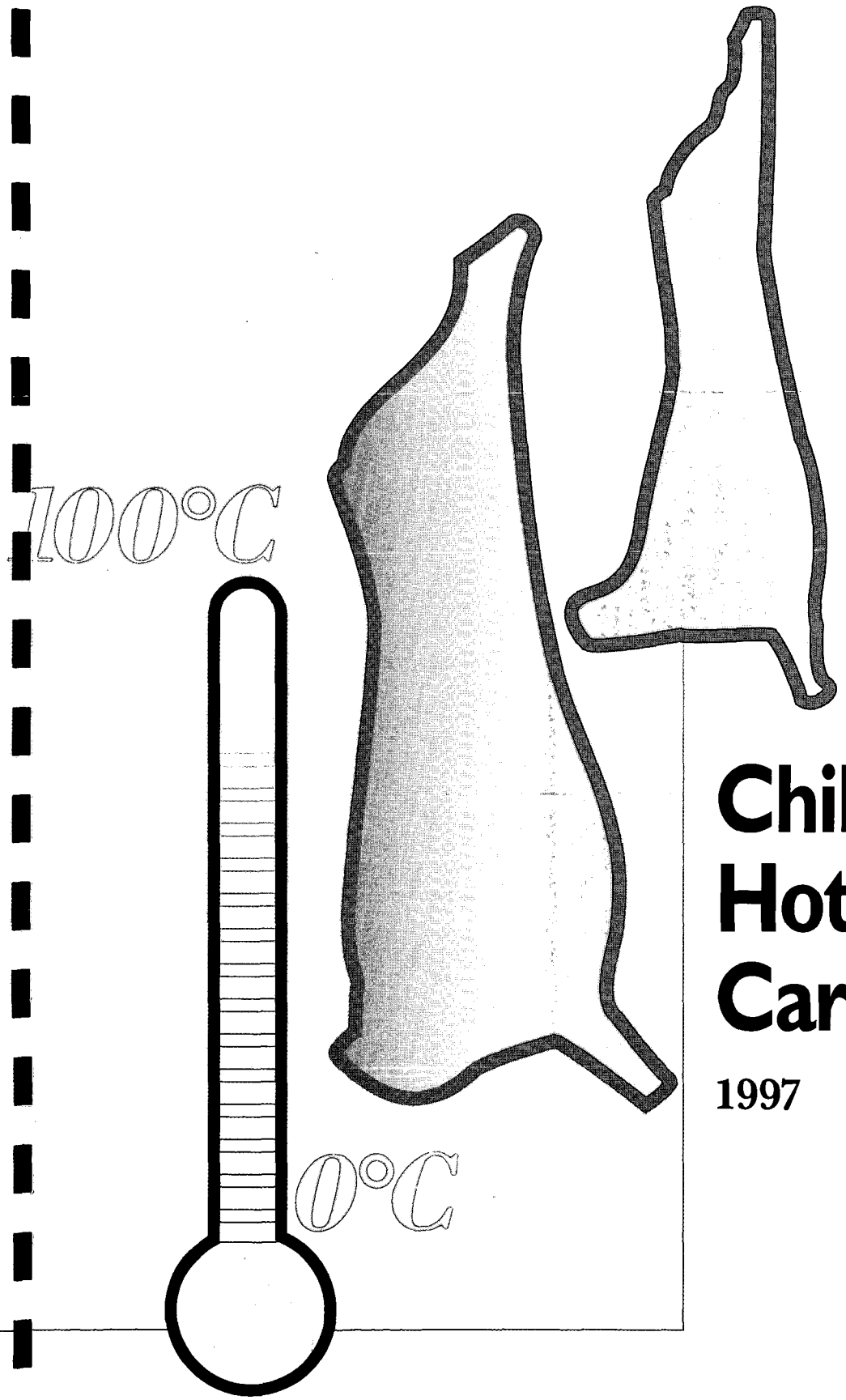

Chilling Hot Sides & Carcases

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Meat Research Corporation

AMT
AUSTRALIAN MEAT TECHNOLOGY

To preserve the meat and to limit microbial growth, carcases are either cooled as soon as possible after slaughter or are processed directly in a hot boning system. Either way, every meat processor should employ best hot carcase chilling practices.

Procedure for Design of Carcase Chillers

When designing a carcase chiller, eight key factors must be pinpointed and taken into consideration:

1. **Determine the number of stock and their weight ranges**
2. **Calculate the total weight of carcases to be chilled – be generous**
3. **Determine the size of each chiller**
   Spacing must be based on carcases not touching.
   The holding capacity of the chillers will determine the loading time. One hour's kill capacity is ideal.
4. **Determine the achievable cooling rates**
   Cooling rates are a function of chiller air temperature, air velocity and carcase weights. Table 1 presents estimated cooling rates for 400kg carcases with heavy fat cover.

Table 1

Estimated cool times for 400kg carcase, heavy fat cover

Air Velocity m/s	Air Temperature 0°C	Cool time (hours) to		
		30°C	20°C	16°C
0.5	0	13.0	20.0	23.5
0.5	6	14.0	23.0	27.5
2.0	0	12.0	19.0	22.0
2.0	6	13.0	21.0	26.0

The heat transfer properties of meat – mass, density, specific heat and conductivity – are the limiting factors on achievable cooling rates.

The longer the chiller loading time, the more difficult it becomes to achieve a specified cooling rate or surface temperature for the first carcases placed in the room. Some operators now install mechanically operated chiller doors and these assist in minimising the period when the doors are open. This type of doors also helps minimise condensation and the adverse effect on the chiller air temperature during loading.

5. **Determine the chiller loading time**
   The chiller loading time affects the peak refrigeration load. Depending on how quickly the chiller is loaded, the peak refrigeration load will be two to three times the average product cooling load. When a chiller is loaded and closed within one to two hours, the peak load is much higher than when loading continues through much of the day.

   The full capacity of the equipment for chilling hot beef sides in modern chillers is used for a maximum of only about four hours during the initial stage of the chilling cycle. Processors might want to consider a conveyorised blast chiller for the first stage since the capacity of the equipment may be utilised at about only 10% or less during the holding periods of the chill cycle.
6. **Specify a time for the return air temperature to drop to 0°C after completion of loading**
   Two hours is readily achievable if the loading temperature is 10°C. The lower the air temperature, the faster the surface temperature will fall. However, it is very difficult to avoid condensation in any chiller if it is being held below 10°C while hot carcases are being loaded. For control purposes, air temperature should be measured at the air return to the coil.
7. **Specify a realistic weight loss which will be achievable**
   While weight loss must be considered, aiming for a weight loss below 1% is difficult to achieve. Additionally, refrigeration equipment costs to achieve less than a 1% weight loss would be very expensive.
8. **Determine the evaporator size and capacity**
   An experienced refrigeration engineer should be able to calculate the refrigeration load using the given information and use this

information to optimise the selection of evaporators and air flow/velocity within the room to achieve the specified performance. The engineer should be able to offer a range of evaporator capacities and fan configurations, with costs and performances, for selection.

The preferred room design, position of fans and position of evaporators must all be considered before final selection. It is a serious mistake to be committed to a particular design and layout before the refrigeration components have been selected.

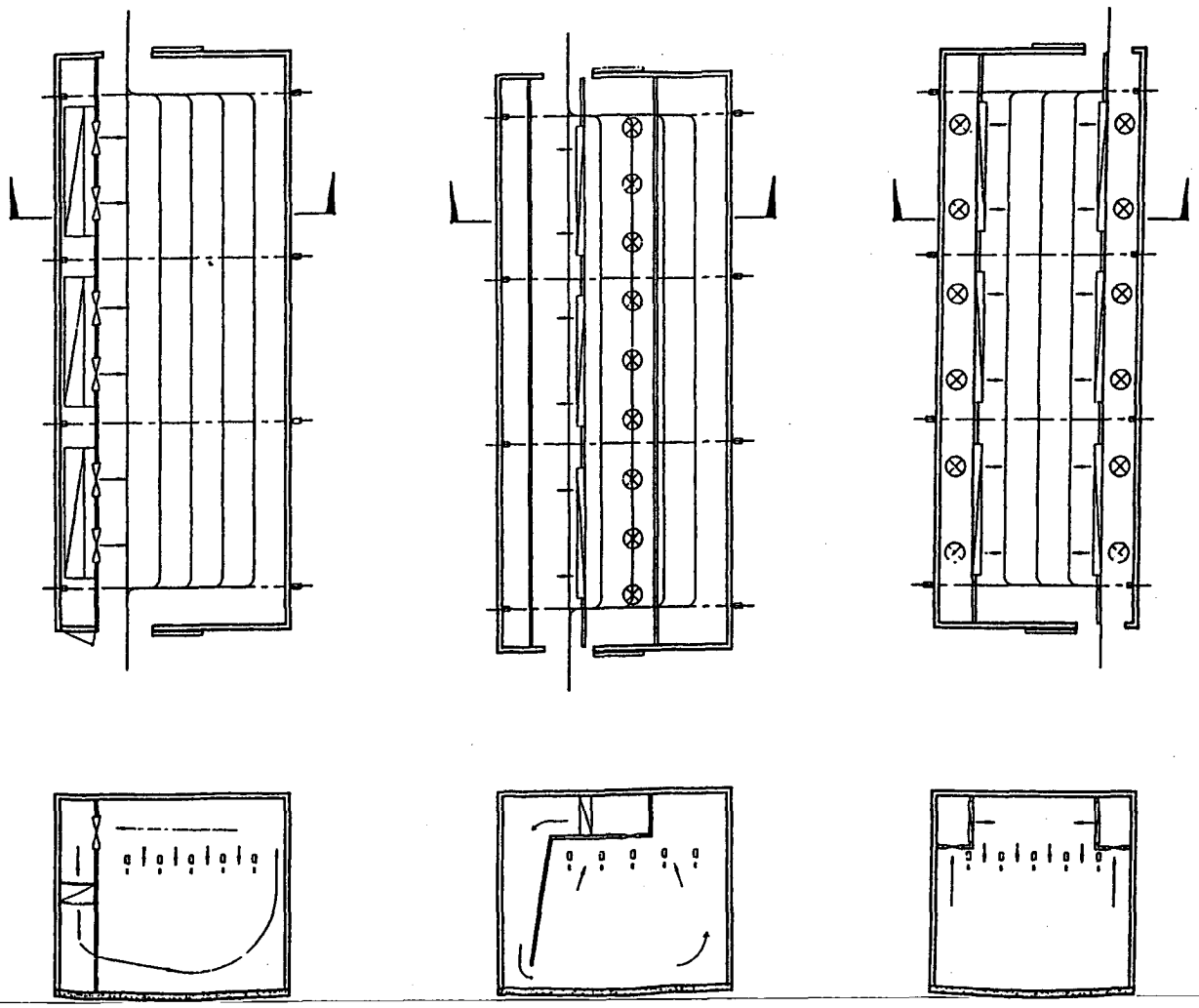
Some options for refrigeration installation are shown in Figure 1. Any or all of these are capable of cooling carcases. Evaporators mounted outside the chiller room are more expensive than most other options but have become popular in recent years because drip trays under evaporators above carcases are eliminated, condensation risks are less and maintenance access is readily achieved without entering the product chamber. Almost any arrangement of evaporators and fans, however, will chill your product – the important criteria being adequate evaporator capacity and air circulation throughout the room. The fans must be capable of distributing air flow throughout the room both during its use for rapid chilling and as a holding chiller. Warm spots must be eliminated.

Best Practice – Hot Carcase Chiller Control

The chiller should be loaded so that no two sides or carcases touch.

Do not exceed either the design rate of loading the chiller or the maximum design load.

Figure 1 – Options for refrigeration installation



point is reached, moisture will condense on the evaporator coils and the air coming off will be drier. Equipment is available which can be programmed via a computer or programmable logic controller to carry out these functions automatically, according to the program selected.

- Where the carcases are to be boned on the establishment, ideally, the surface temperature should not be allowed to rise above 7°C. Where carcases are to be transported to another establishment, lower temperatures are recommended but the air velocity should still be reduced as described prior.

Reheat for Boning

Regulations and practices which lead to rapid chilling can result in tough meat due to cold shortening – no ES – and can often result in hard fat in carcases presented to boners.

One method of softening the fat for boning is to raise the chiller air temperature prior to boning. This will increase the surface temperature but only marginally affect internal tissue temperatures – provided the reheat is only carried out over two to three hours before boning.

Some operators have tried introducing hot gas into chiller evaporators to warm the chiller. This is often difficult to control and can adversely affect the operation of the refrigeration plant if carried out in the early hours of the morning when refrigeration plant loads are at a minimum.

Electric reheat elements fitted to evaporator coils designed on the basis of 3 kw per tonne of product are readily controlled via a programmable controller. With this system, hard fat can be tempered in as little as 40 minutes. Tests on these systems verified that there were no adverse microbiological consequences in using reheat, provided a rapid lowering of temperatures was achieved at the beginning of the chill cycle. This means reheat should only be considered for use in conjunction with chillers fitted with a high standard of refrigeration equipment.

Additional Information

Meat Technology Update 94/1, "Condensation in Carcass Chillers"

CSIRO Workshop Proceedings, 1993, "Chilling of Sides and Carcases and Subsequent Chilled Holding"

MRC/AMT Information Brochure "Temperature Measurement in Abattoirs", 1997

If you need any further information or advice your nearest Australian Meat Technology Office can assist you:

Additional information

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

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An alternative to controlling the chiller on the return air temperature is to provide a temperature control system which uses both deep butt and surface temperature measuring probes to control the refrigeration evaporator and fan speeds. Once the surface temperature is near the air temperature, the fan speed should be slowed and the evaporator temperature raised and controlled to avoid surface temperature rise. The chilling rate should be further reduced when the deep meat temperature has fallen to about 20°C. Care is needed to ensure that the probes are correctly inserted and that the carcase selected is representative of the chiller load.

Where carcases are to be transported from the meat processor to customers at very low temperatures, then the chiller air temperature should be set at 0°C from the start of chilling. Again, once the surface temperature is near that of the air, the fan speed should be slowed and the evaporator temperature raised.

Air and carcase temperatures should be recorded continuously.

For beef, mixing large and small carcases in one chiller should be avoided.

Due to food safety requirements, the optimum in chiller control is to reduce product surface temperatures to a maximum of 7°C as quickly as possible. The surface temperature reached should be maintained until the carcase is required for boning.

Chilling Cycles

According to an MRC survey on the micro-biological quality of Australian meat, microbial growth on carcases during the first 18-24 hours of chilling is relatively easy to control, provided surfaces are allowed to dry. Low surface temperatures are important.

In addition to the control of microbial growth, certain practices should be followed to achieve optimum meat quality:

- For weep to be minimised in vacuum-packed chilled beef, the ideal is to reduce the deep butt to below 30°C within 10 hours of slaughter.
- Too slow a chilling rate will result in increased drip of electrically stimulated carcases.
- Too rapid a chilling rate when ES is not practised will result in cold shortening.
- Fast chilling of heavy beef sides is essential to provide uniform colour.
- To avoid bone taint and other unusual odours in beef which is to be boned overseas, the deep butt must be reduced to 16°C within 20 hours of slaughter.

Assuming carcases have been electrically stimulated, six key practices contribute to a quality out-turn from a chill cycle:

1. Apply sufficient refrigeration to the chiller during loading to prevent condensation. (10°C return air temperature and at least 75% fan capacity are adequate.)
2. Commence active refrigeration with maximum fan speed as soon as possible after dressing is completed. Use chillers with no more than two hours' kill capacity so active refrigeration commences within that time frame. This is dependent, however, on kill rate.
3. Have sufficient evaporator capacity in the chiller, and adequate engine room capacity to service it, to achieve a return air temperature of 0°C to 2°C within two hours of commencement of active chilling.
4. For meat which is to be boned the next day, continue this phase of chilling until the heat transfer rate of the meat becomes the factor which controls the speed of deep butt temperature reduction, rather than the amount of refrigeration effort being applied. (This is determined when the surface temperature has fallen to near the air temperature.)

   Reduce the fan speed to about 50% of capacity and gradually raise the return air temperature to not more than 6°C for the remainder of the chilling cycle while ensuring the surface temperature does not exceed 7°C. The air temperature should rise at a rate of no

more than 2°C per hour to prevent secondary condensation on the chiller steelwork. Electronic back pressure controllers are available to permit automatic adjustment of the evaporator capacity to match the refrigeration load and minimise the temperature differential (TD) across the coil.

For occupational health and safety and industrial reasons, a short re-heat phase can be carried out immediately prior to boning to soften the external fat layer. If automatically controlled electrical elements mounted on the air-off side of the evaporators are used, the return air temperature during re-heat should be maintained at no more than 15°C for a period sufficient to soften the surface fat. The deep butt temperature will not rise during the re-heat phase and usually continues to fall as equilibration of temperatures through the meat occurs.

5. For meat that will be shipped in chilled or frozen quarters or carcase form, continue active refrigeration at the higher rate since temperature reduction in a chiller is cheaper in energy cost than in a freezer, and hard fat is not a problem. During the holding period, however, air velocity should be reduced, as described above.

6. Do not partly load the chiller – unless there is no other option – if the evaporators in a particular chiller are properly sized for a full chiller load and there is adequate engine room capacity to service them but the evaporators do not have automatic back pressure control (i.e. the evaporators operate at system suction pressure of perhaps as low as -10°C at all times). Evaporators tend to remove a weight, rather than a percentage, of water from the product stored in a chiller or freezer.

   Special precautions may be necessary when chillers are part-loaded.

   Irrespective of direction of air flow – lengthwise down the chiller or transverse, the air flow from the evaporator should pass through full rows of carcases at standard spacing. This will minimise the short circuiting and uneven cooling. Evaporators outside the loaded area of the chiller can then be switched off, better matching the capacity to the load.

   If automatic back pressure controls are fitted which automatically match the refrigeration to the heat load in the room, only the avoidance of air by-pass is necessary. The same type of problem arises if small stock are loaded into a beef side chiller – for example when the capacity will far exceed the size of the load and greater proportional weight loss will occur.

Although the surface area of sheep and lamb carcases varies according to the square of its dimensions, the weight or volume varies according to the cube. Thus, the surface area per kilogram of carcase weight of a lamb is much higher than that for beef.

The ratio of surface area to weight has an important influence on both the speed of chilling and weight loss during chilling. This means that the smaller the animal, the higher the weight loss percentage – unless some factor is introduced to prevent evaporation of water from the carcase.

Weekend and Holding Chillers

For weekend chilling followed by boning, a balance must be sought between microbial growth and "boneability".

The following cycle is in line with regulations:

- When sides or carcases are held in the active chiller after the desired deep butt temperature is achieved, the air velocity can be reduced to 0.5 m/s and the refrigerant temperature raised to within 2°C of the set temperature. This will reduce variations in the chiller temperature and minimise shrinkage. Note that reducing the air velocity without reducing the approach temperature – the amount by which the refrigerant temperature is less than the circulating air temperature – may increase weight loss, since the temperature differential across the evaporator coils will be greater. If dew