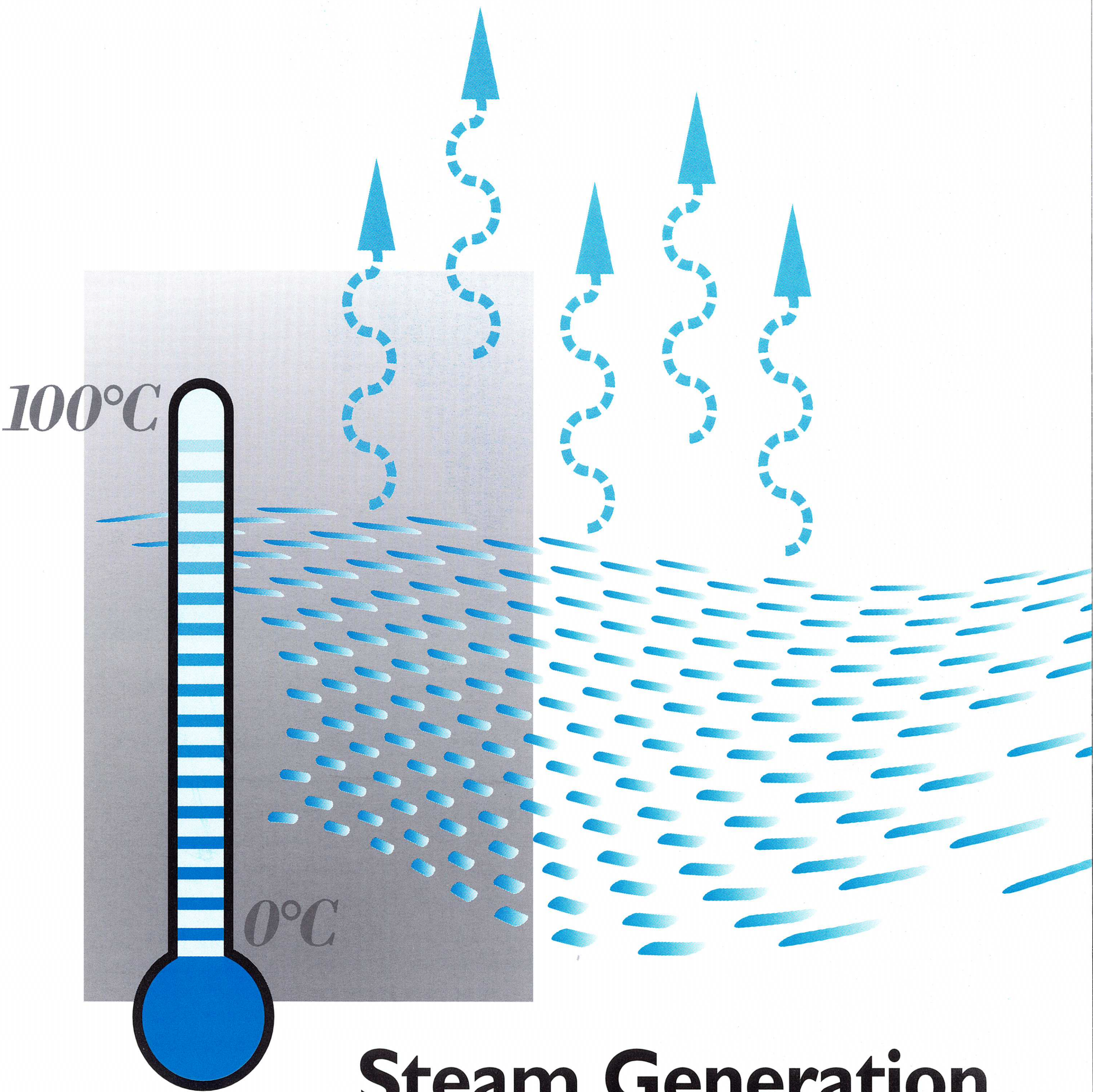


Steam Generation Systems

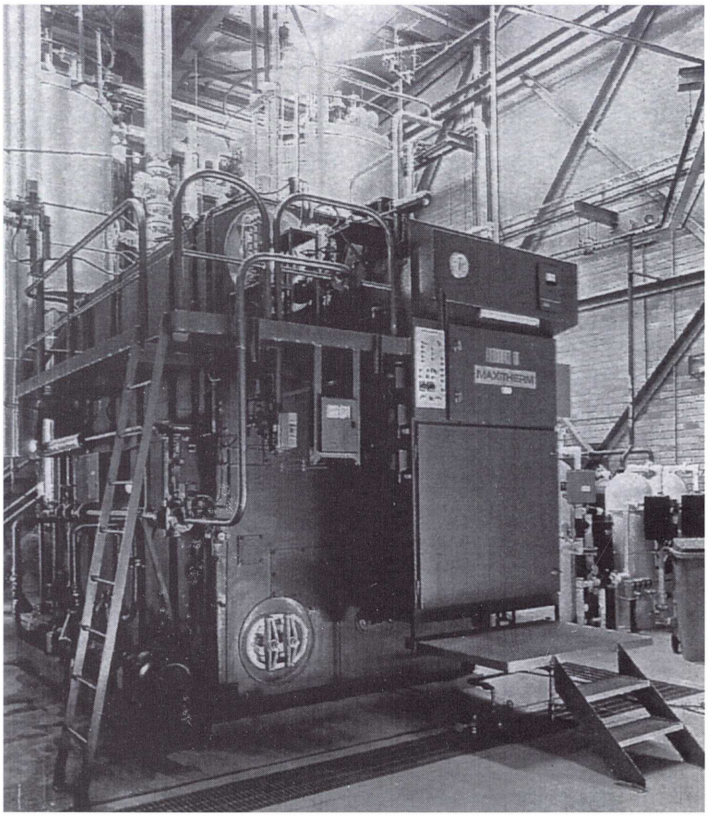
1997

Meat Research Corporation

AMT
AUSTRALIAN MEAT TECHNOLOGY

Steam is used in abattoirs mainly to provide heat for the rendering process, for the generation of hot water and to maintain temperatures in water and tallow storage systems. Steam generation systems are generally based on one or more medium capacity boilers (5 to 10 000kg/h), operating at a pressure of 1000kPa, fired by a range of fuels including heavy and light fuel oils, coal and natural and liquid petroleum gases. In some abattoirs use has been made of a range of waste materials as fuel, including wood (offcuts and chips), waste oil and tallow. In all installations, the aim is to achieve a reliable supply of steam at a reasonable cost.

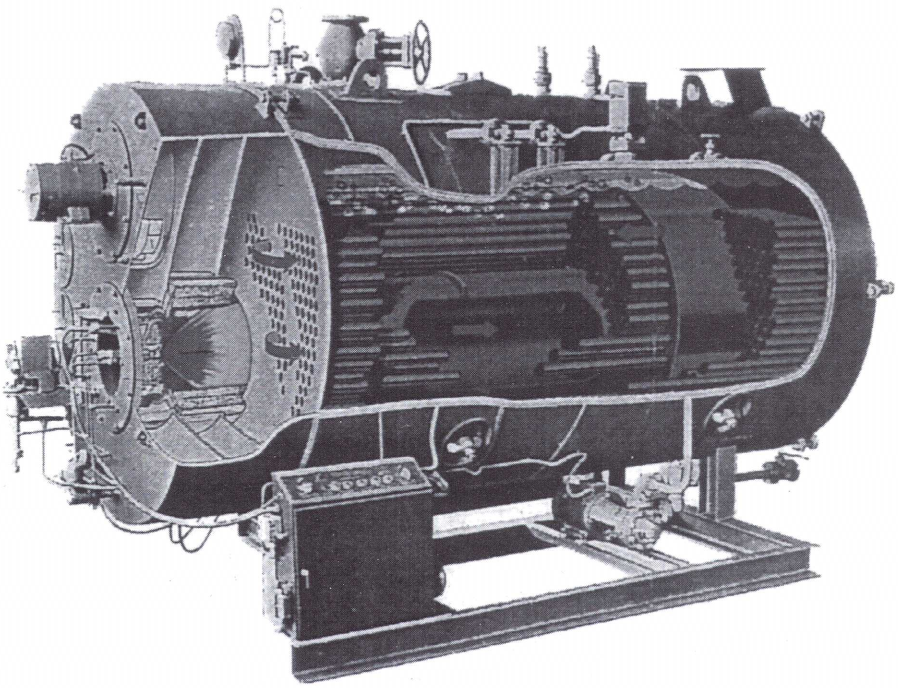
FIGURE 2 **General view of Water-tube Boiler**



Boiler Types

The reasonable steam demand and operating pressures of abattoirs means boilers of all types are in use. The most common types are dry and wet back fire-tube shell boilers and 'D' type water-tube boilers. Both types are suitable for firing with most common fuels. Wood waste as a fuel requires a large furnace volume, which is best provided by a water-tube boiler or the older style 'Colonial' boiler. Examples of fire-tube and water-tube boilers are illustrated in Figures 1 and 2.

FIGURE 1 **Part-sectional view of Fire-tube Boiler**



The different types of boilers have advantages and disadvantages.

Water-tube boiler:

- can accommodate all fuels;
- acceptable for limited or unattended operation;
- most suitable where high steam capacities are required;
- generally more efficient than a fire-tube boiler;
- smaller water volume allows the boiler to respond quickly to steam demand;
- generally more expensive than a fire-tube boiler at smaller capacities;
- requires more care in feed water treatment.

Fire-tube boiler:

- a simple form of construction;
- can accommodate most fuels;
- feed water quality and treatment less critical;
- large volume of water better able to accommodate varying steam loads;
- form of construction generally limits steam capacity to less than 9000kg per hour;
- less acceptable for unattended operation.

Boiler Feed Water Treatment

All natural waters are far from pure, containing many minerals in the form of salts. The salts of calcium and magnesium, commonly found in 'hard' water, readily precipitate when the water is heated to form scale on heat transfer surfaces. The objective of feed water treatment is to prevent scale forming, to reduce the risk of corrosion and to ensure that clean steam is produced.

All boilers require careful attention to be given to the quality of the feed water. In the boiler, steam is produced by application of heat to evaporate water. Any solids contained in the feed water are left in the boiler, resulting in an increase in the solids concentration, increasing the potential for scale formation. Any build up of scale can significantly reduce the efficiency of the boiler, cause overheating of the heating surfaces and increase the risk of corrosion.

A coating of scale 1mm thick can easily result in a 5 percent increase in fuel consumption; if the thickness is allowed to increase to 3mm the fuel consumption can increase by 15 percent. Once scale has formed it is difficult to remove and the best approach is to prevent its formation.

Ideally, all condensate from steam-using equipment should be returned to the boiler for re-use as feed water. However, loss of steam within the system usually means that less than 60 percent of the condensate is available for re-use and fresh water must be introduced. This water must be treated to ensure that it is made suitable.

Feed water treatment systems can include :

- water softening, where the calcium and magnesium scale forming salts are replaced by non-scale forming sodium salts – the level of total solids in the water does not change;
- de-aeration of the feed water, where oxygen and other gases are removed in a feed water heater and released to the atmosphere;
- internal treatment, where a range of chemicals such as phosphates and tannins are added to the boiler to inhibit corrosion, prevent the formation of scale and modify the sludge to assist in its removal;
- automatic blowdown of the boiler contents, to ensure that the sludge is discharged and total solids are kept within acceptable limits, which is around 3000mg/l.

Boiler Blowdown

Chemical treatment of the boiler feed water results in an increase in the total dissolved solids (TDS), which are further increased by the evaporation of water in the production of steam. High TDS in the boiler can cause foaming and the carryover of solids and water in the steam. To minimise problems the TDS in the boiler should be kept below 3000mg/l, which is achieved by regularly draining (blowing down) some of the boiler water.

The quantity of blowdown needed to ensure that the TDS level is kept below the recommended level is determined by the TDS of the feed water, the TDS to be maintained in the boiler and the evaporation rate. The required blowdown rate (kg/h) is calculated as follows:

$$\text{Blowdown Rate} = \frac{F \times S}{(B - F)}$$

where F = feed water TDS in mg/l

S = steam generation rate in kg/h

B = maximum TDS in boiler in mg/l

The blowdown rate for a boiler generating 8000kg/h of steam, with a TDS in the feed water of 300mg/l and a boiler TDS of 3000mg/l, would be:

$$= \frac{300 \times 8000}{(3000 - 300)} = 889 \text{ kg/h}$$

If the boiler is operating at a pressure of 1000kPa.g the blowdown water will be at a temperature of 184°C and have a heat content of 782kJ/kg. A blowdown rate of 889kg/h would be equal to a heat loss of 695MJ/h, equivalent to 29kg of coal, or 18 litres of distillate, or 17m^3 of natural gas per hour. This energy can and should be recovered by a system making use of automatic control of the blowdown and waste heat recovery. With the proper equipment it is possible to recover up to 90 percent of the waste heat.

Figure 3 indicates a simple two-stage system proposed by Spirax Sarco Ltd to recover both the latent and sensible heat of the blowdown water. In the first stage the high-pressure and high-temperature blowdown is introduced into a low-pressure vessel, where the blowdown gives up some heat by producing flash steam. In the second stage the blowdown is further cooled in a heat exchanger. The claimed recovery rate in such a system is over 90 percent of the available heat.

Condensate Return

In the meat processing industry steam is used to provide heat to the rendering process, to generate hot water and to maintain temperatures in water and tallow storage systems. In providing heat the steam is condensed, with the condensate being discharged from the system. Provided the heating equipment is properly maintained this condensate is pure distilled water, requiring minimal treatment for re-use in the boiler.

The meat processing industry has some concern regarding the re-use of condensate, due to the possible risk of contamination of the boiler with fats. However, the potential benefits are such that every effort should be made to overcome the problem. It has been suggested that one means of guarding against contamination is to use a turbidity measuring device in the condensate return line set to activate a dump valve and alarm when fat is detected. Installation of a fat intercept tank in the condensate return system has been shown to provide boiler protection. The advantage of an intercept tank is its simplicity and reasonable cost. The general arrangement of an intercept tank is indicated in Figure 4.

FIGURE 3 Arrangement for waste heat recovery from boiler blowdown water recommended by Spirax Sarco

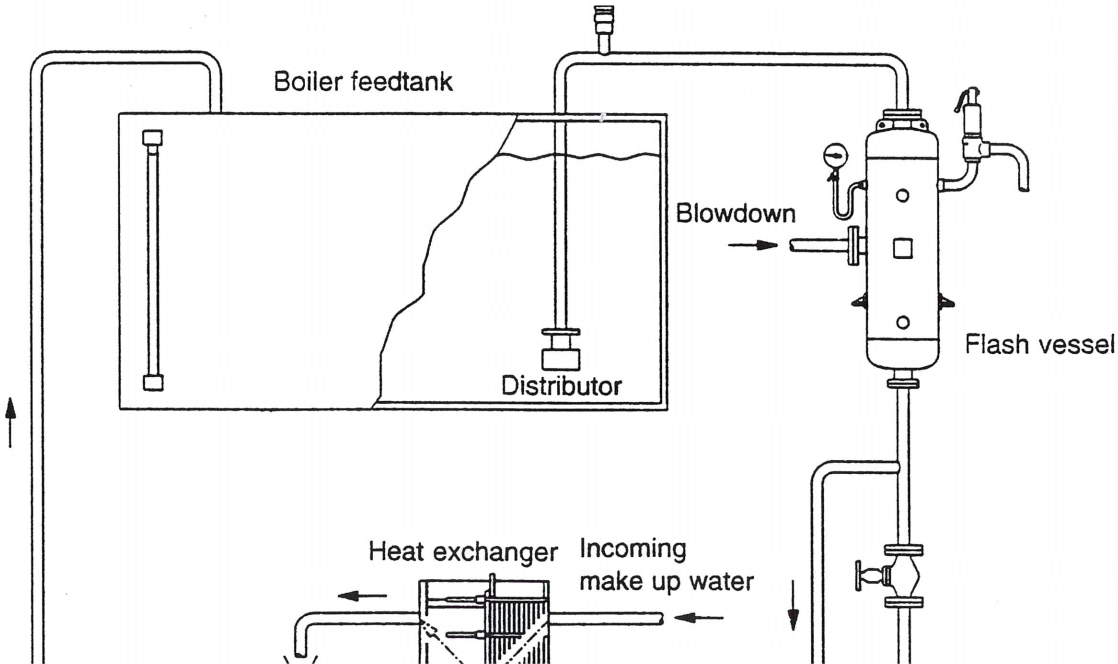
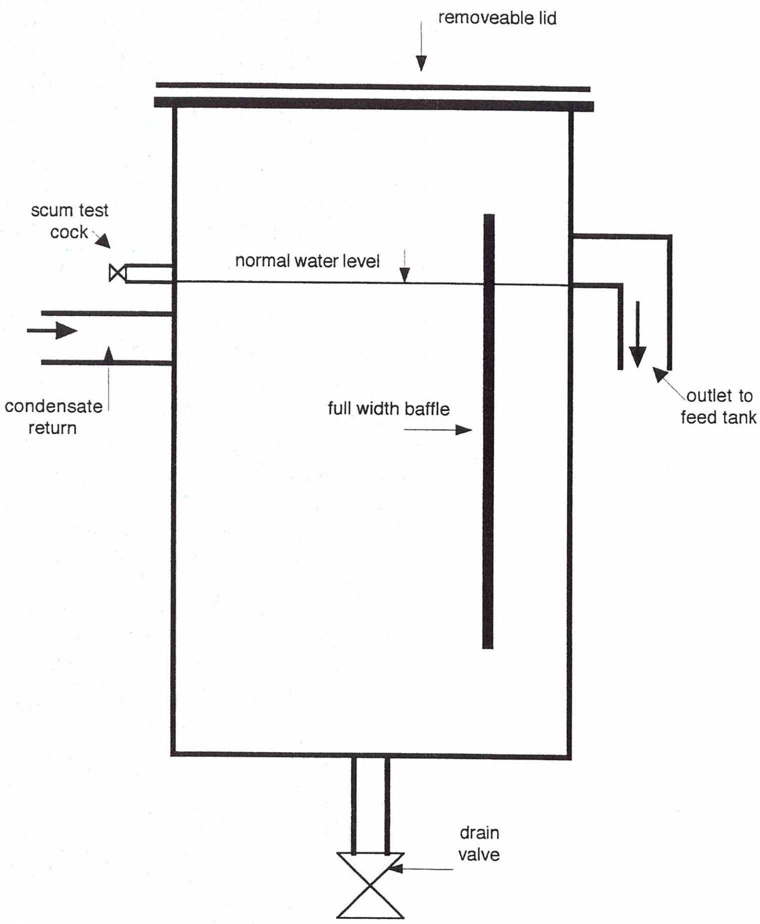


FIGURE 4 General arrangement of Fat Intercept Tank



Concern regarding possible fat contamination should not discourage the recovery of heat in the condensate. The two-stage heat recovery system described above can be applied to condensate, with the low pressure flash steam being used to replace high pressure steam in suitable heating applications. The latent heat in the condensate can be used to preheat water.

Boiler Feed Water Tank

An adequately-sized boiler feed water tank is essential for an efficient boiler operation. The minimum capacity of the feed water tank should be equivalent to one hour's steaming capacity of the boiler, with freeboard to accommodate all available condensate return.

For a feed water tank to be of good design it should have the following design features:

- be of adequate size;
- be elevated to minimise the risk of cavitation at the feed water pump; and have
- a large-sized supply line to the feed water pump;
- the cold water inlet and pump supply line located as far apart as possible;
- the capacity to heat the feed water to a temperature of at least 80°C to 90°C;
- a large plan area to aid the release of oxygen from the feed water;
- a closed top having an adequately-sized vent;
- an easy and safe means of access;
- adequately-sized drainage and overflow lines run to drain.

There are many advantages of having a well-designed feed water tank capable of operating at a high temperature, including:

- reduced load on the boiler;
- reduced risk of damage to the boiler due to 'cold shock';
- reduced risk of corrosion due to the lower oxygen levels in the feed water.

Small amounts of oxygen can cause severe damage in the boiler. However, the ability of water to retain oxygen is reduced as its temperature rises. Operating feed water tanks at the highest possible temperature will ensure that the oxygen is released at the tank.

Additional Information

More detailed information on this subject is provided in the following:

'Water Treatment, Storage and Blowdown for Steam Boilers', Spirax Sarco Ltd Technical Reference Guide TR-GCM-01, 1996.

'Energy Management for the Meat Industry', CSIRO Meat Research Laboratory Seminar Papers, 1983.

'Cost Effective Energy Use in Meat Processing', Energy Authority of NSW, 1985.

'Energy Conservation Case Studies', New Zealand Energy Research and Development Committee, August 1981, p. 51.

Additional information

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

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