AQIS Notice Meat: 99/17 **NFS: 29**

Title: 1. Animal welfare explanatory notes,
2. Standard operating procedure - Animal care - Penetrating captive bolt stunning and sticking of cattle, and
3. Literature Review "Penetrating Captive bolt stunning and exsanguination"

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CO File No:

* Central & Regional Office	Last Notice 99/3	*Managers, Export Meat Establishments	Last Notice
*OIC Inspection Staff Meat Establishments	Last Notice	*Licensed Meat Exporters	Last Notice
*Meat Inspection Staff	Last Notice 99/3	* Managers, Export Slaughtering Establishments	Last Notice 99/3
* Managers, AQA Establishments	Last Notice	* Export Meat Industry Organisations	Last Notice
* State/Territory Departments Responsible for Agriculture	Last Notice	* AUS-MEAT	Last Notice

PURPOSE

The purpose of this notice is to

1. rescind AQIS Meat Notice 99/3 and provide AQIS On-Plant Veterinary Officers updated explanatory notes to underpin the current Operational Guidelines for the Welfare of Animals at Abattoirs and Slaughterhouses;
2. provide a copy of an agreed Standard Operating Procedure for the use of the penetrating captive bolt on plant and
3. provide a scientific literature review to support the Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle.

BACKGROUND

The guidelines are produced to assist in the management of the stun to sticking procedure and give general guidance on AQIS expectations with respect to animal handling at the abattoirs.

The guidelines follow AQIS Meat Notice 95/35, which required the development and implementation of Animal Care Statements by management. There has been a subsquent requirement in AQIS Meat Notice 98/27 that MSQA's will be required to have Animal Care Statement's incorported as Standard Operating Procedures before they can be approved.

AQIS Meat Notice 99/3 provided explanatory notes to slaughter establishments to facilitate the interpretation of the guidelines, give guidance on AQIS's expectation with regard to animal handling and welfare, and to remind on-plant staff on how the reporting mechanism should work for animal welfare incidences identified on plant.

A recent meeting between AQIS, scientific experts in animal welfare, industry and the Meat and Livestock Australia, discussed issues which have arisen out of AQIS Meat Notice 99/3.

SCOPE

Based on advice from the scientific expertise available at the Stun-to-Stick Working Group meeting AQIS has resinded AQIS Meat Notice 99/3 and issued this AQIS Meat Notice in its place, to

1. update the animal welfare explanatory notes (Attachment 1);
2. require the up-grading of the animal care standard operating procedures, particularly for the use of a penetrating captive bolt stunning and sticking in cattle based on the generic Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle(Attachment 2);
3. provide a copy of the literature review "Penetrating Captive Bolt Stunning and Exsanguination" (Attachment 3) being the scientific basis for the Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle.

PROCEDURES

The OPVO should read the explanatory notes and then reassess the animal welfare compliance of the operation at the registered establishment

- where discrepancies are identified the OPVO should discuss these with their Area Technical Manager
- general operational issues that need referring to Central Office should be referred through the ATM
- incident reporting should follow the approach detailed in the explanatory notes.

The QA Manager on plants where the use of a penetrating captive bolt stunner occurs should assess their operation with the SOP attached to this notice, 'Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle'

- where there are deficiencies, the deficiencies will need to be addressed
- timeframes should be negotiated with the OPVO and should not exceed one month from the date of issue of this notice.

RESPONSIBILITIES

INDUSTRY:

- Incorporate GMP into the stunning and sticking procedures based on times provided in the Operational Guidelines for the Welfare of Animals at Abattoirs and Slaughterhouses and the explanatory notes. Times have been based on references in the scientific literature and a list of references is provided. The list of references is not comprehensive.

- Where there is the use of a penetrating captive bolt stunner the company will prepare a specific standard operating procedure for this operation. Work instructions will be amended to align with the SOP, and documentation maintained as required. Appropriate corrective actions will need to be developed and documented, to ensure animal welfare does not become an issue during operational periods.

- QA teams will undertake appropriate monitoring to ensure the operators have welfare under control, and maintain documentary evidence of control. Additional monitoring required under the penetrating captive bolt stunning SOP, such as accuracy of placement of the bolt, can be incorporated as part of the Meat Hygiene Assessment program.

AQIS:

- Provide on-plant staff with the opportunity to more accurately assess the industry systems to see they comply with GMP and identify some critical limits that should not be exceeded by operators. Such limits should be incorported into the SOP's and monitored by the company.

- Where there is the use of a penetrating captive bolt stunners the OPVO will need to ensure that the SOP procedure is implemented and operating effectively. The OPVO will need to implement monitoring procedures to assess the effectiveness of the company's control over the SOP. It is expected that the monitoring would be part of the check the checker role and covered under the NPMS. Where the SOP is not operating effectively the OPVO may apply sanctions to ensure the welfare of the animals at stunning is maintained. Such sanctions may include the application of a stun-to-stick interval based on good manufacturing practice.

REFERENCES

Animal Welfare Explanatory Notes
AQIS Meat Notice 95/35
AQIS Meat Notice 98/27
Operational Guidelines for the Welfare of Animals at Abattoirs and Slaughterhouses
Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle.

Brian Macdonald
Director
Meat Inspection Division

ATTACHMENT 1

ANIMAL WELFARE EXPLANATORY NOTES FOR AQIS ATM'S AND ON -PLANT VETERINARY STAFF

Animal welfare is a veterinary responsibility, which is clearly defined in the Export Meat Orders. These explanatory notes endeavour to provide the veterinary professional in the public health arena with improved background knowledge in this discipline, and to support interpretation of the 'Operational Guidelines for the Welfare of Animals at Abattoirs and Slaughterhouses'.

GENERAL PRINCIPLES:

The principles of animal welfare at the abattoir is to ensure

1. live animals have basic freedoms of access to feed, water and movement prior to slaughter;
2. the animal is not stressed unduly prior to stunning;
3. stunning is swift and effective;
4. the stun to stick interval is as short as possible; and
5. dressing does not commence until primary bleeding has effectively finished.

Additionally, the on-plant veterinary officer should ensure the animals arrive in a condition, which assures public health and the animals welfare. This should be monitoring animals at arrival and should be noted on the relevant NPMS Form under Activity 2 – Animal Handling / Animal Welfare.

Animals with gross pathological conditions presented for slaughter by the farmer may be placing the animal's welfare at risk. Farmers who persistently compromise the welfare of animals should be reported using the incident reporting process. To facilitate this process the OPVO should capture relevant tail tag data from such animals in an Excel file. Information that would need to be captured includes tail tag, date, sale yard and transporter.

Examples of compromising an animals welfare is by sending severe cases, to the abattoir, of the following

1. cancer eye in cattle,
2. animals with broken legs,
3. prolapsed uterus in sows,
4. black mastitis in cows and
5. actinomycosis which has become gross and restrictive in cattle..

It should be noted that some of these cases may be treated as emergency kill at the abattoir (OPVO should again familiarise themselves with the relevant part of the EMO's which refers to the "Emergency Kill".)

As a guide it should be noted that an animal's welfare could be considered compromised where a limb is broken or the animal has a gross pathological condition associated with a poor body score. Such animals are candidates for the emergency kill.

INCIDENT REPORTING:

Wherever there is observed non-compliance regarding animal welfare at the abattoir the veterinary officer on-plant is obliged to undertake the following (a)

1. notify the plants ATM and direct management to make immediate provision for the animals welfare – if management is unable to comply, take appropriate sanctions to ensure animals welfare is maintained
2. collect evidence and take photographs if possible
3. prepare a compliance incident report,
4. provide a copy of the report to the
    - company,
    - relevant State Authority (you may wish to make phone contact first), and
    - MID Operations-AQIS, Canberra.

The OPVO could be called as an expert witness in any civil or AQIS instigated legal proceedings, which might follow a report. Therefore the report must contain accurate information about the following

- details of the incident,
- the name of the driver/person involved,
- the name of the transport company involved/tailtag or brand details/sale yard,
- dates and times.

Where the incident is reported the ATM will pass the information to the relevant State Authority for further action if this has not already been done by OPVO.

ANIMAL HANDLING FROM TRANSPORT TO POINT OF STUNNING:

The discipline of animal behaviour when handling livestock must be considered an important part of training for livestock personnel at the abattoir.

Animals will balk at changes in light, changes in texture of ground, slopes, narrow openings and new object within their line of sight (b). When **forced,** using dogs or inexperienced handlers, through yards animals will balk, therefore allowing the animals to **look, see** and then **move**, will result in relatively rapid movement of livestock . This area is where many animal welfare problems can arise due to poor yard design.

Many yards were not designed to allow free movement of stock into the stunning race, however closer attention to these details in re-design of yards will allow personnel the opportunity to move stock easily, quickly and with minimum stress to animals and handlers alike. Well-designed yards will save time and money.

- Unloading from the Transport Vehicle

This is an area of legislative responsibility covered by both State and Commonwealth law. The transport industry's peak body, the Australian Livestock Transporters Association (ALTA) has developed a package for its members, which incorporates the requirements for good animal handling practice.

The package has been named 'Truck Care' and individual copies of the package have been provided to each export abattoir's management. The aim is to encourage management of the registered establishment to promote the package to all transport operators at the abattoir gate.

The export meat industry through its peak bodies of Export Meat Industry Advisory Council (EMIAC) and the Meat and Livestock Australia (MLA) has clearly indicated that transporters caught mis-handling animals will not be contracted to collect animals for slaughter by the abattoir.

The AQIS OPVO should ensure the welfare of all animals on the registered establishment, by random assessment of all livestock handlers' capabilities at a frequency identified in the NPMS. Assessment of transporters will not be possible in most cases due to many deliveries occurring at night. Assessment of transport operators should be undertaken, when time permits, during daytime stock deliveries.

- Removal of Downer Stock from Vehicles

    . downer or moribund small stock should be destroyed prior to removal from a transport vehicle unless removal can be undertaken humanely and with empathy,

    . live animals dragged by the ears or wool, dropped from the back end of the truck or over the side rails constitute an animal welfare problem which needs immediate action and shall be reported.

. downer or moribund large stock, including pigs, will be destroyed prior to removal from a vehicle, unless the animal can be placed onto a cradle to support its removal alive.

. due to new gun licensing laws tranporters do not carry firearms in the truck. As a result, after hours contact details must be provided by abattoirs, for transporters, to facilitate the rapid destruction of downer or moribund animals on the truck. Such contact details must be in clear view to all livestock operators at the off-loading point.

- Use of Dogs and Electric Goads

. use of dogs should be banned in lairages particularly for pigs, calves and cattle. Dogs may be useful for working sheep, and possibly goats, in the lairage but at all times these animals should be muzzled. Numbers of dogs used in the lairage should also be limited.

Dogs may be useful to work cattle and sheep in holding paddocks which ajoin the yards of the abattoir.

All dogs working stock will need to be muzzled.

. use of electric goads should be minimised. There use may be permitted to move large stubborn animals into a knocking box. Goads which are considered acceptable are the commercial hand held units generally purchased through stock agents. Excessive use of the goad or application of the goad to areas such as the vulva, testes, eye, ear or head should not be tolerated.

- Time Off Feed Prior to Transport and Slaughter

. The pig industry has recently developed a standard, which states that pigs should be off feed a minimum of 6 hours prior to transport for the following reasons(c)
  - to ensure high quality of meat produced
  - reduced feed wastage on farm
  - reduce GIT contamination due to vomiting.

. Recent research work has also identified the slaughter of pigs within 24 hours of having had feed removed, will reduce the likelihood of contamination of the carcase with pathogenic organisms (d).

. AQIS is aware of similar work that has been conducted by other meat industries in this area. *This information is currently being sourced and will be provided in the future. It should be Noted that Cattle Care recommends a period of 6 hours off feed prior to loading for transport.*

STUNNING:

Stunning is the process where an animal is rendered **insensible to the perception of pain.**

Stunning is defined as reversible and irreversible.

Reversible stunning is considered to be 'that stunning where the animal can recover' and has been accepted as mushroom head stunning and head-only electrical stunning. It is not recommended that proof of reversibility of a stun is pursued at the abattoir.

Irreversible stunning is considered to be penetrating captive bolt, CO2 gas stunning and head-to-back electrical stunning. Head-to-back electrical stunning is the only truly irreversible stun due to the fibrillation of the heart at the same time as the brain is electrically interrupted or discharged. Most of the time a penetrating captive bolt will result in a complete irreversible stun where well-maintained equipment is used, the critical speed of the bolt is achieved and there is accurate placement of the pistol. However, if these factors are not achieved it cannot be considered 100% effective, even with head restraint (e). With this in mind AQIS, industry and a group of scientific experts have prepared a standard operating procedure Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle for the use of penetrating captive bolts to ensure that any potential animal welfare issue is identified early, and aleviated immediately. The Model SOP 'Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle' could be adapted for use with other methods of stunning.

- Aim of the Different Types of Stunning

1. penetrating captive-bolt
   . the bolt should pass between the two cerebral hemispheres and hit the region above the hypocampus resulting in massive electrical disruption of all areas of the brain (the hypocampus is the point of crossover for the nerve fibres of both hemispheres before the nerves exit through the brain stem)
   . the captive bolt will have a concave piercing end which accumulates tissue as it passes into the cranial cavity resulting in a percussive wave within the brain tissue increasing the disruption to normal nervous impulses, and resulting in a shearing effect on the axons causing physical damage to the cells.
   . a captive bolt should not be applied to the poll region in stock due to its reduced effectiveness.

2. mushroom-head captive bolt
   . this stun will rapidly accelerate and decelerate the brain in the cranial cavity with the effect of causing massive stimulation and firing of neurones. Often associated with this is general sub-dural haemorrhage.

3. electrical head only
   . correct placement of the electrodes will result in the passage of an electrical wave from one side of the brain to the other, again resulting in massive neurone stimulation.
   . this stun will induce an epileptiform seizure with loss of cognition and generalised disassociation with surroundings lasting up to 45 seconds in duration.

4. electrical head to back
   . the stun will result firstly in an epileptiform seizure and secondly fibrillation of the heart
   . the net effect is the loss of heart functionality, general blood stasis and reduced oxygen supply to the brain.

5. CO2 stunning
   . this stunning method is currently only suitable for pigs
   . concentration of the CO2 for effective stunning should be a minimum of **60%** and aim to maintain 80%

- Problems with the Different Types of Stunning

  Problems to lookout for and ensure are corrected are the following in

  1. captive-bolt and mushroom-head stunners
     - poor maintenance of equipment
     - inexperienced operator
     - incorrect charge for the type (head/bone structure) of animal
     - poor placement
  2. electrical head only and electrical head to back stunners
     - inexperienced operator
     - incorrect electrical settings
     - sharpening the tips of the electrodes on pig head to back stunners
     - incorrect placement of the electrodes
     - the test light should not operate when there is no contact with the skin, that is, when the circuit is not complete.
  3. CO2 stunning
     - incorrect concentration of CO2
     - too many pigs in the cage
     - no staged entry into the gas chamber

- Placement of Penetrating Bolt and Mushroom Head Stunners

  Refer to the guidelines (‘Operational Guidelines for the Welfare of Animals at Abattoirs and Slaughterhouses’) for the pictorial reference point for correct placement of the stunner. This placement must be

accurate. Misplacement must be considered as resulting in an ineffective stun.

- Placement of Electrodes

1. electrical head only
   - the electrodes shall be placed on, and span at least part of the dorsal cranium just behind the ears and in front of the first cervical vertebra
   - incorrect placement is on cervical vertebra 1, 2 or 3, as this causes curarization with little or no effect on the brain, but does result in complete paralysis of the body. The net effect is an animal able to perceive pain and external stimuli.
   - filed tips of the electrodes which penetrate the skin and enter the subcutaneous fat in pigs can result in an ineffective stun
   - fat is an insulator to electricity and the effect of the electrodes penetrating the subcutaneous fat will be an ineffective stun due to reduced electrical current to the brain.
2. electrical head to back
   - the electrodes shall be placed on the cranium - poor placement of the head electrode means the back electrode will cause fibrillation of the heart without insensibility - the animal will be sensible to the perception of a potentially painful stimulus such as cardiac fibrillation.

- Essentials of Electrical Stunning Equipment

1. electrical stunning equipment should have a light which can be easily observed by the operator. The light should be attached to a timing mechanism, which ensures the correct current for the appropriate length of time, is applied to the animal. This light should be illuminated during the application of the stun and should stop illuminating when the correct current and voltage have been applied for the correct time.
2. if an incomplete or ineffective electrical stun occurs the light should not operate
   - under such circumstances the animal should be allowed to recover prior to re-stunning. Recovery is recommended to allow the neurones to repolarise, hence ensuring the next stun is effective.
   - before the next stun the equipment should be replaced with effectively operating electrical equipment.
3. Where electrical stunning is used, recording devices/gauges must be in clear view of the operator.

- Electrical Parameters for an Effective Stun

Electrical parameters considered to be minimum guidelines are
. sheep - 1 Amp for 4 seconds at 80 to 200 volts

(0.6 Amps for kids and lambs) (h)

. cattle - 2.5 Amps for 4 secs at 400 volts (f)
. calves - 1.0 Amp for 4 secs at 400 volts (j)
. deer (Dama dama) - 1.0-1.3 Amp for 4 secs at 400 volts (g)
. pigs - 1.25 Amp for 1 sec at 80 to 280 volts (h)
. poultry - 120 to 150 mAmps (h)

- Time to Return to Sensibility after an effective stun using a

1. captive-bolt
   . for all animals - correct frontal application should be indefinite
2. mushroom-head
   . cattle - any time up to 5 minutes
3. electrical head only
   . sheep - 45 seconds (i)
   . deer - 60 seconds (g)
   . cattle - 60 seconds (j)
   . pigs - unknown (*believed to be 45 seconds*)
4. electrical head to back
   . if applied properly in all animals, sensibility should not be an issue.
5. CO2 gas stunning
   . considered to be indefinite if concentration is above 60 percent CO2 concentration.

- How to Recognise an Effective Stun

All the signs identified below would confidently suggest an effective stun, however the two marked with an asterisk should indicate the stun was effective

1. captive-bolt and mushroom-head
   . the animal drops immediately and stays down*
   . uncoordinated hind leg movements - kicking
   . no corneal (‘blink’) reflexes*
   . cessation of rhythmic breathing
   . no vocalisation
   . no rotation of the eye ball
   . no co-ordinated attempts to rise
2. electrical head only and electrical head to back
   . immediate epileptiform seizure with all limbs extended*
   . eyelids are clamped shut*
   . after the electrical stimuli is removed there is relaxation
   . animals are recumbent with little or no paddling

It is important to note the presence of a tonic and clonic phase of the seizure in the sequence described for electrical stunning, can be taken as a sign that the animal has been effectively stunned. There is no point in trying to assess the corneal or other

reflexes during these phases as the animal is convulsing and no meaningful result will be obtained.

In stunning, particularly of cattle, the design of the knocking box and dry-landing areas are important. There are currently available commercially cradles which allow the animal to cast after release from the knocking box post-stunning. Such cradles allow safe access by the operator to both front and back of the animal and will position an animal favourably for Halal incision.

AQIS recommends that head restraint in the knocking box will be valuable in ensuring a high degree of effectiveness of captive bolt stuns. This will allow for a more accurate application of the stun equipment.

STUN - STICK INTERVAL:

The stun to stick interval is a crucial animal welfare parameter that is aimed to be as short as practical, particularly where the stun is reversible. The operational guidelines clearly identify most of these intervals for the different species and this document should be continually referred too.

The operational guidelines intentionally do not provide a stun to stick interval for use of a captive bolt. The aim of the captive bolt is to produce insensibility, which is irreversible in 100% of the bolt's applications (e). Research indicates that this will be the situation if there is correct placement of the bolt, correct velocity and diameter of the bolt.

As a result of this research, considering other scientific studies and after consultation with animal welfare scientific experts and industry, the stun to stick interval for a captive bolt stun will not be mandated. It will be essential that all registered establishments operating captive-bolt stunners implement the Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle recommended by AQIS, Food Science Australia, Meat and Livestock Australia and the industry bodies.

STICKING:

Sticking is the procedure that initiates **primary bleeding** hastening the onset of **irreversible insensibility** of the animal and reducing the perception of pain.

Sticking should be conducted without undue delay and should result in the bilateral severance of jugular veins and carotid arteries. The term 'Stick' is defined at Order 188A of the Export Meat Orders. This does not refer to thoracic severance of the aorta as 'the only stick'. The stick is defined as the commencement of primary bleeding and includes the **HALAL** cut. The thoracic stick is the preferred method of sticking and should follow a religious transverse cut due to the potential for the occlusion of the cut

peripheral arteries (e.g the carotids) by clotting or constriction of the cut end, which can delay bleeding and the onset of insensibility.

Anatomical differences in the blood supply to the brain will result in various times between and within species to reach a point of irreversible insensibility to the perception of pain after the stick is performed.

These times are based on one of two lines of theory developed from the scientific research.

The first theory is

. the loss of the visually evoked light response is the point of irreversible insensibility.

The second theory is

. the point of an iso-electric EEG (less than 10 μv) signifies the point of irreversible insensibility.

AQIS in general will apply the iso-electric EEG results (this generally provides a longer time from stick to an iso-electric trace and therefore assures the welfare of the animal), however where this research has not been conducted in a species the visually evoked light response results will apply (these results will be marked with an asterisks).

It should be noted that consideration must be given to biological and physiological variation within a species and as a result the longer time period will be advised to give confidence that individual variance to the normal in a population are considered.

Guidelines on the Time (in Seconds) to Reach Irreversible Insensibility from Point of Sticking, for reversible stunning

.	sheep	8-10 sec(k)
.	cattle	30 sec(f)
.	deer	20 sec(l)
.	pigs	45 sec
.	calves	73 sec(j)

OPVO’s should note that these times are to be used in conjunction with the times identified for an effective stun in the Stunning Section. It is important that the stun to stick interval is as short as possible for reversibly stunned animals. The example provided below is a guide to assessing the effectiveness of the stunning process and the time indicated, in this example, for stun to stick would be considered a baseline and therefore poor manufacturing practice. In sheep,

an effective stun lasts for a maximum of 45 seconds.

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0 **45 secs**

Time to reach irreversible insensibility is 10 seconds after the stick.

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0 **10 secs**

Therefore, the Stick must occur within the first 35 seconds after an effective stun.

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Stick

What is described in this example is the upper critical limit for a stun to stick interval in sheep that have been reversibly stunned and times longer than the upper limit are an animal welfare issue which requires immediate attention.

No dressing procedure, shall occur until after sticking has been performed and the required time period to meet irreversible insensibility, indicated above, has been met for reversibly stunned animals.

AQIS on-plant staff should be ensuring that the stun to stick interval meets those intervals prescribed in the 'Operational Guidelines for the Welfare of Animals at Abattoirs and Slaughterhouses', in the overwhelming majority of stuns during processing. Manufacturers who are unable to achieve the prescribed limit should re-assess their operation and make appropriate changes to meet these limits which are considered GMP.

OTHER POINTS FOR CONSIDERATION:

- Electro-immobilization after reversible stunning and prior to sticking is not acceptable

  This practice is not acceptable where an animal has been reversibly stunned and does not comply with the NCCAW position on electro-immobilization (m). The practice allows for the perpetuation of poor stunning practices through masking deficiencies in the area of effective stunning technique.

  AQIS will only accept the practice in the following situations where

1. a captive penetrating bolt stun has been used effectively on cattle as determined by the Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle,
2. reversible electrical stunning is used provided the animal has reached irreversible insensibility after sticking as determined by the guidelines identified on page 10 of these notes.

- Oesophageal Occlusion

This practice is acceptable between sticking and stunning, as a surgical procedure using an incision, which does not exceed 15 cm length (n). Incisions that are a basic work-up procedure prior to rodding will not be accepted as they increase substantially the time between **Stunning** and **Sticking**.

If this procedure is unable to be conducted using an incision approximately 15 cm long then an alternative method should be used as recommended in AQIS Meat Notice 98/3.

The practice of rodding between stunning and sticking has been assessed, after recent scientific consideration to have no animal welfare implications provided the Standard Operating Procedure – Animal Care – Penetrating Captive Bolt Stunning and Sticking of Cattle is in place and operating effectively.

- Calves and Halal Sticking

Calves have a prolonged bleeding time due to the presence of the recurrent vertebral arteries. This bleed out time can reach as long as 200 seconds if the sticking cut is not performed properly. The effect of the electrical stun is assumed to last for approximately 60 seconds (j).

A second electrical stun may be applied where the cut is considered not to be effective.

A thoracic stick immediately after the halal stick is desirable.

- Mushroom Head Stunning and Halal Status

An issue which has the potential to cause problems for on-plant AQIS staff is the cavitation of the cranium by the use of high charges in the mushroom head captive bolt. Determination of what is Halal and what is non-Halal is an issue between the company and the Halal slaughterman.

AQIS has the responsibility to ensure the Halal program is operated as documented by the company. The OPVO should ensure that a non-halal status carcase is separated throughout the processing line and this procedure is consistent with the companies approved program.

REFERENCES:

a) AQIS Meat Notice 87/7
b) Temple G, 1998, "Good Management Practices for Animal Handling and Stunning." Published by American Meat Institute Foundation.
c) Reiser D. and Myler S, "Meat Quality Blueprint to Minimise the Incidence of PSE in Pigs - Case Study Example." prepared for PRDC.
d) Pointons, Coates, Barton, Widders, Chappel, Hathaway, Cecil, 1995 "HACCP Generic Model for Pathogens and Spoilage Organisms in Pre-slaughter Pig Production" Form 9a, point 6c.
e) Finnie J.W, 1993, "Brain Damage Caused by a Captive Bolt Pistol." J. Comp.Path, Vol 109, 253 - 258.
f) Devine C.E, Tavener A, Gilbert K.V. and Day A.M, 1986, "Electroencephalographic studies of adult cattle associated with electrical stunning, throat cutting and carcase electro-immobilization." NZ Vet J, Vol 34, 210 - 213.
g) Blackmore D.K, Cook C.J, Devine C.E, Gilbert K.V, and Jacobson L.H, 1994, "Electrical Head Only Stunning of Fallow Deer (Dama Dama)" NZ Vet J. Vol 42, 38 - 39.
h) Gregory,N. 1996 "Farm Animal Research benefiting Animals" Proceedings of ANZCCART Conference, Wellington New Zealand, August 1995,24 - 34.
i) Newhook, J.C and Blackmore, D.K., 1982c, Electorencaphalographic Studies of Stunning and Slaughter of Sheep and Calves: Part 3 - The Duration of Insensibility induced by Electrical Stunning in Sheep and Calves" Meat Science, 7, pp 19 - 28.
j) Devine C.E, Tavener A, Graafhuis A.E. and Gilbert K.V., 1987, "Electroencephalographic studies of calves associated with electrical stunning, throat cutting and carcase electro-immobilization." NZ Vet J, Vol 35, 107 - 112.
k) Tidswell S.J., Blackmore D.K. and Newhook J, 1986, " Slaughter Methods: electroencephalographic (EEG) studies on spinal cord section, decapitation and gross trauma to the brain in lambs." NZ Vet J, Vol 35, 46 - 49.
l) Cook C.J, Gilbert K.V, Devine C.E, Dean J.M and Hogg B, 1994, " Minimum duration of effective head-only electrical stunning of fallow deer (Dama dama) and time to loss of consciousness following a throat-cut." NZ Vet J, 42, 156-157.
m) National Consultative Committee on Animal Welfare, Position Statement No. 20, "Electro-immobilization of Animals", NCCAW 14, September 1994.
n) AQIS Meat Notice 95/3.

OTHER REFERENCES:

Model Code of Practice for the Welfare of Animals - Land Transport of Pigs SCARM Report 63

Model Code of Practice for the Welfare of Animals - Land Transport of Poultry
SCARM Report 65

Model Code of Practice for the Welfare of Animals - Land Transport of Horses
SCARM Report 62

Model Code of Practice for the Welfare of Animals - Air Transport of Livestock
AQIS 1986

Model Code of Practice for the Welfare of Animals - Rail Transport of Livestock
Australian Bureau of Animal Health 1983

Model Code of Practice for the Welfare of Animals - Sea Transport of Livestock
Australian Agricultural Council, July 1988, Resolution 11.

Model Code of Practice for the Welfare of Animals - Road Transport of Livestock
Australian Bureau of Animal Health 1983

Model Code of Practice for the Welfare of Animals - Livestock (including Poultry) at Slaughtering Establishments (Abattoirs, Slaughter-houses and Knackeries) Draft January 1998

Attachment 2

PURPOSE

- The purpose of this procedure is to establish and implement uniform practices for the humane slaughter of cattle to ensure that their welfare is not compromised and that they do not experience pain or undergo suffering.

- This procedure forms part of an overall approach to the handling of animals and should be referenced in the SOP 'Animal Care - Livestock Handling'.

- The document aims to reinforce the understanding that there are 3 factors involved in humane slaughter. These are:

(i) animal factors;
(ii) facilities and equipment;
(iii) human factors.

2. SCOPE

- These procedures apply to all cattle being processed through the abattoir (with the exception of approved religious slaughter).

3. DEFINITIONS

- Cattle - bovine animals
- Competent - an operator who has undertaken a training course in stunning and slaughter of livestock delivered by a senior person recognised as having the necessary qualifications and experience. The operative has been assessed as having the required knowledge and practical skills and his/her performance is reassessed periodically by a supervisor to ensure a high level is maintained.
- Humane – characterised by compassion.
- Insensibility - unaware of the environment and unable to perceive pain
- Sticking - severance of the brachio-cepahlic trunk and other major vessels in the vicinity of the heart
- Stunning – a procedure which instantaneously renders the animal insensible to the perception of pain.

4. BACKGROUND

- Society rightly demands that animals be handled humanely and that they do not experience pain or undergo suffering. Furthermore, inappropriate handling of animals may jeopardise product quality and consistency. Inappropriate slaughter methods may mean that the product will not be accepted by some markets.

5. REFERENCES

- Operational Guidelines for the Welfare of Animals at Abattoirs and Slaughterhouses 2 edition 1995
- AQIS Meat Notice 95/35 Animal Care Statement
- AQIS Meat Notice 98/27 Animal Care Statement as SOP
- Export Meat Manual Volume 3 Animal Welfare
- Meat Technology Update 99/2

6. METHODOLOGY

(i) Stunning

- Cattle will be handled up to the stunning restraint position (restrainer or knocking box) in accordance with the procedures detailed in SOP 'Animal Care - Livestock Handling'.
- The use of electric goads in the restrainer/knocking box is restricted to those circumstances when it is necessary to facilitate the delivery of a quick and effective stun
- The animal must be adequately restrained and the restrainer/knocking box must not cause undue stress to the animal.
- Only penetrating captive bolt stunners will be used.
- All operators using these stunners must be suitably trained and skilled in the correct stunning techniques to ensure all animals are immediately brought to a state of insensibility which lasts up to death following sticking.

- Operators must follow the pistol manufacturer's/approved supplier's recommendations in selecting the gun and cartridge size that are appropriate for the type of animal that is due to be stunned.
- Only approved operators who have been assessed competent will stun animals, except in the case of an emergency when any competent person may stun the animal.
- Operators will ensure that the captive bolt stunner is operating correctly. The operator must check to ensure that the captive bolt retracts to its fully primed position after each shot (before 'resetting') and if it does not, exchange it for another implement and not use it again until it is adequately cleaned or repaired.
- Operators will ensure that the captive bolt stunner is applied to the correct position on the head of the animal as indicated on the diagrams in the references.
- Operators must be able to recognise when an animal has not been correctly stunned and, in these cases, re-stun the animal immediately.
- Operators must ensure that replacement guns are in position ready for use in case of mechanical failure.
- Operators must minimise the time the animal is in the restrainer/knocking box and the number of animals from the restrainer to the bleeding station. Animals must not remain in the restrainer/knocking box during breaks or stoppages.

(ii) Stunning effectiveness

- All stunning operators must be familiar with the signs of an effective stun which are:

  a) Immediate collapse
  b) Muscles of back and legs go into spasm
  c) Uncoordinated hind leg movements - kicking
  d) No coordinated attempts to rise
  e) Cessation of rhythmic breathing
  f) No bellowing
  g) No rotation of eyeballs
  h) Glazed 'glassy' appearance of eyes
  i) Absence of corneal ('blink') eye reflex.

- Any animal that does not immediately show the signs of an effective stun must be immediately restunned.

(iii) Maintenance of insensibility

- All operators working between the stunning and sticking locations (including the stunner and the sticker) must be trained to recognise the signs of possible recovery of brain function:
  a) Rhythmic breathing (but not 'gasps')
  b) Righting reflex - turning its head and neck while suspended
  c) Corneal ('blink') eye reflex.

- The presence of any of these signs will initiate an immediate restunning of the animal and the foreman and/or QA officer will be notified.

- An immobile tongue hanging out of the mouth is a valuable sign of insensibility but is not a requirement for the diagnosis of insensibility

(iv) Sticking

- The operator (s) responsible for sticking shall, before making any incision, test the corneal reflex of one eye of each animal by touching the surface of the eye with the finger.
- Any sign of a 'blink' indicates that the animal is regaining brain function and it shall be immediately restunned using a captive bolt pistol which is immediately at hand. The foreman and/or QA officer will be notified.
- In the event of a delay, all stunned carcases will either be observed continuously for signs of possible recovery of brain function, or be bled without waiting for them to reach the sticking station.

(v) Routine maintenance of implements

- Each captive bolt stunner will be individually identified.
- Stunners which fail during the shift are returned to the maintenance area and presented to the authorised person for repairs. Such instruments will not be reused until they are repaired.
- Back-up or reserve stunners are issued daily in case of mechanical failures.
- A maintenance log book is maintained by the approved maintenance person to indicate which stunners have been issued on each shift, who they have been issued to, that they have been stripped and cleaned daily and been repaired where necessary.
- Before supplying, or returning, a stunner for use, the approved maintenance person shall satisfy himself that it is in working order (preferably by using a velocity meter).
- Only approved personnel who have been assessed as competent animal stunners are issued with captive bolt instruments.

7. MONITORING

(i) Stun-sticking locations

- The stunner operator will observe every animal after stunning for the signs of an effective stun (except that he may not be required to check the corneal reflex) and will re-stun immediately if doubt exists

- The stunner operator will check, after each stunning, that the captive bolt retracts to its fully primed position before 'resetting' and if it does not, exchange it for another implement and not use it again until it is repaired or cleaned.
- The stunner operator, or an alternative operator located adjacent to the knocking box/restrainer, will test the eye for the presence of the corneal reflex.* Any sign of a 'blink' indicates the possibility of an ineffective stun and the animal will be immediately restunned..
- All operators working between the stunner and the sticker will, in addition to their allotted tasks, observe bodies for signs of rhythmic breathing and/or head righting and alert the nearest operator with a captive bolt pistol to this behaviour.
- The operator responsible for sticking shall, before making any incision, touch the animal's eye to check for the corneal reflex. Any sign of a 'blink' indicates the possibility of an ineffective stun and the animal will be immediately restunned. The foreman and/or the QA officer will be notified.
- Senior management will conduct a risk assessment to determine and document which operative (s) will assess the corneal reflex as part of their duties. The risk assessment should take into account such factors as the time delay between stunning and sticking, occupational health and safety and previous performance.

(ii) Quality Assurance Officer Monitoring

- A minimum of 5% of the kill on each shift (or 10 bodies, whichever is the greater) will be monitored and recorded (on the MHA Slaughter Floor Process Monitoring Form) for:
  a) Corneal reflex - to be tested just after stunning and also just before sticking
  b) While shackled - absence of rhythmic respiration and righting reflex
  c) Rate of stunning to be at a level that maintains chain speed but does not allow an excessive accumulation of bodies in stun-stick area.
  d) Accuracy of stunning - examine skulls for bolt entry at correct 'crossover' point.
  e) Number of animals requiring more than 1 shot

- The documentation held by the maintenance section will be checked at least once a week

8. RESPONSIBILITIES

- Approved maintenance person : responsible for the maintenance and testing of captive bolt pistols and maintaining records relating to this
- Stunner operator: effective stunning and checking for effective stunning
- Stunner operator, or an adjacent operator*: testing of corneal reflex on all bodies
- Operators between stunning and bleeding: observation of respiration or righting reflexes
- Bleeder: testing of corneal reflex on all bodies prior to sticking

- Foremen: Responsible for issue of pistols and suitable cartridges- ensure that all persons with access to captive bolt pistols have a current 'Statement of Attendance' after participating in the 'Instructions for Safe Operations - Humane Stunners'
- QA officers - check and record results for a minimum of 5% of all cattle (or 10 bodies whichever is the greater) processed. Check documentation held by the maintenance section.

9. CORRECTIVE ACTION

- If at any time more than 2 consecutive animals require restunning, either due to ineffective initial stuns or apparent regaining of sensibility, all stunning operations with the pistols and cartridges in use shall cease. Replacement pistols alternative cartridges or higher-powered cartridges shall be used. In this situation, or if more than 2 % of a monitoring lot (or 5 animals, whichever is the greater) require more than 1 shot the Foreman (or QA officer) must be advised. The Foreman will determine the cause and take appropriate corrective action. The Foreman's findings and corrective action shall be documented.
- If an examination of the heads or skulls reveals that more than 2% of animals (or 5 animals, whichever is greater) are being stunned in an incorrect location, the Foreman shall draw this fact to the attention of the stunner operator and may remove that person from the position until such time as further training has been provided.
- If stunning inadequacies are due to faulty implements rather than operator error, the Foreman or QA officer shall notify workshop staff and ask to see the documentation relating to cleaning, maintenance and testing of the pistols.

10. DOCUMENTATION

- Statement of Attendance - Instructions for Safe Operations, Humane Stunners
- Recorded Routine - Maintenance of Humane Stunners
- MSQA Slaughter Floor Process Monitoring Forms.

11. VERIFICATION

- The above documents are available for examination by internal and external auditors.
- The internal and external auditors and the plant OPVO will observe all aspects of the stunning and sticking process.

Note: ***This Standard Operating Procedure is to be read in conjunction with the AQIS publication 'Operational Guidelines for the Welfare of Animals at Abattoirs and Slaughterhouses 2nd Edition 1995'***

ATTACHMENT 3

PENETRATING CAPTIVE BOLT STUNNING AND EXSANGUINATION

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SUMMARY

There is no one region in the brain which is a centre for consciousness. However, damage to regions in the brain stem is associated with a rapid onset of complete unconsciousness. This indicates that when concussion causes interference to the brainstem, it is likely to be particularly effective in inducing unconsciousness. There is considerable evidence that the concussion produced by the correct use of a penetrating captive bolt pistol can produce immediate unconsciousness. Although the induction of unconsciousness during concussion can be abrupt, recovery is not invariably so swift. There are situations where recovery is phasic, and only partial, and this can make it difficult to qualify the presence of consciousness or unconsciousness. When concussion is accompanied by the absence of respiration due to interference with the medulla in the brain stem, the concussion is particularly deep. The absence of breathing is a valuable guide to the depth of brain stem disturbance and concussion. A positive corneal reflex following stunning is likely to be providing a warning that the recovery of consciousness is imminent.

The effectiveness of the stun depends on matching the right equipment (gun type and cartridge strength) for a given animal, the accuracy of the shooting position and gun maintenance. These in turn depend to some extent on the skill and judgment of plant staff. Abattoir surveys have indicated that, with appropriate attention to the above factors, it is possible to have close to, or even actually attain, 100% successful stunning with a single shot. Furthermore, there is a very low prevalence (1 in 1000) of recovery following successful stunning.

If an animal is effectively stunned with a penetrating captive bolt pistol, as indicated by the presence of certain signs, and the absence of others, there is little possibility of return of brain function. Appropriate monitoring at all stages between stunning and sticking would ensure that, on those few occasions when brain function was returning, it would be immediately detected and the animal restunned. Under these circumstances, exsanguination (sticking) has no role in terms of animal welfare; its only function is to

relieve the carcass of blood. Thus, with effective initial stunning and appropriate subsequent monitoring, it appears unnecessary to specify a stun-stick interval.

AIMS

(1) To provide an overview of present thinking about the control of consciousness in the brain, and (2) to review current scientific knowledge as to whether penetrating captive bolt stunners applied to the frontal areas of the head reliably cause permanent loss of consciousness. From this review the risk of recovery of consciousness can be assessed, and a strategy for working alongside the EU requirement of stun-to-stick times can be developed.

INTRODUCTION

With the exception of certain forms of religious slaughter, ' humane slaughter' of an animal in an abattoir normally involves:

(i) restraint to prevent injury to employees, and enable the stunning device to be accurately placed on the head and effectively applied;

(ii) stunning to cause instant loss of consciousness; and

(iii) exsanguination (bleeding) resulting in loss of blood supply to the brain and irreversible brain death. If the stunning method causes irreversible loss of consciousness (as a result of severe brain trauma), exsanguination is only needed to relieve the carcass of blood.

Slaughter could only be considered to be inhumane when the animal has a functioning brain capable of perceiving pain or fear-provoking stimuli, i.e. the animal is conscious.

DISCUSSION

Concepts on Concussion and Unconsciousness

To understand the working of the brain during consciousness, it is helpful to consider the three major divisions of the brain:

- Forebrain
- Midbrain
- Brain stem

The cortex of the forebrain can be divided into two functional components, the primary cortex and the association cortex. The primary cortex is the first part of the cortex that receives sensory input from afferent pathways. Responses in the primary cortex occur in

both the anaesthetised and unanaesthetised states. So, a response or activity in the primary cortex does not represent consciousness. The speed of a response is, however, influenced by anaesthesia, and so certain patterns in the activity or response in this part of the brain have been useful experimentally in qualifying consciousness. Responses in the primary cortex are essential for conscious perception; without them conscious perception for the modality, which that part of the cortex serves would not occur. But, the signal in the primary cortex has to be transmitted to other regions of the brain before perception occurs. Perception occurs in the association cortex.

An example of a projection from the primary cortex to an association cortex is the passage of impulses from the occipital (primary visual) cortex to the posterior parietal cortex and the inferior temporal cortex. In the posterior parietal cortex the object in the visual field is recognised as to *where* it is; in the inferior temporal cortex it is recognised as to *what* it is. In the case of the somatomotor association cortex, parts of the association cortex are in the frontal lobes of the brain and they are involved in *planning movements*. They are connected to the somatomotor cortex, which controls muscle activity in the body. The somatomotor cortex is situated on the rostral margin of the central fold (sulcus) facing the somatosensory cortex. Different parts of the somatomotor cortex are responsible for activating different parts of the body.

The circuitry in the brain which serves a wide range of conscious perceptions and behaviour is now well understood (Carlsson, 1994). Part of this understanding has come from clinical reports of damage to specific brain regions. For example, there are instances where the visual association cortex has been damaged, and the subjects have been unable to recognise an object by sight, and yet it could be recognised by feeling it with the hands. Similarly, when the auditory association cortex has been affected, there has been difficulty in perceiving and producing meaningful speech.

The important conclusion from this knowledge is that the association cortex is essential for higher levels of consciousness such as perception, recognition and thinking. The association cortex is not, however, essential for more rudimentary aspects of consciousness such as the ability to be aroused or ability to walk.

Consciousness is not invariably an all-or-none phenomenon. During concussion there can be degrees of disturbance of consciousness, but before these are described, it is worth considering some other features of normal consciousness.

Consciousness encompasses:

- sensory information which provides or allows awareness
- emotions in response to the awareness and to thought

The sensory modalities in consciousness include:

- vision
- hearing
- balance
- touch

- kinaesthesia
- taste
- smell
- pain
- heat
- cold

These sensations along with learned experiences help in producing thoughts and emotions. Some sensations and emotions are *involuntary*, but they are not subconscious (eg. hunger), whereas some complex actions can be involuntary as well as *voluntary*, occurring whilst the subject is either subconscious or conscious. For example, scratching when asleep or awake, teeth grinding or talking in one's sleep. Paradoxes such as these can make diagnosis of consciousness or unconsciousness in certain situations difficult. Physical responses to some types of nociceptive stimuli can occur at both conscious and subconscious levels, and this can add complications when attempting to establish whether a subject or animal is insensible to pain.

Although, in some situations, the interface between consciousness and unconsciousness can be difficult to define, during concussion, consciousness can be quickly switched off and the interface is more distinct. Unconsciousness can be virtually instantaneous when a subject is struck on the head, and recovery can also be abrupt, but it is often associated with absence of memory. This raises the question whether there are key areas in the brain, which can control the switch between consciousness and unconsciousness. To help answer this, we need to examine some experiences in humans when operations were performed on the brain without a general anaesthetic. In the past it was recognised that using a local anaesthetic was an effective and usually the safest method of anaesthesia in intracranial surgery.

During these operations it was found that the whole cortex of one diseased cerebral hemisphere could be removed without disturbance of consciousness (ie. conscious awareness). On the other hand, rapid changes into and out of coma sometimes occurred when regions of the brain stem and third ventricle were manipulated. For example, light pressure against the surface of the medulla was capable of producing unconsciousness (Cairns, 1952). In one case, unconsciousness was produced by needle puncture of the medulla oblongata:-

> "The patient had previously had six uneventful cisternal punctures. The seventh was attempted with her sitting up, but only a few drops of venous blood were obtained. She was therefore placed recumbent on her left side and the needle was reinserted. At the moment when the needle entered the cranium the patient's head gave a sudden short backward movement and she rolled backwards, with the result that the needle which was already deep in the cistern, if not in the medulla oblongata, was driven about 2 or 3 cm deeper. It was immediately withdrawn, and at the same moment the patient cried out, clutched at her side with both hands, and was motionless, with open staring eyes. There was no response to loud calls. She remained thus for 10 to 15 seconds. Then her eyes

began to move, and she leaned slowly forwards and began to rub her right leg, saying in an expressionless voice, “My leg, my leg”.
Then she recovered her normal liveliness and said, “Please repeat the puncture”. Asked what had just been happening to her, she said, “I felt a sudden blow in the right side, my leg feels so strange that it doesn’t belong to me any more”. Tests showed that the right leg was analgesic. In the next half-hour the feeling of strangeness in her leg disappeared. When fully recovered the patient’s account was that the needle was already in and not painful when suddenly she felt a jab and a shock run through the whole of her right side Everything went black before her eyes. It was as if she suddenly saw her whole life rush past her like lightning. Then she lost consciousness. Later she heard her name being called from a long way off, and gradually awoke. She had the feeling that the whole of her right side, and especially her right leg, did not belong to her. (Cisternal puncture:- a needle is inserted through the foramen magnum to the subarachnoid space below the cerebellum and dorsal to the medulla to tap cerebrospinal fluid.).

Puncturing the medulla has not produced unconsciousness in all cases. In some it has produced a sudden sense of dying. Patients have been known to cry out “I am going to die”, but this may have been due to a disturbance of breathing. In other cases where unconsciousness occurred, this effect was said to precede respiratory and circulatory failure or disturbance.

The regions of the brain stem that can provoke immediate unconsciousness when lightly manipulated or damaged include the: lamina terminalis, roof of the third ventricle, thalamus, pons, reticular formation and the medulla. In the case of the thalamus, lesions can be associated with coma, tonic fits, decerebrate rigidity, states resembling petit mal, hypersomnia, and akinetic mutism. Milder interference can produce unconsciousness associated with petit mal fits. Unconsciousness can be readily induced by physical manipulation of the anterior part of the third ventricle.

Usually there is no effect on consciousness from puncturing the frontal lobes of the cerebrum of the brain with a needle, so long as it is not associated with a concussive blow. In addition, massive bilateral ablation of the frontal lobe creates no disturbance of crude consciousness, but it does disturb the will, initiative, foresight and inhibitory powers (Carlsson, 1994). Removal of the whole forebrain which would include the thalamus, would be more catastrophic and would cause unconsciousness in humans. When only the brain stem and thalamus are present the subject can

- Sleep and wake
- Breathe
- Swallow
- Grimace
- Respond to painful stimuli
- React to hunger, loud sounds and crude visual stimuli by movement of the eyes, eyelids and facial muscles

- May be able to taste and smell, to reject unpalatable foods and accept such foods as it likes
- Utter crude sounds, cry and smile
- Show displeasure when hungry and pleasure (in a babyish way) when sung to
- May be able to perform spontaneously crude movements of its limbs.

This is not consciousness as the psychologists consider it. In the case of rats, the effects of decerebration are not so severe as they can

- Right themselves
- Right themselves when dropped from a height
- Move spontaneously and actively
- Walk off the edge of a table if not restrained
- Be aroused from sleep by a noise or by light tactile stimuli
- Show some ability to localise a sound in space
- Eat and drink, but they require prompting
- Groom themselves, to the extent that they keep themselves clean
- React to nociceptive stimuli as if they were painful
- Become poikilothermic.

In many situations there are grades or depths of unconsciousness. There are degrees of recovery of consciousness for which we have no precise terminology that describes the states which lie between coma and full consciousness. Take the following example:

> "On July 16, 1944, a young soldier received a severe wound to the left cerebral hemisphere and cerebellum. On the second day the track of his left parietal wound was cleaned out down to the posterior horn of the left ventricle, and his wound healed without infection. At first he was in a deep coma, and his residual deficiencies only gradually became apparent as his unconsciousness gradually lessened.
> July 17: deeply unconscious and inert, but cried out if interfered with
> July 23: opened his eyes when called by name
> July 26: more alert. He had right hemiparesis and aphasia.
> Aug 5: can now hold short conversations
> Aug 12: speech improving and he proved to be emotionally facile. His visual fields could now be tested and he proved to have complete right side blindness in the brain
> Aug 17: severe sensory loss in his right limbs
> Sep 11: he remembers being hit, but thereafter nothing for at least two weeks and probably more
> Dec 16: he finds that he has difficulty in grasping the meaning of a picture.

Clearly, recovery in this case was protracted, there was no distinct interface between consciousness and unconsciousness, and we have no exact words which describe the gradations in recovery.

There are also gradations in the induction of unconsciousness. Concussion that occurs during boxing contests can be divided into four stages or depths (Parkinson et al. 1978). In stage 1, there is impairment of memory, but motor control and activity are normal. In stage 2, there is impairment of memory and motor activity, and the individual is clumsy, slow and does not show controlled or fully coordinated physical responses. In stage 3, motor activity ceases except for breathing, which may, however, be impaired or somewhat irregular. The subject is unable to stand. In stage 4, the medulla is affected and breathing ceases. The medical attendant at a boxing match is particularly watchful for stage 4 concussion, as this is potentially lethal if respiration cannot be reinstated.

Respiratory arrest is a useful criterion of brain stem impairment and unconsciousness during concussion. However, if the subject or animal is breathing this does not necessarily signify that it is conscious. Absence of a corneal reflex can also be used in assessing the depth of concussion. If the reflex is absent, it can be concluded that the pathway leading to the optic chiasma and brain stem and back to the eye through the effector pathway, has been affected. It is usually assumed that this is due to disruption of function in the brain, but it could in some circumstances be due to concussion of the optic nerve. Theoretically, optic nerve impairment following concussion could occur in two ways:

Neurapraxia – failure of function without structural damage, for example by concussion of the nerve within the foramen of the orbit

Axontomesis – failure associated with damage to the nerve fibres from compression of the optic nerve. This could be due to compression by a haemorrhage that has leaked into the optic nerve sheath from the ophthalmic artery, or from oedema impinging on the nerve (Karnik et al., 1981).

There is no simple way of distinguishing between optic nerve concussion or compression and disruption of the neural pathway within the brain.

Respiratory arrest is the most immediate life-threatening consequence of brain injury. In the longer term, a raised intracranial pressure is also very serious for the survival of the subject. This occurs when there is haemorrhage or oedema following the insult. If intracranial pressure exceeds the localised or generalised arterial pressure of the blood in the brain, there is a risk of arterial compression or collapse, hypoxaemia and permanent brain damage. In non-comatose humans, raised intracranial pressure is often associated with reduced systemic blood pressure which could make the likelihood of arterial collapse in the brain greater (Bailey, 1942). As intracranial pressure increases the onset of coma is abrupt, and in the human coma will have occurred once the haemorrhage exceeds 8% of the cranial cavity volume (Steiner et al., 1975). The raised intracranial pressure could also have a direct effect on brain stem function by pressing onto that region. Lateral displacement of the brain stem region seems to be more frequently associated with unconsciousness than vertical compression (Ropper, 1989).

Summarising this evidence, it can be concluded that:

- A functioning association cortex is essential for mental activity and for higher planes of consciousness such as memory, perception, recognition

and thinking. A functioning brainstem and thalamus are essential for rudimentary forms of consciousness in humans.

- There is no one region in the brain, which is a centre for consciousness. However, damage to regions in the brain stem is associated with a rapid onset of complete unconsciousness. This indicates, that when concussion causes interference to the brainstem, it is likely to be particularly effective in inducing unconsciousness.
- Although the induction of unconsciousness during concussion can be abrupt, recovery is not invariably so swift. There are situations where recovery is phasic, and only partial, and this can make it difficult to qualify the presence of consciousness or unconsciousness.
- When concussion is accompanied by the absence of respiration due to interference with the medulla in the brain stem, the concussion is particularly deep. The absence of breathing is a valuable guide to the depth of brain stem disturbance and concussion.

Captive bolt stunning

There are numerous references that confirm that captive bolt stunning with a penetrating bolt can produce immediate unconsciousness. Electroencephalogram (EEG) recordings were used by Lambooy and Spanjaard (1981) to investigate the humaneness of captive bolt stunning of cattle. They concluded that frontal stunning almost certainly ensured immediate unconsciousness because delta and theta waves (tending to an isoelectric line) appeared on the EEG directly after stunning. Daly et al. (1986) concluded that captive bolt stunning in sheep produces an immediate and profound brain failure.

There are differences of opinion as to whether the stun itself consistently produces *permanent* insensibility. Blackmore and Delany (1988) state that when animals are stunned with a captive bolt pistol in the correct position in the frontal region with a projectile of sufficient velocity, insensibility is immediate and *permanent*. Similarly, Daly et al. (1985) found that visual evoked responses (which when present indicate that the brain is functioning) were not present in sheep for the five-minute period between captive bolt stunning and exsanguination. They concluded that insensibility can confidently be assumed to exist until death occurs through exsanguination.

The effectiveness of captive bolt stunning in obliterating responsiveness in the brain depends on the velocity of the bolt (Daly, 1987; Daly et al. 1985). Using cartridges of lower strength than those recommended by the manufacturers can lead to an increased incidence of poor stunning. Subsequent work by Daly and Whittington (1989) and Daly (1991) in over 2,500 cattle showed that effectiveness (judged from the physical signs in the animal) also depends on the type of animal (bulls being more difficult to stun effectively), and accuracy of the shooting position.

Finnie (1993) states that the penetrating captive bolt probably produces rapid unconsciousness, but claims that captive bolt stunning should be immediately followed by further actions to ensure that the animal is rendered permanently unconscious.

If there is the possibility of animals recovering from the stun, then presumably the sooner an animal is stuck, the less the chance of recovery. Thus, in the interests of animal welfare, the concept of specific stun-stick intervals has been suggested.

If one can be certain that the effect of the captive bolt stun is permanent, then it is unnecessary to define a stun-stick interval. The effect of the captive bolt stun is unlikely to be permanent if the stun is initially ineffective. Thus, the first step in ensuring humaneness of the slaughtering procedure is to confirm that the stun has been effective. The signs of an effective stun (Fricker and Riek, 1981; Finnie, 1995, 1997; Grandin, 1983, 1998a) include:

- Immediate collapse
- Brief tetanic spasms which may be followed by uncoordinated hind limb movements
- Immediate and sustained cessation of rhythmic respiration
- Absence of coordinated attempts to rise
- Absence of vocalisation of animals
- Glazed 'glassy' appearance of eyes
- Absence of eye reflexes

The presence of the corneal ('blink') reflex at any time after captive bolt stunning casts doubt on the effectiveness of the stun. This reflex can be tested by lightly touching the surface of the eye. The closure of the eyelids indicates the presence of the reflex. The corneal reflex depends on an intact ophthalmic nerve to carry the stimulus to the brain and an intact facial nerve (cranial nerve VII) to control the eyelid muscles (King, 1987). While it is theoretically possible for one or both of these nerves to be concussed or destroyed by the captive bolt itself, this is unlikely to be the case with cattle (Daly et al., 1988). Part of the nervous control responsible for the expression of the corneal reflex is located in the brain stem, close to the region of the brain associated with the maintenance of sensibility through the reticular system. Again, it is possible that only that part of the brain stem controlling the corneal reflex may be damaged (Blackmore and Delany, 1988). Thus, once again, there is the theoretical possibility of a corneal reflex being absent even though other brain stem functions are present.

In practice, however, it appears that the corneal reflex is a useful indicator of the effectiveness of a captive bolt stun. Lambooy at al. (1981) demonstrated the presence of the corneal reflex in 2 veal calves following concussion stunning with a mushroom headed stunner. In both cases, the EEG pattern indicated that the calves had not been effectively stunned. Similarly, with 7 calves shot in the nape of the neck with a penetrating captive bolt pistol, the animals were fully conscious, according to the EEG, as long as there was a corneal reflex (Lambooy and Spanjaard, 1981). Schutt- Abraham

et al. (1983) stunned 7 sheep with a non-penetrating captive bolt pistol. In 4 animals there was no loss of the corneal reflex while in one additional animal the reflex was lost for about one minute before returning. They reported that there was an evident correlation between the extent of the cranial damage and the cessation of the corneal reflex.

Shaw (1989) found the corneal reflex to be absent in 97 of 100 animals (including cattle, calves, sheep and goats) stunned with a penetrating captive bolt pistol. The reflex was tested within 15 seconds of stunning and all animals were judged, using the criteria of Fricker and Riek (1981), to have been effectively stunned. Two of the remaining 3 animals in the series of 100 could not be tested because the eye remained closed, while a corneal reflex was present in one calf which was otherwise judged to have been effectively stunned.

Thus the majority of the evidence in the literature demonstrates that animals that have been effectively stunned do not have a corneal reflex, while the reflex is present in animals that have been ineffectively stunned. This knowledge could be applied to ascertain whether there is justification on welfare grounds for a particular stun-stick interval.

If all the signs of an effective stun, including the absence of a corneal reflex, are present immediately following the stun, and the corneal reflex is still absent just prior to sticking, then it is reasonable to suppose that the stunning-sticking procedure is humane. This would apply regardless of the stun-stick interval. Thus, if the employee responsible for sticking tested the corneal reflex on each animal just prior to sticking, and the reflex was absent, then one could be reasonably certain that the stunning-sticking procedure was humane.

It should be noted that a positive corneal reflex can occur in both conscious and unconscious animals and so it does not distinguish between these states (Gregory, 1998). Thus, the presence of a corneal reflex in a stunned animal does not constitute proof that the stun was inhumane or that the animal is presently conscious. Furthermore, recovery from an ineffective stun is likely to be progressive, in that the animal will gradually pass from an unconscious to a conscious state. In these circumstances, the corneal reflex is likely to be providing a warning that the animal is in the process of regaining consciousness.

The captive bolt does not depend on penetration of the skull by the bolt in order to be effective (Daly et al., 1986; Lambooy, 1981). In fact, insertion of a bolt into the brain through a trephined hole does not usually induce unconsciousness or loss of evoked responses. According to Lambooy (1981) the animals looked dizzy but they could stand if placed on the floor (from a hammock) following insertion of the bolt. Nevertheless, the track made by the bolt will result in bleeding, and in some animals this could cause localised impairment of brain function. When the captive bolt is fired through bone, it produces a penetrating fracture of the skull at its entrance. Bone

fragments are scattered along and around the track it takes in the brain, and this results in a larger zone of brain damage than that created directly by the bolt.

The ideal shooting position in the head depends on the species, velocity of the bolt and the type of animal within the species (Anon, 1993). It is usually assumed that the ideal position corresponds to the intersection between two imaginary lines drawn between the base of the horn and the corner of the eye on the opposite side of the head. This recommendation stemmed from the position that was recommended during the 19th century for striking an ox with a poleaxe (Gregory, 1989). In sheep, shooting in the poll position at the back of the head is just as effective as the frontal position (Daly and Whittington, 1986). Whereas, in cattle poll shooting is not recommended because it is less effective in eliminating evoked responses (Daly, 1987). It is suggested by the gun manufacturers that the area of the ideal shooting position increases with the velocity of the bolt.

There is little doubt that even in the challenging environment of a commercial abattoir it is possible to consistently stun cattle humanely. Grandin (1998b,1999) assessed stunning efficacy (percentage of cattle rendered insensible with one shot from a captive bolt) in 19 beef plants and reported that 21% of these plants had a perfect score of 100% for stunning efficacy. Furthermore, recovery from the stun was extremely rare. More than 1000 cattle were observed on the bleeding rail, only one showed obvious signs of sensibility. Poor stunner maintenance and poor ergonomics of bulky pneumatic captive bolts were the major cause of missed stuns, when imperfect stunning occurred.

HUMANENESS OF THE STUNNING-STICKING PROCEDURE

The effectiveness of the stun depends on matching the right equipment (gun type and cartridge strength) for a given animal, the accuracy of the shooting position and gun maintenance. These in turn depend to some extent on the skill and judgment of plant staff. It is important to assess each situation separately when deciding whether standards at a given plant are satisfactory, and whether a delay in the time to sticking would be acceptable. This can be achieved by implementing a Quality Assurance scheme for each plant.

It is recommended that plants include in the 'Standard Operating Procedures for Animal Care', which form part of the plant's *Meat Safety Quality Assurance (MSQA) Manual,* such measures (Anon., 1999) as the following:

- **Check for effective stun:** Examine all animals immediately after the stun for the signs of an effective stun and test stunned animals for the corneal reflex just prior to sticking.

- **Selection, training and ongoing supervision/assessment of stunning operators:** This should not be an area where casual employees are used. They need to have

good training on how the device is used, where it is applied, signs of effective stunning, what to do if the effectiveness of stunning is in doubt.

- **Back-up stunning devices:** There must be provision of back-up stunning devices which are immediately accessible and ready to use so that the animal can be restunned without delay.

- **Operational care/maintenance of stunning equipment:** If the operator believes the device is malfunctioning in any way, he should immediately use a back-up device.

- **End of shift maintenance of stunning equipment:** Manufacturers of captive bolt stunners generally recommend daily dismantling of the device for cleaning and checking.

- **Other employees:** Employees working between stunning and sticking (e.g. shacklers) should have similar training to the operator performing stunning and have ready access to a back-up stunning device. If an animal is recovering from the stun, the aim must be to detect, restun and bleed it before consciousness fully returns. Heads should be checked regularly for correct placement of the bolt. There must be good feedback to the stunning operator. In this way, it should be possible to achieve as close as possible to 100% compliance.

- **Verification activities by QA Officers:** With the aim of assessing the level of compliance, it is suggested that at least 5% of:

  (a) **carcasses** be observed for indications of inadequate stunning;

  (b) **carcasses** be checked for the corneal reflex just prior to exsanguination (bleeding); and

  (c) **heads** be checked for bolt penetration in the correct anatomical location.

If it is found that there is adequate compliance with the criteria that are associated with each of these requirements, then it seems unnecessary to specify a stun-stick interval.

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