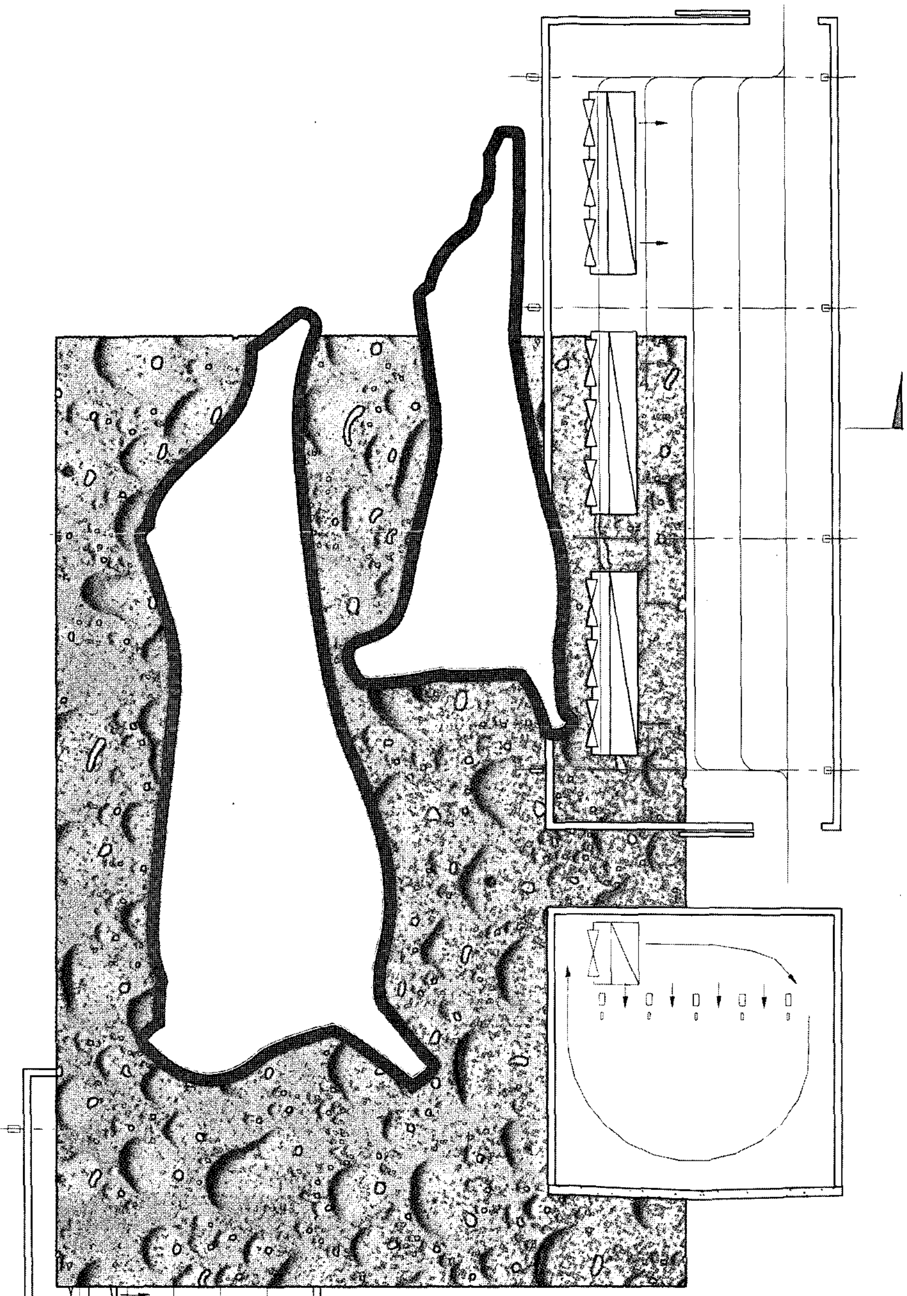
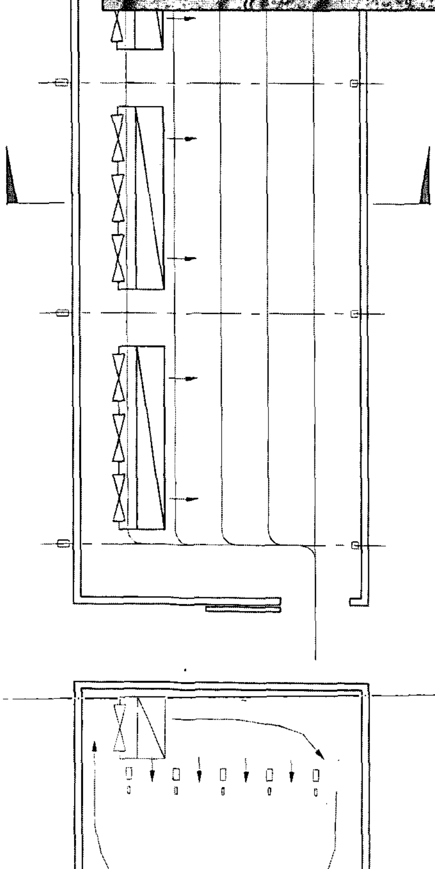




Carcase and Side Chiller Design and Layout

1997

Meat Research Corporation

AMT
AUSTRALIAN MEAT TECHNOLOGY

Meat processors must meet legislative, meat quality, hygiene, economic and production requirements for carcases in chillers. If these requirements are to be achieved, then cooling air must be distributed evenly throughout a chiller, and this requires adequate refrigeration and air distribution systems.

Before designing a hot carcase or side chiller, the refrigeration engineer will require certain information:

- Number and weight of sides or carcases
- Production rate
- Time until load-out
- Load-out temperature

Size and location of carcase chillers

The first step in designing a chiller is to decide the number and size of chillers required, keeping in mind that one large chiller will cost substantially less to construct than two smaller rooms of the same capacity.

Flexibility in design and operation is required to allow daily emptying and cleaning of each chiller. In the case of medium to large plants, each chiller could hold one to two hours' production. Excessive loading times increase carcase cooling times, and delay the commencement of the active chilling phase – and this leads to higher weight loss.

Chillers should never be located above abattoir working areas or other chillers because deterioration of insulation between the upper and lower rooms of an abattoir may result in heavy condensation on the ceiling of the space below.

For the same reason, chillers should not be located below refrigerated areas – particularly freezers. Chillers should also not open directly off slaughter floors since condensation, caused by the entry of warm, moist air, can occur. Ideally, a refrigerated load-in passage should be provided.

The ceiling height and length-to-breadth ratio of a chiller is dictated by the proposed air distribution pattern and space availability. When air is blown from the centre of the room using back-to-back cooling units above the rail, a room length-to-breadth ratio of 3:1 and a ceiling height of 2m above the rail will allow space for adequate refrigeration capacity. Similarly, when air is blowing across the room, wall length and height must be available to mount sufficient cooling capacity.

Refrigeration capacity

Once the insulation thickness and temperatures of adjacent areas are known, then the refrigeration requirements for the carcase chiller can be calculated. There is often a lack of appreciation of the actual instantaneous refrigeration load at the commencement of the chill cycle. Some designers only calculate the average load while others apply an arbitrary factor, say 1.5 times the average load, to allow for this initial load.

The ratio of peak load to average load is dependent on loading rate and, unless some consideration is given to this, there may be a serious lack of capacity during loading and during the initial chilling cycle.

Indications of lack of capacity include:

- Condensation problems
- Inability to maintain air temperatures in the chiller during loading
- Excessive time for the air temperature to reach the set point during the active chill cycle

The peak load may be up to 3.7 times the average load if the chiller is loaded in two hours compared with 2.5 times if loading takes six hours.

Effect of cooling unit design

The selection of the cooling unit (evaporator) plays a vital role in chiller design and layout. After all, the cooling unit has a greater effect on cooling times and product quality than any other component of the carcase chilling system.

An evaporator consists of rows of finned tubes through which the refrigerant flows. Air is either blown over the finned tubes in a forced draught cooler (FDC) or drawn through in an induced draught cooler (IDC). Although FDCs are preferred in most applications, due to marginally lower weight loss, both configurations are fairly equal in performance.

In both cases, fans must be mounted well clear of the coil blocks with fan diameter equal to coil height. This ensures that air flow and velocity are evenly distributed across the coil. Poor air distribution through an evaporator can seriously affect performance and reduce the effective use of available coil surface area.

It is an advantage to have variable fan speeds so air-flow may be reduced in the latter stages of the chilling cycle to assist in the control of carcase weight loss.

Finned coil evaporator design is a complex subject. Factors such as tube diameter, fin spacing, number of rows of tubes, direction of refrigerant and air flow, face area, etc influence performance.

Best results are generally achieved by designing a large face area, shallow depth and a low refrigerant (ie coil) to air on temperature differential of 3.0°C to 3.5°C and an air-on to air-off temperature differential of approximately 1°C. (This varies during the chilling cycle – being highest at the start and should reduce as the cooling load reduces.) It is generally unwise to reuse old, second-hand coolers for carcase chilling as these were most likely deep coils, and use of such could result in higher carcase weight loss.

The use of modulating back pressure temperature regulation also aids in producing good temperature control and minimum weight loss by continuously adjusting the refrigerant flow to the load. As a result, the evaporator operates at the highest possible suction pressure condition as the load reduces.

Chiller layout

Chillers and evaporators have numerous possible arrangements, and each arrangement has its advantages and disadvantages. All arrangements, however, have the same aim: to provide an even flow of cooling air over the carcase surfaces.

Cross Flow – Evaporators above the rails

The cross-flow arrangement is one of the most common, with best results achieved if the evaporators cover most of the rail length of the chiller. (Figure 1)

Air distribution is uneven with higher velocities opposite the coolers. Operators can take advantage of this by placing the heaviest carcases on the rail opposite the evaporator.

Air distribution can be improved by providing baffles or turning vanes to direct air down over the carcases.

A common problem, however, is condensation under evaporator drain trays.

Longitudinal Flow – Evaporators above the rails

Another common arrangement is the longitudinal flow with evaporators above the rails. (Figure 2) Unfortunately, this arrangement is not suitable for long narrow rooms since evaporators would need to be too deep and require excessive throw. To eliminate short circuiting and maximise face area, the evaporators should extend the full width of the room.

Again it is difficult to attain uniform air distribution as the air velocity will be higher at the ends of the room.

Both arrangements in Figures 1 and 2 have been modified by constructing a false ceiling, with slots above the rails to direct the air over the carcases. This improves air distribution but increases cost, creates a cleaning problem and is a potential condensation source.

FIGURE 1 Cross Flow – Evaporators above the rails

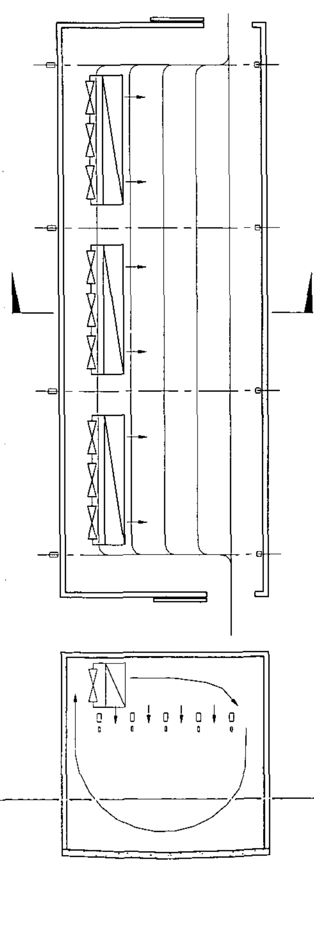
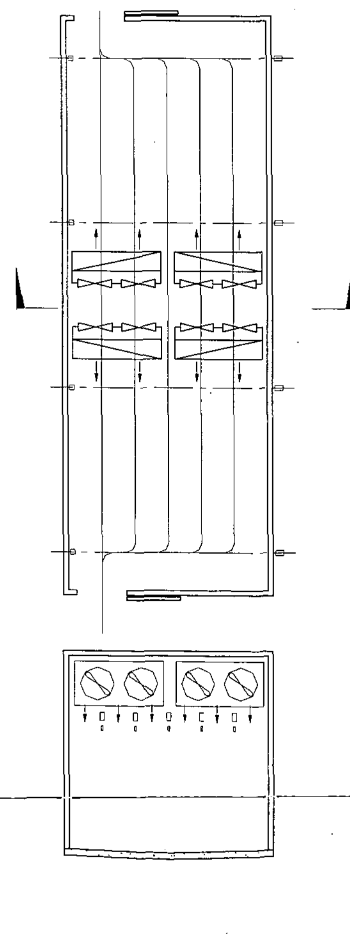


FIGURE 2 Longitudinal Flow – Evaporators above the rails

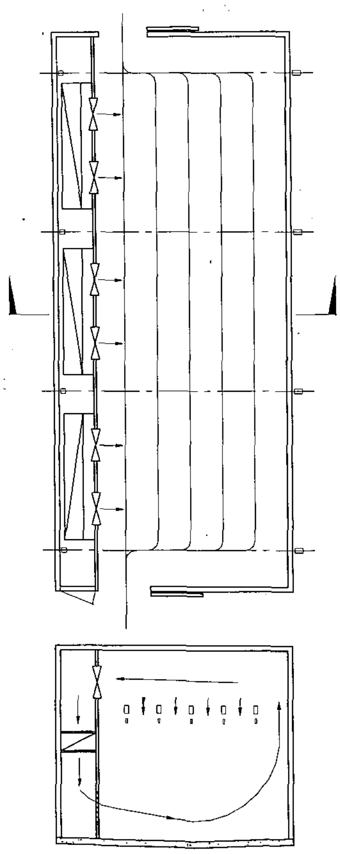


Side Plenum

The side plenum arrangement (Figure 3) is very popular with new chiller construction. Its key advantage is that major potential condensation sources – such as evaporator drains and pipework – are outside the product area. Although air flow may be either top discharge or bottom discharge, bottom discharge tends to be favoured because it keeps cold air away from the rail support structure, further reducing the potential for formation of condensation. Air velocity tends to be higher on the rail opposite the evaporators.

Although construction costs are higher due to the increased floor area, maintenance access is available at all times.

FIGURE 3 Side Plenum



Most evaporator arrangements will provide satisfactory cooling rates as long as adequate evaporator capacity and air circulation are provided.

Additional information

"Product Loads for Beef Carcass Chilling," The Institute of Refrigeration, 1977

"Process Design Data for Beef Chilling," Int J Refrig, 1989, Vol. 12

"The Production of a Chilled Meat for Export," CSIRO, Workshop Proceedings, 1991

"Cost-Effective Refrigeration," Workshop Proceedings, 1992, Massey University Department of Biotechnology

"Chilling of Sides & Carcasses & Subsequent Chilled Holding," CSIRO, Workshop Proceedings, 1993

Additional information

Additional help and advice are available from Food Science Australia, Meat Industry Services Section:

	Phone	Fax
Ian Eustace	(07) 3214 2117	(07) 3214 2103
Neil McPhail	(07) 3214 2119	(07) 3214 2103
Bill Spooncer	(02) 4567 7952	(02) 4567 8952
Chris Sentence	(08) 8370 7466	(08) 8370 7566

Or contact:

Processing and Product Innovation

Meat & Livestock Australia

Tel: (02) 9463 9166
Fax: (02) 9463 9182

Email: ppi@mla.com.au