooling rate and freezing time is affected by four factors:

#### 1. Plate temperature

Lower suction temperature will provide faster

**FIGURE 2 Comparison of freezing rates**



freezing and increase compressor power costs. Suction temperatures below  $-33^{\circ}\text{C}$  will result in the system operating below atmospheric pressure, drawing air (which must be purged out) into the system through any leaks. The most economical and practical operating temperature for the particular application should be selected.

#### 2. Carton board material

Solid fibreboard provides lower resistance to heat transfer than E-flute which has less resistance than B-flute corrugated cardboard.

In plate freezers, almost all heat transfer is through the top and bottom surfaces of the meat carton. Therefore, if the rate of freezing is critical as in hot-boning application, a single layer of fibreboard, as in beef box and lid cartons, is advantageous.

#### 3. Depth of carton

Within the range of cartons normally used by meatworks, (150mm to 165mm) depth has a moderate influence on freezing rate. For larger cartons, reducing the carton depth from 165mm to 150mm will reduce the time to freeze to  $-6^{\circ}\text{C}$  by about 10%. Very rapid freezing rates can be achieved by using shallow cartons of less than 140mm deep.

Cartons should not be mixed on the same plate if they have a small difference in depth because the cooling rate of the shallower cartons will be slowed by not being pressed

against the plates. However, due to the very shallow carton depth, half-depth cartons used for some types of offal may be mixed with full depth cartons and still achieve adequate freezing.

#### 4. Plate closing time

Cartons loaded onto the top plate do not experience

the full refrigerating effect until the module is fully loaded and all plates are closed. Due to the design of most manually loaded plate freezers, the top plate is loaded first, with plates indexed until loading is completed on the bottom plate. The plate stack is then closed and all cartons are subjected to full refrigeration from both top and bottom surfaces.

Cartons loaded first are only resting on the refrigerated surface during loading, which may take three to four hours depending on production rate and work breaks. Some manufacturers have addressed this problem by modifying the loading arrangements to allow a partial closure of the plate stack at intervals during the loading period.

Results from recent trials indicate initial cooling rates of the cartons refrigerated from the bottom only could be 18% - 36% slower than for cartons in contact with plates on the top and bottom surfaces immediately after loading. Although this delayed cooling is not significant for conventionally boned meat, the reduced cooling rate during the first few hours could be important when attempting to conform to AQIS or FSIS when hot-boned meat is loaded onto the top plate.

The average cooling rate of conventionally chilled and boned 80 CL trimmings from 10°C to 0°C, based on two runs, was 1.03°C per hour for cartons between the top plates and 1.33°C per hour for cartons between the bottom plates.

Hot-boned meat has a much higher initial temperature than the product in the trials (28°C - 30°C compared with 10°C - 12°C). Therefore, owing to the greater temperature differential, cartons of hot-boned meat will initially cool at a higher rate.

During earlier trials with hot-boned meat on the same plate freezer, cartons loaded onto the second-bottom plate cooled at an average rate of 3.1°C per hour between 29°C and 7°C and at an average rate of 1.95°C per hour between 10°C and 0°C.

The cartons on the bottom plate also remained on the freezing plateau for a shorter period and cooled more rapidly in the post-plateau phase due to the difference in refrigerant temperature. The temperature of the refrigerant in the discharge line

from the top plate was 3°C - 4°C warmer than the bottom plate. A possible explanation is, owing to the difference in head, the flow of refrigerant in the top plates is lower than the bottom plates.

### Additional information

"Consideration of Relative Advantages of Small Capacity Plate and Air Blast Freezers for the Freezing of Cartoned Meat", Australian Meat Technology, 1996, Meat Research Report 2/96

### Additional information

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