THE MEDAL ELECTRICAL STIMULATION UNIT

B. W. HOLT[1], A. CUTHBERTSON[1] and A. J. GIGIEL[2]

[1]Meat and Livestock Commission, Bletchley, Milton Keynes, England
[2]Meat Research Institute, Langford, Bristol, England

INTRODUCTION

Specifications for new beef chillers in the UK now usually include two basic requirements. One is that EEC Directives covering Intra-Community trade require carcasses to be chilled to 7°C before shipping or cutting, and the other that this is accomplished within 24 h to provide a quicker turnover and to reduce evaporative loss, drip and chiller space.

Unfortunately, such chillers cannot be used to their full potential without endangering meat quality. Cooling carcasses swiftly can cause marked cold shortening of many of the major muscles impairing their tenderness. As a general guide, cold shortening can occur in any muscle if its temperature is reduced below 11°C before rigor mortis is sufficiently advanced, as judged by its pH value being less than 6.2 (Bendall, 1972). It follows that meat nearest the cooling surface of the carcass will be most susceptible to cold shortening, with the expensive loin area likely to cause most concern, especially in lean carcasses where there is little fat to provide insulation. Carcasses put straight into a rapid chiller are likely to contain a considerable proportion of meat which has been toughened through cold shortening, and which will remain tougher than comparable carcasses cooled more slowly, even after ageing.

Electrical stimulation (ES) of carcasses removes the risk of cold shortening by bringing rigor mortis forward by 8-10 h. After ES, carcasses can be put into rapid chillers an hour after slaughter and a 24 h turnover can be achieved without risk of toughening. Apart from the avoidance of cold shortening, improvements in the tenderness and colour of meat have also been reported following application of ES (e.g. Savell et al, 1978; George et al, 1980). The extent of the benefits, especially tenderness, is greatly influenced by the cooling rate. With rapid cooling (immediate refrigeration at 0°C or less), there may be little improvement in tenderness beyond avoiding cold shortening. With delayed cooling (8 h in air at more than 10°C), significant improvements have been demonstrated arising from acceleration of ageing under conditions of high temperature and low pH.

Encouraged by the potential benefits of ES, MEDAL (Meat Equipment Development Association Ltd.), a consortium of five British abattoir equipment manufacturers, has developed a unit which has been operating in a British abattoir since late 1979 and is the first on-line automatic ES unit in Europe.

DESIGN

The unit has been designed after research to find the conditions best suited to achieve the rapid onset of rigor mortis throughout all the muscles of the carcass, including the forequarter. The maximum effect of ES is obtained by stimulating with a high voltage (700 to 1000 v) along the entire length of the carcass as soon as possible after death.

In commercial practice, there are difficulties in passing an electric current along the length of the carcass until the carcass is on the dressing line and the head has been removed. Stimulation of the carcass after it has been split into two sides is not practicable due to the violent reaction of the sides and the difficulty of maintaining electrical contact. For these reasons, the unit has been designed to operate on the dressing line before carcass splitting.

A key consideration in the design was that it should be able to operate with complete safety for personnel, particularly under the adverse working conditions of abattoirs, and with reliability which is ensured by the careful selection of materials and the rugged construction of the unit.

Since beef slaughter lines differ, the design took into consideration the need to adapt the apparatus for varying line systems and speeds.

Electrode design

To achieve good electrical contact and stimulation along the length of the carcass, the current is passed from the severed neck muscles to the Achilles tendon. The lower electrode is a robust stainless steel pan, shaped to contain the severed neck of the carcass, which is raised under pneumatic power until it meets the carcass neck, pre-loading powerful springs which ensure that good electrical contact is maintained throughout stimulation. This system allows carcasses varying greatly in size to be stimulated automatically. The upper electrode takes the form of the two hooks through the Achilles tendon making contact with the earthed rail.

Electrical characteristics

The voltage applied across the carcass consists of mains derived discrete mono-polar sinusoidal pulses. The peak voltage is adjustable from 250 to 1000 in discrete steps and the pulse repetition frequency is adjustable from 16.7 to 50 pps.

Safety

In order to meet Britain's high standards for the safety of personnel using these high voltages, the area for stimulation is surrounded by an enclosure consisting of a cabinet of aluminium structural tube and stainless steel sheet, roofed and enclosed against water spray during operation. The prototype unit which is 4.2 m long and approximately the same height is illustrated in the Figure.

Carcasses enter and leave the cabinet via a pair of doors at each end. Interlocks ensure that carcasses cannot be stimulated unless the doors are closed, and barriers are used to stop personnel entering the cabinet accidentally while the doors are open. The whole unit and rail is electrically bonded to earth to ensure that harmful voltages cannot be present on the structure.

Operating principle

The prototype unit is designed to work on a timed interval conveyor, but the operating principle outlined below can be adapted to suit other line systems, such as a continuous conveyor.

Carcasses are moved into and out of the cabinet by a timed interval conveyor, resulting in their being introduced into an overhead conveyor system at fixed spaces. The conveyor moves the carcass to each work station where it remains for an interval governed by control equipment, the time depending on the speed of the line. For instance, if the line is working at a speed of 60 carcasses per hour, there is a total time of one minute in which to accommodate the work and the movement of the carcass between stations. If the conveyor movement is at a safe practical speed of 0.3 m per second and work stations are 2.4 m apart, the timed interval is 52 seconds.

One or more electrodes are used, depending upon the line speed, and are placed inside the safety enclosure. Carcasses are brought into the enclosure by the conveyor system, the operation of the doors interlocked with the conveyor control equipment. The unit and the control system are pneumatic, this being safer and more reliable than either electrical or hydraulic power. With the doors safely closed, the lower electrode/s rises up to make contact with the carcass and the stimulating current switched on. After stimulation, the current is switched off, the electrode/s lowered, the door opened and the carcass moved to the next station.

The voltage is applied to the carcass in a series of bursts, the duration of which may be varied from 10 to 40 seconds. Polarity is automatically reversed between bursts to avoid polarisation of electrodes. The rest interval between bursts can also be varied from 1 to 7 seconds, as well as the total duration of stimulation which can range from 30 to 90 seconds.

Operation of prototype unit

The unit is designed to operate on a timed interval conveyor operating at 60 carcasses per hour. It is sited between evisceration and carcass splitting and, because of evidence indicating the desirability of maximising the duration of stimulation, the unit takes up two stations. The voltage is applied for a total of approximately 90 seconds in four equal bursts. The first two bursts are given through the electrode at the first station with an interval of 1 second between them during which time the voltage is reversed. The carcass then moves with the line to the second station and the sequence is repeated. At the time of writing, the unit is set to provide a peak voltage of 700 at 25 pps but, as noted earlier, the unit is flexible and it is possible to vary these as well as the length of stimulation and the number of burst periods within it.

RESULTS

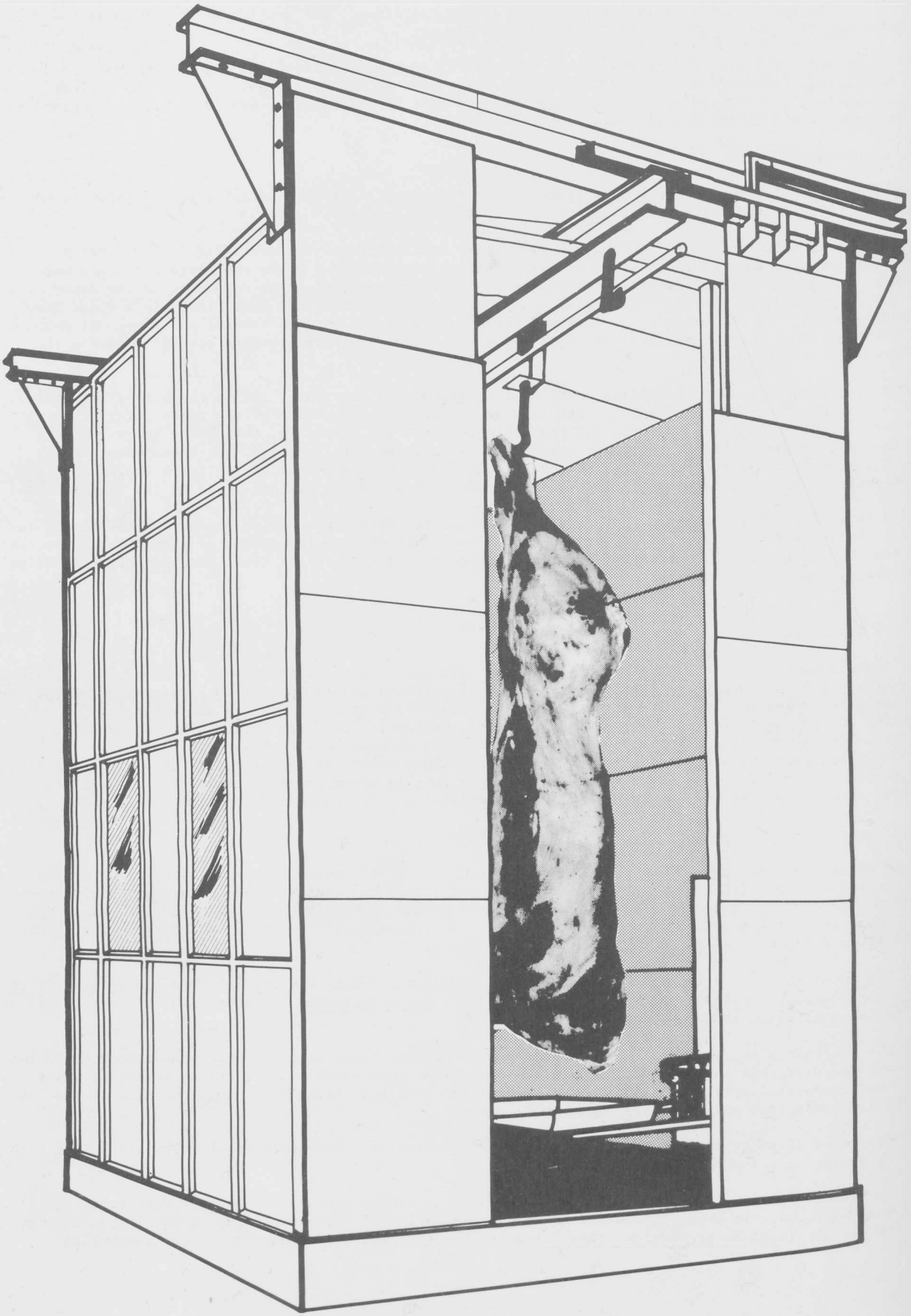
In order to assess how well the ES unit is achieving the objective of hastening the onset of rigor mortis, work is being carried out to monitor pH in matched groups of stimulated and unstimulated carcasses. Preliminary results from this work are given in the Table, which shows muscle pH values obtained in four groups of test carcasses measured approximately 50 minutes post mortem. The conditions of stimulation, applied approximately 30 minutes after slaughter, were 700 v, 25 pps for 90 seconds.

The pH of the muscles in the stimulated carcasses compare favourably with the results obtained by Bendall et al (1976) in the laboratory, with the exception of the pH of M. semimembranosus in Group 1 which did not fall as low as that later obtained in Group 4.

The pH of the muscles in the unstimulated carcasses are lower than those obtained under laboratory conditions (approximately pH 7.0). This may be due to increased spontaneous contractions of carcasses during sticking and bleeding under commercial conditions, and a small amount of electrical stimulation which results from a low voltage applied to stiffen all carcasses during hide removal.

In all cases, the difference in pH between stimulated and unstimulated carcasses within each group were highly significant, averaging 0.4 pH units over all groups.

In Groups 2, 3 and 4 there was no danger of cold shortening in the muscles tested even if very rapid chilling rates had been employed. In Group 1, however, there was some risk of cold shortening in muscles in thinner areas of the carcass (e.g. M. pectoralis superficialis) but that would have been of little commercial significance.



Cost benefit

Preliminary estimates of the cost effectiveness of ES indicate a significant financial advantage. A differential in favour of ES of £0.022/kg saleable meat has been estimated for an abattoir applying ES compared with a similar abattoir without the facility to stimulate. In making the estimates it has been assumed that the abattoir applying ES is handling 1000 cattle per week and chilling to achieve 7°C in the deep leg in 24 h, followed immediately by boning and vacuum packing, with ageing in packs for 8 days before dispatch. The other abattoir is assumed to chill to 7°C over 48 h, followed by boning and ageing of the meat in packs for 8 days. Most of the financial advantage given above stems from the saving in weight loss. No allowance has been made in the calculations for any quality advantages which may also accrue from ES, such as improved tenderness and colour.

CONCLUSION

Experience so far with the MEDAL stimulator shows that the design aims have been met. The onset of rigor mortis is accelerated throughout the carcass and the unit has met the stringent safety requirements of the British Health and Safety Executive. Under the rigours of the abattoir environment, the unit is standing up well.

Given this favourable start, MEDAL is now marketing the equipment and considering further developments involving electrical stimulation.

REFERENCES

BENDALL, J. R. (1972). Meat Chilling - Why and How? ARC Meat Research Institute Symposium No. 2 (April).

BENDALL, J. R., KETTERIDGE, C. C. and GEORGE, A. R. (1976). J. Sci. Fd. Agric. 27, 1123.

GEORGE, A. R., JONES, R. C. D. and BENDALL, J. R. (1980). Meat Science, 4, 51.

SAVELL, J. W., SMITH, G. C. and CARPENTER, Z. L. (1978). J. Anim. Sci. 46, 1221.

Muscle pH in four groups of stimulated and non-stimulated carcasses

Group	Muscle	Stimulated No.	Stimulated pH	Stimulated Standard deviation	Non-stimulated No.	Non-stimulated pH	Non-stimulated Standard deviation	Difference	Standard error of difference
1 Steers	SM	65	6.49	0.14	77	6.76	0.11	0.27	0.022
1 Steers	PS	67	6.54	0.080	79	7.02	0.12	0.48	0.017
2 Steers	LD	105	6.21	0.22	86	6.60	0.20	0.39	0.030
3 Cows	LD	19	6.21	0.17	19	6.62	0.22	0.41	0.066
4 Steers	SM	8	6.30	0.093	8	6.62	0.082	0.32	0.047
4 Steers	TB	8	6.28	0.041	8	6.76	0.056	0.48	0.026

SM = M. semimembranosus
PS = M. pectoralis superficialis
LD = M. longissimus dorsi
TB = M. triceps brachii