EVALUATION OF MECHANICALLY ASSISTED BONING TECHNOLOGY

M.284E

December 1994

Meat
Research
Corporation

A combined report of various research projects conducted from February 1992 to November 1994

by

DAVID CAPLE & ASSOCIATES PTY LTD
Level 1
273 Lower Heidelberg Road
East Ivanhoe VIC 3079
Phone (03) 9499 9011
Fax (03) 9499 9022

The project was funded by the

Meat Research Corporation
PO Box A498
Sydney South NSW 2000
Phone (02) 9380 0666
Fax (02) 9380 0699

CONTENTS

1. EXECUTIVE SUMMARY

This project presents an evaluation of the introduction to the South Burnett Meat Works at Murgon, Queensland of the Carni Liberator System from Proman Technology AB from Sweden. This technology was funded by the Meat Research Corporation and introduced in 1992 to facilitate the assessment of the benefits and efficiencies when compared with conventional boning chains.

Three evaluation methods were used to assess this technology being:-

- process efficiency - by Gibson Associates.
- OH & S benefits - David Caple & Associates Pty Ltd.
- comparative force measurements - CSIRO Meat Research Laboratories.

The evaluations were unable to confirm an equal level of productivity could be attained to conventional boning systems. Indications in the production statistics indicated a potential for even further improvements however, the intervention of industrial relations issues resulted in a ceiling on production output from the mechanical assisted boning technology.

The mechanical assisted technology did provide less strain exposure to the boner when processing heavier BULLS than the conventional boning chain. This was primarily due to the capabilities of the mechanical system to eliminate much of the force required by the boner in separating the cuts and manually supporting the larger cuts of beef.

The mechanical system did provide over 50% reduction in the use of the hook by the boner however, when using trained boners, it was found that they used similar or even more force on their knife when processing beef on the mechanical assisted technology. This was possibly due to their difficulty in adapting to working with a paced system of work controlling the speed of boning rather than the independent control over their movements when working on a conventional chain.

This project identifies a number of problems ~~for the Meat Research Corporation~~ to be considered when introducing and evaluating new technology. It was evident in this evaluation that ~~the following~~ issues were not adequately planned and incorporated into the initial phases of process design and implementation. These included issues of process specification detailing the support technologies and layout requirements to enhance the Proman system. Retrofit changes were found necessary to enable the larger sizes of carcus to be processed and to support the cuts of meat once they ~~left~~ the Proman rail.

The cross training of experienced boners was met with levels of resistance due to their perception of a boner's job profile and the incorporation of slicing and wider range of boning skills required. As a result, boners tried to adopt their conventional skills to the Proman cutting system resulting in more force exertion than required. A profile of training competencies would have enabled targetted skill training to match the design features of the Proman system. Such training packages should be provided by the supplier for all users including maintenance and cleaning staff for use in the systems induction programs. Job design where boners experienced in conventional chains were now also involved in a wider range of boning tasks and also aspects of slicing which expanded their skill base and was different to their traditional perception of their job profile.

The opportunity to amend and modify the new technology based on the evaluation and feedback from the users, maintenance, and cleaning staff need to be incorporated into the early phases of the technology introduction. Inflexibility in the initial design and the expectation that no modifications will be required, can result in a product retaining a range of compromise features which reduce the credibility of the technology amongst the various user groups.

The definition of the process philosophy and outputs should be communicated with such new systems. These issues include process speed, quality objectives primal cuts processed, and the range of primal cuts suited to maximise the profitability of the system.

It is recommended that prior to future technology introductions a planning phase clearly documenting the human resource issues be incorporated to avoid some of the problems encountered with this particular project. Although the manufacturers claim increase in quality and productivity were not totally realised during the evaluation phase, this does not necessarily detract from the future potential of the Proman system. Certainly, many of the manufacturers claim in reducing OH & S risks were verified but, at this stage, many of the productivity benefits will not be fully quantified until the industrial relations issues are resolved.

David Caple
Project Leader

1.1 Background and Project Objectives.

The South Burnett meatworks in Murgon in Queensland have been evaluating machine assisted boning technology since 1992. With funding from the Meat Research Corporation, they purchased and installed the Carni Liberator System from Proman Technology AB from Sweden.

The manufacturer claimed that "the Carni Liberator System provides technology for improved working conditions and efficiency. Must reduced physical strain. Better working conditions. No lifting. No carrying". The manufacturer also suggests that the boning productivity could increase by 40% using this machinery. Currently, the boning tally at Murgon is (60 units minimum and 75 units maximum). Traditionally, an increase in productivity would be achieved through an increase throughput tally. Such a large increase would not likely to be achievable through normal industry methods. If the proposed increase in productivity were to be achieved, there could be expected to be a sharing arrangement in the benefits between the profitability to the company and increased wages for the workers.

The two variables that control productivity of the boning room are:-

- the cattle types; and
- the through put rate.

The cattle types control the ultimate output through carcass weights and potential yields of boneless meat. Heavier cattle will obviously carry more meat and ox will yield better than cows but worse than bulls. A perceived advantage of the Proman System was an ability to handle the full range of carcass weights including bulls without introducing an extra load on the operator or slow down of the production system.

The objectives of this study were:-

(1) To determine any differences between the physical load on the boner in working with the Proman System compared to conventional boning.

(2) To identify other health and safety benefits for the boner working on the Proman System.

(3) To assess the work practices, productivity and quality improvements relating to the Proman System.

(4) To offer recommendations on future installations and evaluations of technology based on the findings from this report.

2. METHODOLOGY

This report contained a combined Methodology from three participating projects being:-

(1) David Caple & Associates - OH & S Issues.

(2) CSIRO (Meat Research Laboratories) - Knife and Hook Forces Comparison.

(3) Gibson Associates - Human Resource Management Issues.

The Methodologies For The Health And Safety Issues Included:-

2.1 Force Analysis

The force being applied by the boners to their hook and knife were quantified by the CSIRO experiments. This was based on a base data of MVC (Maximum Voluntary Contraction). This measures the maximum force an operator can exert, in this project, pulling down with their arm against a resistance. Ergonomic research recommends exertion should be restricted below 10-20% of MVC for repetitive tasks.

The CSIRO team developed and calibrated force sensors attached to the hook and the knife used when boning. These sensors measured deviation of the hook, and knife blade, as the boner exerted increasing force on the meat whilst performing their duties.

2.2 Systems Analysis.

A series of flow charts were developed identifying where the boning of meat was undertaken for both the conventional and Carni Liberator Systems. (Appendix 1, 2 and 3).

These systems identified those tasks where the boner utilised the hook and the knife to enable direct comparison between work methods using the different technologies.

Introduction of Change

The management processes associated with the introduction of this new technology to the workforce were investigated and evaluated. The contribution of this change process were assessed within the context of the technological benefits claimed by the manufacturer.

2.3. Manual Handling.

The dynamic nature of the manual handling tasks predominantly involves the boner handling the individual cuts of meat. It also relates to the forces exerted in pushing and pulling cuts of meat.

This aspect of the research quantified the actual kilograms physically supported by the boner in the course of their working shift. This was based on their MVC abilities Appendix 6 shows the MVC and percentages exerted for each operator. Due to their hygiene requirements, the support of the meat cut is via a hook to avoid contact of the operators hand with the meat tissue. A sample of the cuts of meat were taken from the production area and weighed to determine the weights of the individual range of cuts handled together with an estimate of the total weights manually handled with the conventional and the Proman systems.

The working heights for the Proman system were measured and shown in Appendix 7 of this report.

2.4. Postural Analysis.

Using a video based system to record the range of working postures of boners, the comparison was done between similar work areas in the conventional boning room with those using the Proman system. As the Proman system is not involved with all of the tasks in the boning operation, comparisons were only made where similar tasks were being performed. Analysis was conducted by looking at deviations of the;

- lower back
- shoulder
- elbow
- wrist

of the boner.

These deviations were recorded for both the dominant (knife) hand and the non dominant (hook) hand.

Using the slow motion facility of video analysis, we were able to record the deviations of each of these body parts from the bio-mechanically neutral position and record the extent of time that each of these postures were held. Ergonomic research indicates that static posture of body parts away from their neutral position can cause an accumulation of muscle fatigue and increases the risk of injury to the operator. The details of the analysis are provided in Appendix 8 & 9 of this report. This system is similar to the RULA (McAtamney & Corlett, 1991) and the OWAS (Wilson & Corlett 1992).

These systems are tools used in ergonomics to assess the static postures of operators using video techniques.

Our methodology modified these techniques to suit the application for meat workers as the conventional assessment methods were not found to be appropriate for the range of postures in this application.

2.5. Operator Survey.

A subjective assessment survey was sent to five meat works across Australia with the request that boners complete the questionnaire. A total of 250 were distributed. The objective of the questionnaire was to determine what parts of their body do the boners feel fatigue after a shift and what reasons do they attribute towards this fatigue. The survey was conducted on an anonymous basis and the completed forms were sent back to our office for collation and analysis. This survey used a Coilet body map to enable the boners to mark on an outline of a body shape, those areas on their body where they experienced fatigue and also a rating scale between 0-10 where they could mark the extent of fatigue or discomfort that they would rank for the particular body parts nominated.

Boners from the Murgon site were amongst the sample invited to participate in this survey.

2.6. Productivity.

Issues relating to productivity were studied in the Gibson Associates project based on the relationship between the kilograms of meat produced (output per labour hour input). Using data on the average carcass weight and the total production weight as well as the hours spent on each sex of beast, a production measure used was:

$$\text{Kg/labour hour} = \frac{\text{total kgs production weight}}{\text{labour numbers x time worked}}$$

Issues relating to the quality of the meat were not focused on in this study however, observations were made on the focus towards carcass yield based on the cleanliness of the bones with a direction towards maximising the weight of meat removed. This was compared against optimising the through put of high value cuts to maximise the dollar value of meat processed per unit time.

3. RESULTS

1. Force Measurements - Hook and Knife

1.1 Review of Field Trials

The initial evaluation period was spent discussing the experimental plan and organising people, animals and equipment. Jap-Ox was eliminated as it is not usually processed through the Proman room. Two boners were identified who had significant experience on both systems. Three days of trialling were required to collect three replicates of the experimental matrix (8 carcasses per boner per day).

Eight BULL carcasses were processed on Day 1 without interruption. Proman force and speed parameters were freely set (12 times) by the boners.

On Day 2, a target of eight COW carcasses was set. Proman force and speed parameters were set using a set and forget strategy (4 or 5 times) that was different to the BULL trial day. The target was achieved on time, although the hook strain gauges failed completely, invalidating the COW hook effort.

1.2 Limits on Interpretation

Interpretation of the results is limited by the lack of randomisation of treatment combinations, and the lack of replication. The following sections describe the consequences of these limitations.

1.3 Lack of Randomisation

The experiment was designed to minimise trial time by following the most efficient processing order (PREP, CL1, CL2, CL3, Conventional; swapping boners every four quarters). A random treatment order of quarters would have required much more frequent equipment moves, and operator and knife changes.

It is important to note the effect of not randomising the order of the trials. On each trial day, Proman modules were done first, followed by simulated Conventional. Therefore, the effect of carcass type on knife effort is confounded with day-to-day variations in knife effort; and, the effect of system on knife effort is confounded with time-of-day variations.

When comparing BULL and COW you must take into account that they were processed on different days. For example, average COW effort readings taken at the start of the week could be higher than readings taken just before the weekend.

More importantly, when comparing Proman and conventional you must take into account that the boners could take a few carcasses to warm up in the morning, go steady throughout the day, and have to speed up towards the end. Another scenario is that the boners may warm up quickly and then process very fast in the morning and then do a more relaxed pace in the afternoon.

The point is that we do not know which scenario applies and therefore these effects cannot be removed from the effort data we use for the statistical analysis. Randomisation of trial order is used to average out (or spread evenly) sources of experimental bias.

1.4 Sources of Bias

The purpose of this section is to establish sources of experimental bias and assess their likely impact on the final results discussed later in Section 4. Table 1 shows a significant system, carcass type interaction.

Type of Effort	BULL	COW
Knife	+ 2.0%	+ 19.0%
Hook	- 55.7%	- 42.8%

Table 1: Effect of Proman System on Boning Effort compared to effort boning on conventional technology.

In assessing experimental bias, the most likely scenario is that the operators were more familiar (short-term) with processing BULL carcasses and were able to capture more of the system benefits by selecting appropriate force/speed settings more frequently to accommodate carcass weight variations.

Also, with the clear bias towards conventional, the 19% increase in Proman knife effort (COW) is probably close to the maximum for the current level of performance of the system. At the other end of the scale, the 2% increase in Proman knife effort (BULL) is probably not a minimum, suggesting that Proman can reduce knife effort below that of conventional. Examples of force measurement results for both Proman and conventional systems are provided in Appendix 4 & 5 of this report.

1.5 Lack of Replication

Sixteen of the required 48 carcasses (33%) were processed which represents one complete replicate of the experimental matrix for all six factors. This was sufficient for the ANOVA package to estimate first-order effects, however, higher-order interactions were not accurately defined.

The reason for replicating data is to measure the repeatability of the measurement and thus estimate the degree of variance due to random (natural) effects. For example, the treatment combination and others combine to give us a measure of the natural variability in knife effort due to random effects or events.

The lack of replication in this experiment required that the higher-order interactions be combined to form a standard error. Greater replication would have given the analysis more degrees of freedom and less uncertainty, leading to a more precise result.

Hook Conclusions

Hook usage is not well-documented in the Proman process specification. Relative hook durations were significantly different for the two boners using Proman (Operator A 36%, Operator B 19.3%). For conventional they were closer together (Operator A 36%, Operator B 36%). Hook usage was lower for COW than for BULL for both systems.

Proman is clearly designed to minimise the use of the boning hook for the majority of tasks. This is confirmed with Proman reducing hook effort by 36.8% to 63.8% for BULL, and by 2.0% to 60.1% for COW. the large range shows that hook effort is heavily influenced by the operator's boning style.

Average reductions in hook effort of 55.7% for BULL and 42.8% COW are based on the assumption that 25% of boners will require the hook for shin boning.

1.6 Knife Effort Factor Effects

Significant knife effort factor effects that were identified when comparing final results. As only 16 carcasses were processed, there were not enough degrees of freedom to estimate all factor effects and interactions. Some of the higher order interactions (fourth and above) were used to form the residual error term. Not all factors and covariates showed a significant effect in the ANOVA.

Factor Effects;

Remember that BULL and COW knife effort data was analysed separately to avoid confounding day-to-day variations with the other factors.

1.6.1 Carcass Type

Carcass Type is the most dominant factor effect of knife effort. For Proman, BULL requires 46% more knife effort than COW to bone. For conventional, BULL requires 70.5% more knife effort than COW to bone.

Therefore, Proman offers more of a benefit in processing BULL than it does in processing COW (a Carcass Type, System interaction). Given the rough nature of the analysis, these figures correlate well with the 150% tally penalty on BULL.

1.6.2 System

For BULL, Proman brings a 2.1% increase (not significant: ANOVA) in knife effort. For COW, Proman brings 19.3% increase (significant: ANOVA) in knife effort. Again this indicates that Proman offers a greater benefit for BULL than COW.

Note that reductions in knife effort should lead to higher productivity. The greater the mechanically assisted benefit the operator can capture through his/her own skills improvement the greater the scope for productivity improvement.

1.6.3 Operator

As discussed in the methodology, operator is a complex factor. Operator B's strength, body weight and size probably contributed to his greater knife effort than Operator A (30.4% BULL, 38.8% COW). Both boners have extensive experience on conventional systems and limited experience on Proman.

There is no doubt that this factor would bias the experiment in favour of conventional boning.

There was a significant interaction of operator and knife. For COW, Operator B exerted significantly more effort using the 6" knife compared with Operator A (68.8%). No significant difference was observed for the 5" knife. However, for BULL, Operator A exerted significantly more effort for the 5" knife compared with Operator B (72.2%) - although ANOVA did not consider this significant. No significant difference was observed for the 6" knife.

If these figures are representative then for BULL, Operator B should use a 6" knife and Operator A should use a 5" knife to minimise effort.

1.6.4 Knife

Effort for the 5" knife was 3.2% less than the 6" knife for BULL, and 10.1% less for COW. Neither of these was considered significant ANOVA.

A significant third order interaction between knife, side and quarter was identified by ANOVA. No more detail was given but this could mean that, for example, using a 5" knife on Left Hindquarters may exert more effort than using a 6" knife.

1.6.5 Side

ANOVA did not report any significant side effect for BULL or COW, perhaps because of the confounding of side with animal effect. However, averages from the trend analysis indicate that (for BULL) left sides require 4.5% more knife effort to bone than right sides. This correlates with the "off-handed" side phenomenon.

This may however be opposite for FQ and HQ's ie. left FQ's and right HQ's require more effort than their counterparts (side, quarter interaction). This may be the primary source of the knife, side, quarter interaction mentioned above.

1.6.6 Quarter

The only significant effort observed for BULL was that more knife effort was required for the FQ than the HQ (12.5% more). For the COW, this was reversed with more knife effort required for the HQ than the FQ (5.1% more).

The inconsistency between BULL and COW is probably due to the lack of replication in the experiment.

1.7 Covariates

1.7.1 Side Weight

The most obvious difference between carcass types is side weight. BULL side weight ranged from 153.0kg to 214.5kg with a trial average of 180.8kg COW side weight ranged from 62.0kg to 108.5kg with a trial average of 90.3kg.

ANOVA did not identify it as a significant covariate for BULL or COW, probably because it was already factored into knife effort via carcass type.

1.7.2 Quarter Temperature

Quarter temperature was not a significant covariate for BULL or COW. This is not surprising for COW as 31 our of 32 quarters were recorded as 11 or 12 degrees. for BULL, 9 quarters were between 5 and 9.9 degrees, 18 quarters were between 10 and 11.9 degrees and 5 were 12 or 13 degrees.

Some of the colder quarters (5 and 6 degrees) may have caused an effect on knife effort, however, this was not significant.

1.8 Other Effects

1.8.1 Animal Effect

Animal effect is the confounding of system, side and the covariate, side weight. The combination of heavier left sides with lighter right side pairs would have biased the experiment in favour of conventional. For example, BULL Trial set 4, left side 001-214.5kg right side 429-178 0 kg.

Three out of four left sides for BULL were heavier than their right side pairs (Proman) by an average weight of 21.5kg (represents 11.9% of average BULL side weight). This was also the case for COW, with three out of four left sides heavier than their right side pairs by an average weight of 6.8kg (represents 7.5% of average COW side weight).

Although 75% of sides followed this trend, animal effect is third-order and is not likely to be a significant factor.

2. Proman System Performance

2.1 Assessment Criteria

Three assessment criteria are used to assess system performance based on general observations from video analysis. Each module is assessed on both the performance of forequarter and hindquarter processing using three criteria scores (each out of four).

2.1.1 Process Conformance

Process conformance is a measure of how closely the boners follow the written process description. It reflects both on the quality of the description provided and the level of understanding demonstrated by the boners.

The score begins at four and one point is deducted if one of the following occurred during the trials:

- task performed at wrong module
- inappropriate use of hook

Task specialisation is one of the foundations of efficient production systems. Having multiple (pseudo) process standards will always be less efficient and will lead to conflict and confusion. Well defined processes require more attention to detail and order, but offer higher productivity as a reward.

This analysis showed a low level of process conformance.

2.1.2 Impact of Technology

Proman Technology offers benefits by design and by performance. Design benefits are inherent in the system (eg. improved working position) and are easily captured. Performance benefits can only be captured by skilful operation of the machine and is dependent on the boners.

Impact of Technology measures the observed potential for the system to deliver both benefits. For example, machine stripping was observed some (although not all) of the time on several of the modules. Never the less, it received a point as the potential benefit was there all of the time, but it was not always captured.

The score starts at zero and one point is awarded for each of the following potential benefits:

- improves working position/height
- stabilises the quarter
- tensions the quarter
- provides a stripping action (meat from bone)

2.1.3 General Performance

General performance assesses how smoothly the module runs under normal operating conditions. It reflects both the degree of difficulty of the process and the level of skill shown by the operators.

The score starts at four and one point is removed for:

- process problems that occur more than once
- inappropriate selection of force and speed parameters

Use of additional manual techniques is noted but it is neither rewarded nor penalised in the scoring as it is related to the technology.

The system performance results showed that a significant deviation of work methods occurred when compared to those documented. It was also found that many aspects of the process had no documented procedures to follow.

3. Manual Handling

With the conventional system of boning, as each cut of meat is removed from the carcass, the boner throws or drops the cut into the slicing bench below. As the boners move along the chain on the conventional system, they may be required to throw a cut of meat in excess of 1 metre to the appropriate slicing table. Consequently, the manual handling of the cuts of meat, particularly supported by the hook, is a significant component of the load on the non dominant arm with the conventional system. The technique involved in releasing the meat from the hook during the throwing motion is a further contributory factor to potential damage, particularly to the wrist and elbow of the boner.

Quantification of the manual handling performed by the boners at Murgon was as follows;

- average daily production - 600 beasts over two shifts
- average shift production - 300 beasts over two parallel boning lines
- production per boning line - 150 beasts per shift

4 boners are involved in removing the major cuts of beef (a total of 14 boners are used on the line)

- average number of beasts processed per key boner - 37 beasts per shift
- average quarter weight per beast = 80 kgs (up to 150 kg for bulls)
- total weight estimated to be manually handled by each boner = approximately 3000 kgs (3 ton) per shift. This estimate calculates the weight of the cuts of meat supported through the hook as well as the bones which are removed and thrown onto the bone transfer conveyors.

A summary of the individual cuts of meats has been collated below as a sample of those weights which are manually handled using the hook.

MEAT CUT	AVERAGE WEIGHT
RUMP	7 KG
TOPSIDE	20 KG
SILVERSIDE	15 KG
CHUCK	34 KG
KNUCKLE	6 KG
BLADE	12 KG

The weight of each cut depends on whether a cow or a bull is being processed with the cuts of meat from bulls being greatest. The heavier bulls have cuts in excess of 35 kgs which are supported with the hook by the boner.

With the Proman system, the weight of the individual cuts of meat are supported by the rail as the quarters are dismembered and released during the various stages of processing. It is only at the final stage where the cuts are transferred onto the slicing table where manual handling of the meat is found. With the introduction of the self levelling table to support the weight of the meat prior to slicing, the manual handling of the meat has been assisted so that the operator now can slide the meat onto the slicing table. The Proman system should result in a significant improvement to the potential risk of injury to the back, shoulders and non-dominant arm through the virtual elimination of manual handling of the meat and bones.

4. Postural Analysis

This video analysis indicated that the range of postures found in the conventional system and the Proman system involved a similar proportion of extremes of movement except for those tasks where the Carni Liberator eliminated the use of the hook in the non dominant hand. For example, during the removal of the Aitch bone and the rib removal, the conventional boner is requires to abduct their non dominant shoulder whilst applying force through their hook. This is completely eliminated with the Proman system. Results are shown in Appendix 8 & 9.

The range of static postures on the lower back are dictated by the size of the carcass being processed, and with both the conventional and the Proman system, the boners are still required to stoop to near floor height when working on the large beasts, e.g. bulls. Similarly, when working on the shin section and the knuckle at the top of the quarter, the shorter operators are required to work with their hands above shoulder height.

In conclusion, it can be seen that the Proman system provided an improved posture for the back and shoulders for those processors using the Carni Liberator to draw meat segments apart. It did not however, alleviate all the lower or higher reaches involved in working over the range of carcass sizes being processed. Through consultation with the managers at Murgon, some modifications were made to the engineering system to improve these extreme postural tasks. For example, a levelling table was provided at the final workstation to support the weight of the meat as it is finally cut from the Proman system and transferred onto the slicing table. Initially, this handling was performed manually and involved significant forces being applied by the operator. Through ongoing monitoring of the rail heights and facilities provided for shorter and taller operators, further improvements in working posture may be identified, particularly for the extreme highest and lowest reaches.

5. Operator Survey

Subjective assessment of boners experienced in using the conventional system was conducted through the distribution of 250 questionnaires to 5 meatworks across Australia. The objective of the questionnaire was to determine what parts of the body do boners feel fatigue after a shift and what reasons do they attribute towards this fatigue. Responses from 150 boners for 3 of the meatworks were obtained and included in the analysis. The sheet completed by boners is shown in Appendix 10.

It was clearly identified that the major areas of fatigue were to their knife wrist, elbow and shoulder. They also reported the lower back as the other major location. The next order of priority would be to their non dominant wrist, elbow and shoulder. This arm is used for the exertion of force with the hook and the manual handling of the meat cuts to the slicing bench.

These results were consistent for 90% of the respondents who graded their discomfort as "moderate to severe" on an ongoing basis.

The major factors identified by the boners for this fatigue were:

- repetitiveness of the task
- temperature of the fat
- working postures
- speed of the chain

To the question asking what suggestions would they propose to reduce this fatigue, they obviously included the counter arguments to the causal factors but also mentioned the work organisational option of task rotation amongst the boning line.

An interesting side conclusion from this survey was the number of operators who thanked the researchers for an opportunity to voice their opinions about their perception of their job. This indicates that greater utilisation of direct employee consultation may have benefits for further evaluation of technology and work practice initiatives.

Product Assessment

The room at Murgon where the Proman system has been introduced primarily uses trainees as meat processors rather than experienced boners from the conventional room. They generally proceeded well in their skill development however once trained in conventional boning, compromises in technique become evident. With time a number of experienced boners became polarised in their opinions towards the Proman system.

6. Productivity Trials

A series of productivity measures were taken in the Proman room over a period of 9 months. The output of meat was quantified in terms of kg per labour hour. Each shift when the Proman system was operating was assessed. Appendix 11 shows how the measure increased from 20kg in April to over 100kg in December with a single peak of 160kg per labour hour.

Considering that conventional boning chains have tally around 100kg per labour hour, the output from the Proman system improvement to match the conventional system.

The trend on the graph in Appendix 11 indicates that production output had not plateued at this level and a potential to improve further was evident. Apparently Industrial Relations issues resulted in a limit on output to be imposed thus preventing a complete assessment of the system's potential.

4. DISCUSSION

1. Reduced Health and Safety Risks.

1.1 Time and force of hook and knife.

This research identified that the operators do reduce the use of the hook when working on the Proman system between 40-55% depending on the type of carcass being processed. The actual technique used by the operator when boning can significantly increase the use of the hook if they choose to adopt a conventional style of boning whilst utilising aspects of the Proman system.

The actual forces exerted on the knife were greater for the Proman system by 19% with the COW and 2% with the BULL. This is the opposite to what would be expected from the technical analysis of the Proman system. It is explained in our analysis by the use of subjects who were experienced and initially trained on the conventional boning technology who were subsequently retrained onto the Proman system. Due to the machinery controlled time in separating the cuts on the Proman system, we explain the increased force on the knife by the desire for the boner to speed up the time of processing by exerting unnecessarily extra force on the cuts being processed. Further, the operators were not found to utilise the controls on the Carni Liberator system based on the weight of the cuts. Hence, they used the knife to compensate when the force exerted by the technology was insufficient to maintain the performance output.

The results confirmed that force on the knife when boning bulls using conventional technology requires 70% more effort than boning cows. Using the Proman technology, bulls require 46% more effort than cows. This correlates to the 150% tally penalty on bull.

1.2 Range of Postures.

It was found that a similar range of postures were adopted using the two methods of boning. Had the Proman system been designed with a grading height of the rail then the lower reaches towards the floor when processing the bulls and the higher reaches to the shin sections would have been eliminated. This refinement of the process engineering has been incorporated into the conventional boning system but not into all aspects of the Proman prototype. The period of static postures held with the Proman workstations was less than conventional boning. This is due to the opportunity to stand back when the Carni Liberator is activated and simply use the knife along the membrane between the bone and meat cuts.

1.3 Manual Handling.

A significant improvement with the Proman system has been the virtual elimination of manually handling individual cuts of meat being supported on the operators hook. Although in conventional boning, the boner will often use the hook, to guide the meat from the carcass onto the slicing table or conveyor belt below. Consequently, they tend not to support the full weight of the meat cuts on the hook. Both Proman and conventional boners do use the hook for dragging the cut of meat off the carcass were the mechanical assistance is not provided. Similar exertions of force found regardless of boning system utilised for those tasks e.g. shin boning.

1.4 Knife Selection.

The Proman technology enables the use of both a 5 inch or a 6 inch knife. The more flexible 5 inch knife was preferred by the boners although the force data did not quantify a significant difference between the knife selected. A number of covariates were tested however, no significant differences were found between the technologies used. These issues included quarter temperature; side weight; animals process; and operator techniques.

2. Operator Feedback.

With the general consensus of boners suffering significant levels of discomfort and fatigue, any improvement to the physiological demands to the boning system would be of benefit to the boners. This study found that the boners did not perceive that there were significant benefits to them with the Proman system, however, this was related possibly to a range of factors,.and not to the reduced physiological demands described above. The small sample size (2 boners) involved in the force measurements prevents conclusions from comparative questioning.

3. Work Practice Issues.

It was found that the boners within the study were not necessarily following exactly the same practices with the Proman system as expected from their literature. This would suggest that the issue of cross transferring skills for experienced boners from a conventional to a new system of boning may be difficult to achieve the new patterns of behaviour assumed possible. The documentation of standards practices relevant to the new system will need to be more closely monitored to ensure that the training provided enables the operator to achieve the full benefits marketed with the new technology.

A need to fully document all procedures was identified as many aspects of the operators duties were not adequately documented e.g. boning the shin area.

4. Increased Flexibility of Product Mix.

It was found that the Proman system was able to capably handle the BULL and heavier stock which traditionally was processed with a penalty and difficulty on the conventional boning system. This is an advantage for the Proman over conventional boning systems.

Further, the trained operators were able to use a smaller more flexible knife whilst working with the Proman system which they found more comfortable and easier to use.

5. Productivity Issues.

Although the manufacturer of the Carni Liberator system proposed an increase up to 40% over conventional boning, this was not able to be fully evaluated in this trial. Once the skill development resulted in 100kg per labour hour, on introduction of industrial relations issues prevented any further output. Thus, the Proman system was able to match the output of the conventional boning but increases beyond have yet to be fully assessed.

Appendix

1. Proman System Layout.
2. Sequence of cuts - Proman.
3. Sequence of cuts - Conventional.
4. Force measurement of knife - Rib Removal - Proman.
5. Force measurement of knife - Rib Removal - Conventional.
6. Force exertion as % of MVC.
7. Reach heights with Proman.
8. Posture analysis from video mastersheet.
9. Summary sheet from posture analysis on video.
10. Subjective survey sheet on operator discomfort.
11. Productivity Measures of Proman System.

FORCE EXERTION AS % MVC

Operator A	KNIFE CUTTING			HOOK PULLING		
MVC = 36 kgF	FORCE			FORCE		
Proman	Fmax	Fa(av)		Fmax	Fa(av)	
Minimum	30%	9%		41%	5%	
Average	37%	13%		101%	30%	
Maximum	46%	22%		164%	51%	
Standard dev.	5%	3%		45%	6%	
Conventional	Fmax	Fa(av)		Fmax	Fa(av)	
Minimum	32%	10%		69%	18%	
Average	41%	13%		94%	29%	
Maximum	49%	21%		110%	46%	
Standard dev.	5%	3%		13%	9%	

APPENDIX 6.

REACH HEIGHTS WITH PROMAN

rail height =	2100 mm

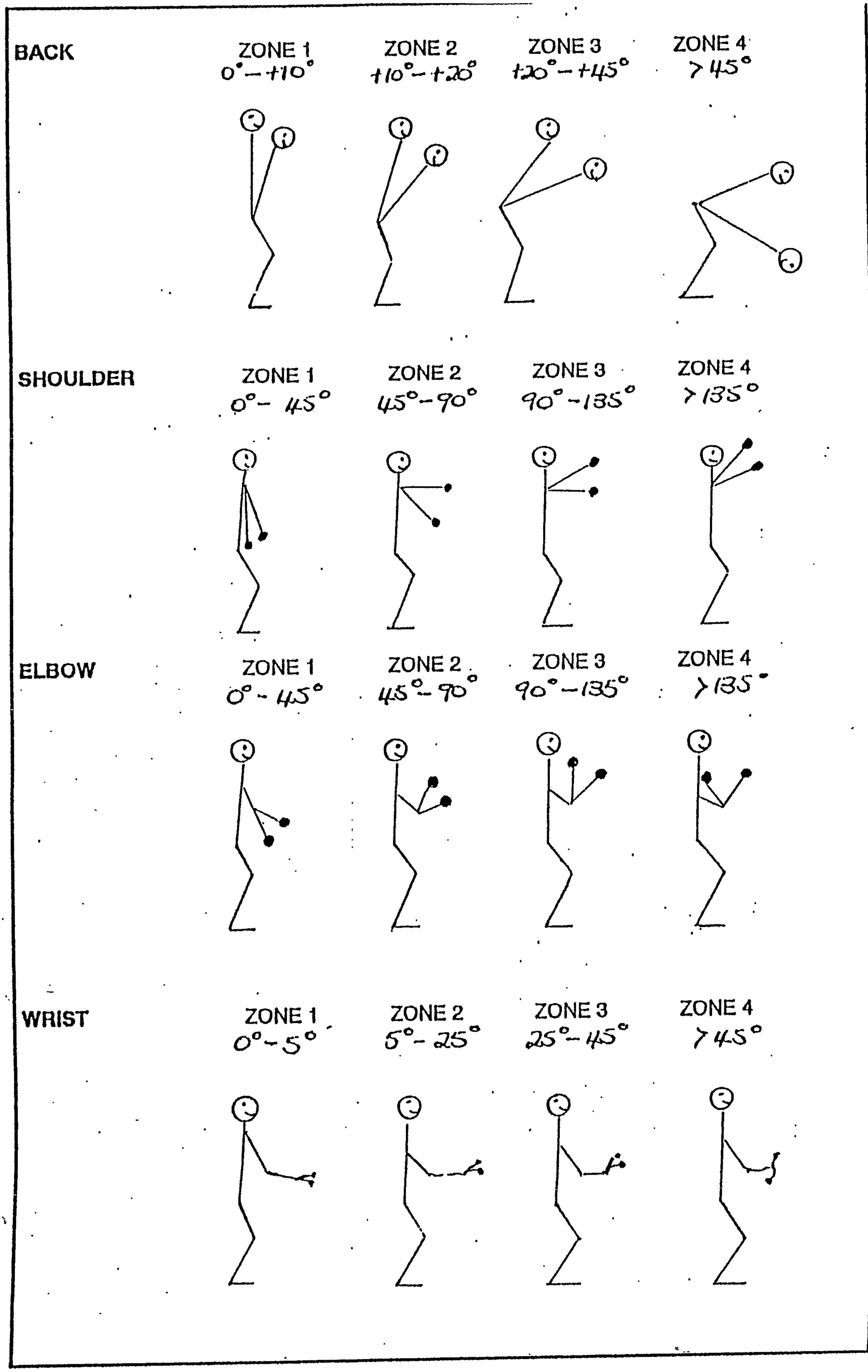
Top Cuts:

shin/shank =	1800 mm
knuckle =	1000–1500 mm

Low & Mid Height Cuts:

marking aitch bone =	1100 mm
dropping tenderloin bone =	700–1000 mm
aitch bone removal =	1200 mm
drop ribs onto bench =	1800 mm --> bench
cut off loin/flank/fillets =	1000 mm
cut off meat sigments to slicer =	600–1000 mm

APPENDIX 7.


BACK
ZONE 1
0°–+10°
ZONE 2
+10°–+20°
ZONE 3
+20°–+45°
ZONE 4
>45°
SHOULDER
ZONE 1
0°–45°
ZONE 2
45°–90°
ZONE 3
90°–135°
ZONE 4
>135°
ELBOW
ZONE 1
0°–45°
ZONE 2
45°–90°
ZONE 3
90°–135°
ZONE 4
>135°
WRIST
ZONE 1
0°–5°
ZONE 2
5°–25°
ZONE 3
25°–45°
ZONE 4
>45°

VIDEO ANALYSIS RESULTS FROM PROMAN SYSTEM

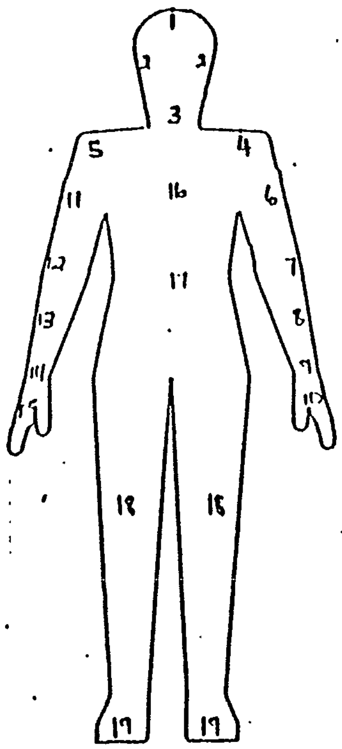
vertical = 0° vertical = 0°

#	task	stat.	video time	back	dominant shoulder	non-dom. shoulder
3	CL2 brisket rib cover FQ chuck sharp knife	5	0.00–0.49	5–15	30–60	45
4	1st prep'y CL. HQ	1	2.07?	10–45	45–65	60
5	1st prep'y CL. FQ	1	3.24?	15	115	115
6	CL1 – HQ – H bone/sep'te butt	2	3.59?	5	75	60
7	CL1 – FQ – brisket bone/ribs	2	4.10	5	45–70	0–70
8	CL2 – HQ – mark cut rump & expose femur (drop head of nuckle)	5	5.18	5–20	45	45–90 (120)
9	CL3 – FQ	6	6.27?	0	45–90	90
10	CL3 – HQ	6	7.00	0	40	30
11	Station 3 – Intercossal ribs	2	8.48?	15	15–40	15–45
12	Station 4 – HQ removed	4	11.00	5–30	0–30 (45)	30 (45)
13	CL3 – HQ	6	12.48	0	45 (90)	30–45 (90)
14	CL3 – FQ	6	13.43	20	45–90	30 (90)
15	CL2 – FQ	5	14.30	0–20	45 (90)	45–90
16	CL2 – HQ mark butted	5	15.47	10	100	30 (80)
17	Station 3 – Intercossal ribs	3	17.58	10	30–45 (110)	30–45
18	MVC	X	18.16	20–40	45–90	30–45
19	Station 4 – HQ	4	20.27	0–15	45–80	0–45

APPENDIX 9.

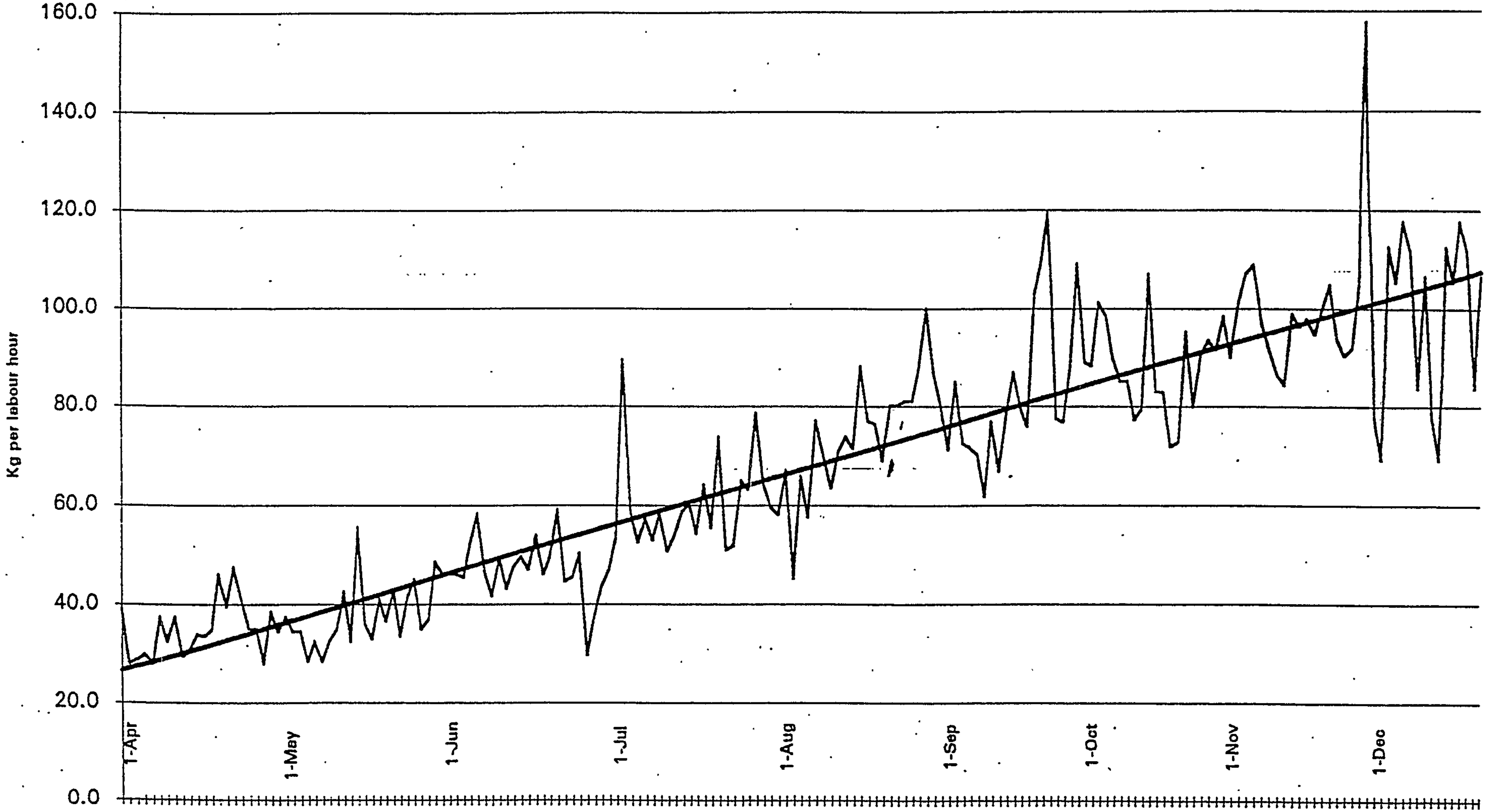
RESULTS

6 Operator Survey



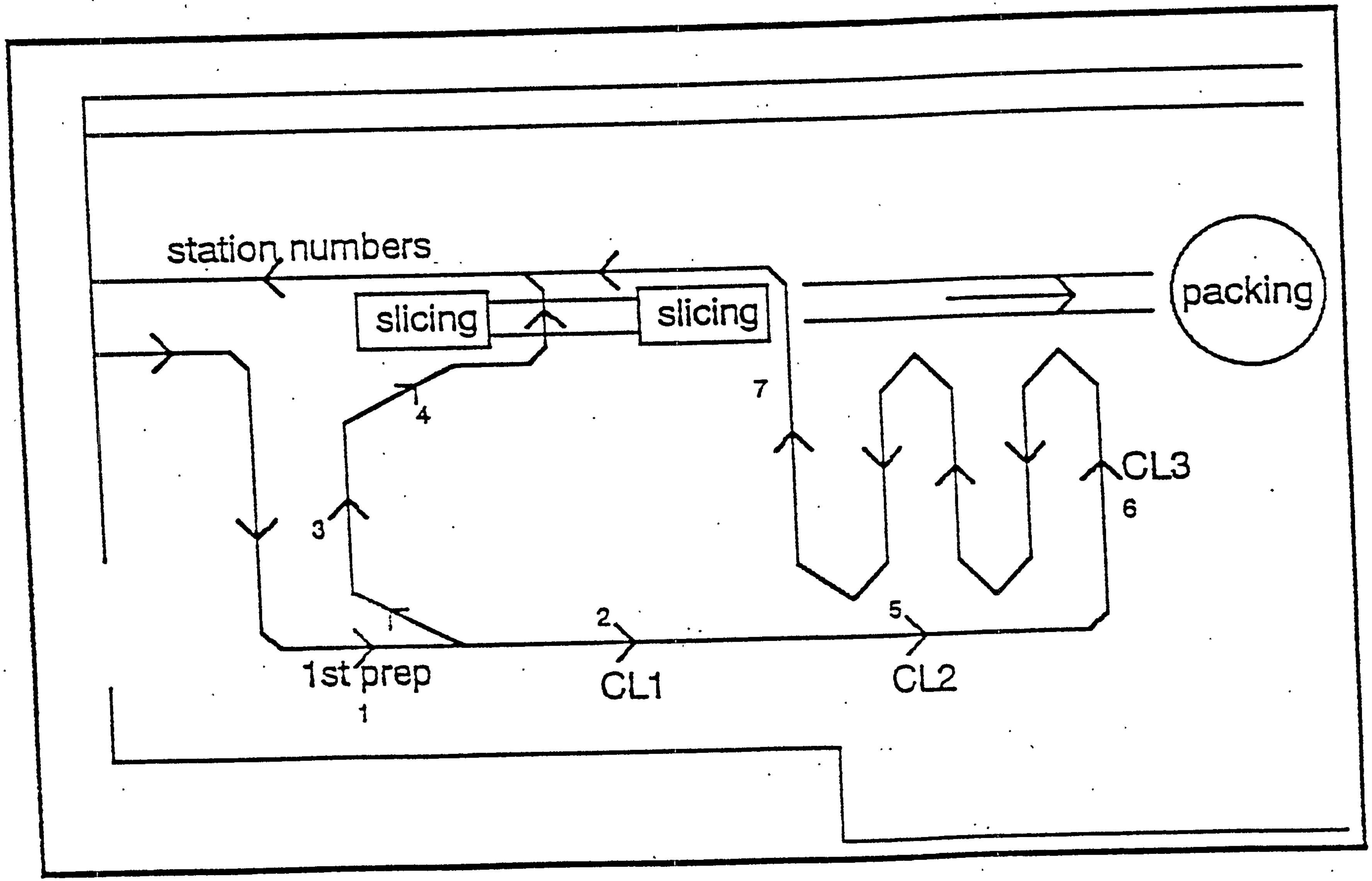
1. Head.
2. Ears
3. Neck
4. Right Shoulder
5. Left Shoulder
6. Right Upper Arm
7. Right Elbow
8. Right Lower Arm
9. Right Wrist
10. Right Hand
11. Left Upper Arm
12. Left Elbow
13. Left Lower Arm
14. Left Wrist
15. Left Hand
16. Upper Back
17. Lower Back
18. Legs
19. Feet
20. Other

- 90% regularly experience discomfort often at severe levels
- main locations
  - lower back
  - dominant (knife) arm
  - dominant shoulder
  - non dominant arm



160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Kg per labour hour
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

PROMAN SYSTEM LAYOUT



APPENDIX 1.

Sequence of Cuts

Proman:

Station #	*HEQ. Tech's*	*Fore Quarter*	*Hind Quarter*
1	1sr Prep'y	open brisket bone shin out	mark aitch bone drop tenderloin open sideflank
2	CL1	ribs removal	aitch bone removal
3		**lift/unhook/push + drop ribs -> table** intercostals ribs	
4			**remove aitch bone loin table boned + flank + fillets** -> table
5	CL2	**Shin blade + brisket chuck** **rib cover** -> table (sliced)	cut shin/shanks **mark knuckle, silverside, topside + rump**
6	CL3	remove **shin/blade** from leg bone	remove all HQ from leg
7		onto table slicing	cuts broken up -> table slicing
		7 man team	

cuts in bold are manually handled

APPENDIX 2.

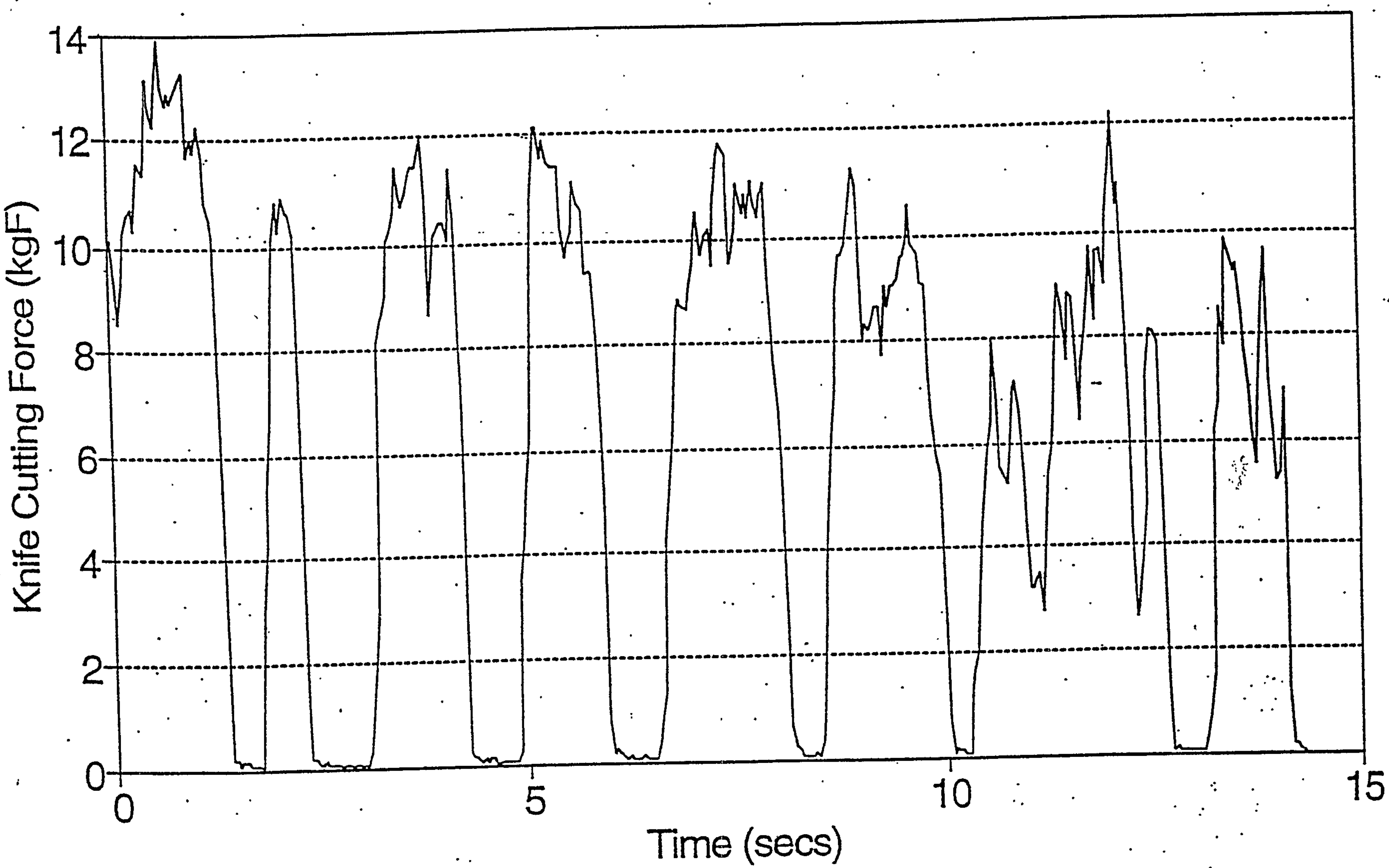
Conventional:

Hind Quarter	*Fore Quarter*
4 men mark backbone – flank – filet – aitch bone removal drop rump remove top (chuck) ribs + intercostal 1 in 3 ribs	**2 men** brisket removal mark top ribs * open ribs
1 man remove knuckle * rump	**2 men** ribs removal + intercossal on table loin removal rib bone removal + fillet
1 man -> drops chucks + topside	
1 man 2 in 3 topside + 1 in 3 silverside	
1 man blade boned out	
1 man shins + rest of silversides	
13 man team	

APPENDIX 3.

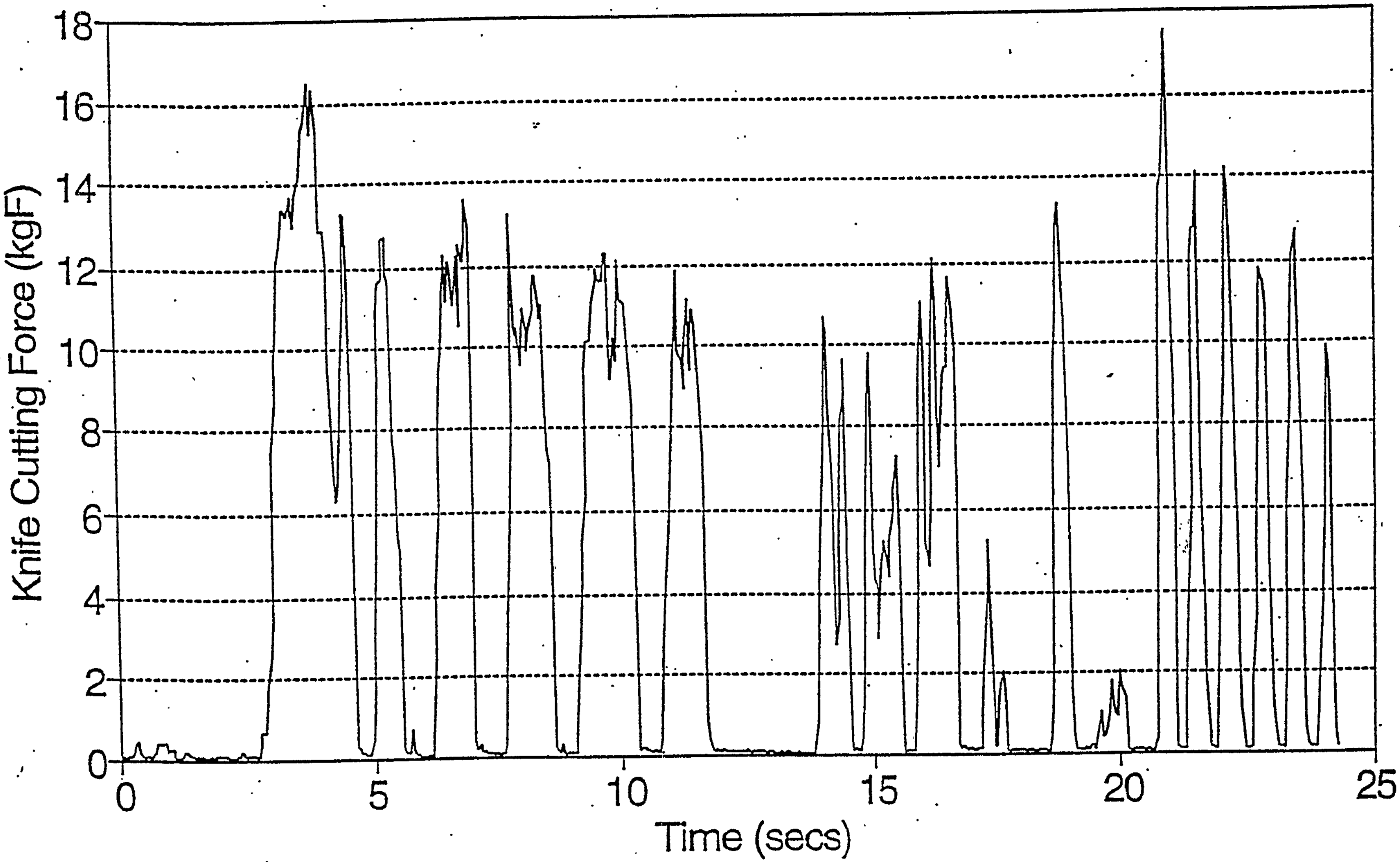
FQ RIB CAGE REMOVAL

PROMAN - TRIAL 7



APPENDIX 4.

FQ RIB CAGE REMOVAL
CONVENTIONAL - TRIAL 20B



APPENDIX 5.