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Prepared by: Alison Small & Drewe Ferguson

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Review of the welfare risks and the science that underpins welfare standards of cattle and sheep at slaughter

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Abstract

A review of the scientific knowledge pertaining to the welfare risks that prevail during the slaughter of cattle and sheep was undertaken in conjunction with a comparative evaluation of different national and international standards or codes relevant to the management of these welfare risks. There was good alignment between current scientific knowledge underpinning the relevant welfare standards and codes. There were no major deficiencies in the scientific knowledge but further research to minimise the risk of prolonged loss of consciousness following slaughter without stunning was recommended.

The standards and guidelines reviewed present a range of requirements or recommendations to industry, in a variety of formats. In terms of managing animal welfare risks within an international supply chain, significant differences can exist between the social and cultural expectations of the communities involved, and therefore, moral and ethical judgements in the absence of underpinning science are difficult to make. Furthermore, implementing standards across a supply chain encompassing a number of different regulatory frameworks is fraught with difficulty. In developing an animal welfare management system for an inter-community supply chain, it is likely that no single existing standard or guideline meets these criteria, and it is suggested that any management system developed incorporates appropriate components from a variety of standards.

Executive summary

In order to maintain consumer and societal confidence that animals destined for slaughter are afforded humane treatment, it is paramount that the highest standards of welfare are implemented and demonstrated, and that these are communicated to the community. To maximise animal welfare outcomes at slaughter, a two stage process is required. Firstly, it requires identification of the prevailing stressors or welfare risks and the probability of their occurrence and secondly, the implementation of effective welfare standards and strategies to mitigate and manage these risks.

The objectives of this project were to: (i) undertake a comprehensive literature review and comparative evaluation of different international standards or codes relevant to the management of welfare risks of sheep and cattle at slaughter and (ii) review the science that underpins these standards and codes.

The review focused on key welfare risk factors that can occur during the presentation:

(i) Injury and/or stress due to unsuitable design or construction of animal handling and holding facilities
(ii) Injury and/or stress due to inappropriate animal handling and management
(iii) Pain and distress due to being conscious during exsanguination

It was concluded that a significant body of research exists regarding the effects of pre-slaughter and slaughter factors on the welfare of cattle and sheep. To that end, there are no major theoretical knowledge gaps but translation of that theory into commercial solutions warrants further development. Areas where further R&D is warranted are:

- Slaughter without stunning and specifically, the significant welfare concern of prolonged loss of consciousness, particularly in cattle.
- Optimization of head restraint to maximise blood flow following neck cutting
- Identification of risk factors associated with prolonged sensibility during exsanguination (eg. neck cut position).
- Optimisation of stunning

Effective stunning prior to slaughter is still seen as the best means for mitigating this risk and therefore, industry endeavours to increase adoption of stunning prior to slaughter in importing countries of Australian livestock are strongly encouraged.

The standards and guidelines reviewed present a range of requirements or recommendations to industry, in a variety of formats. Some are predominantly outcome based (e.g. the AMIC Animal Welfare Standards (AMIC 2009)); others are more prescriptive in their requirements. Many demonstrate a combination of outcome based and prescriptive statements. Science underpins a large part of the standards and guidelines, but there are number of areas in which an ethical judgement must be made, in the absence of clear understanding of the effects of a particular situation on animal welfare. This ethical judgement considers not only the possible impact on animal welfare, but also the social mores of the community in which the judgement is made.

In terms of managing animal welfare risks within an international supply chain, significant differences can exist between the social and cultural expectations of the communities involved, and therefore, these moral and ethical judgements are difficult to make. Furthermore, implementing standards across a supply chain encompassing a number of different regulatory frameworks is fraught with difficulty. Enforcement of a non-legislative requirement is not possible, so the standards within a

management system must be implementable by all stakeholders, and acceptable to all stakeholders. In developing such a management system for an inter-community supply chain, it is likely that no single existing standard or guideline meets these criteria, and it is suggested that the management system developed incorporates appropriate components from a variety of standards.

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1 Background

The acceptance that an animal must be slaughtered to produce meat for human consumption depends very much on the individual's ethical position and values. Meat consumers and those in society who accept or perhaps tolerate this fact, do so, in part, because of their belief that animals are treated and slaughtered in a humane manner. However, when this belief is challenged by evidence of inhumane treatment of animals, the ensuing expression of public abhorrence is both immediate and powerful. Moreover, this expression is often independent of an individual's ethical position. The recent events leading to the suspension of live export of cattle to Indonesia in 2011 and slaughter of pigs in a NSW abattoir (Hawkesbury Valley Meat Processors) in 2012 are testaments to this. In order to maintain this belief that animals destined for slaughter are afforded humane treatment, it is paramount that the highest standards of welfare are implemented and demonstrated.

Cattle and sheep are exposed to a range of different stressors during their preparation for slaughter. The type, intensity and duration of exposure of each stressor and the capacity of the animals to cope or adapt to these challenges will ultimately determine whether animal welfare has been adversely affected. To maximise animal welfare outcomes at slaughter, a two stage process is required. Firstly, it requires identification of the prevailing stressors or welfare risks and the probability of their occurrence and secondly, the implementation of effective welfare standards and strategies to mitigate and manage these risks.

The objectives of this project were to: (i) undertake a comprehensive literature review and comparative evaluation of different international standards or codes relevant to the management of welfare risks of sheep and cattle at slaughter and (ii) review the science that underpins these standards and codes. In this review, we have focused on the welfare risks which prevail during the immediate pre-slaughter and slaughter phases (i.e. from the arrival of the animals at the abattoir to their slaughter).

2 Project objectives

(i) To undertake a comprehensive literature review and comparative evaluation of different international standards or codes relevant to the management of welfare risks of sheep and cattle at slaughter.

(ii) To review the science that underpins these standards and codes.

3 Methodology

A literature review was undertaken of the published material, from Australia and overseas. A critical assessment of the published data and the relevance of the science to welfare standards and requirements at slaughter was conducted.

The review focused on key risk factors affecting the welfare of cattle and sheep at slaughter:

- Injury and/or stress due to unsuitable design or construction of animal handling and holding facilities

- Injury and/or stress due to inappropriate animal handling and management
- Pain and distress due to being conscious during exsanguination

In addition, a comparative analysis of national and international standards/codes that apply during the pre-slaughter management and slaughter of cattle and sheep was conducted.

Having reviewed the science and the relevant standards, a gap analysis was performed to:

- Identify inconsistencies or gaps in the science regarding the welfare risks at slaughter
- Make recommendations about future research to underpin the development of the new welfare standards at slaughter.
- Identify where additional standards may be required to address the welfare risks at slaughter of cattle and sheep.

4 Review

4.1 Welfare risks at slaughter

The welfare risks that can occur during the presentation for slaughter can be broadly summarised:

(i) Injury and/or stress due to unsuitable design or construction of animal handling and holding facilities
(ii) Injury and/or stress due to inappropriate animal handling and management
(iii) Pain and distress due to being conscious during exsanguination

It is difficult to rank these from an animal welfare perspective as the ranking will vary depending on the probability of a specific risk occurring (e.g. slips and falls due to unsuitable flooring in the lairage) and the severity or magnitude of the outcome on the animals (stress, skin abrasions and bruising, fractures). However, being conscious (fully or partially) during exsanguination is perhaps the outcome that invokes the most concern.
Clearly, in the development of welfare standards at slaughter, it is paramount that they reflect the relevant welfare risks and through their effective application, prevent these risks from occurring or mitigate the impacts should they occur.

4.2 Review of the underpinning science

The following review of the science and literature is structured according to the three primary welfare risks identified above. It is apparent that some, or more specifically some factors associated with each risk, have received more research attention than others. The best example here is the considerable body of literature pertaining to the welfare impacts of consciousness during exsanguination and how this can be practically avoided. The fact that there may be no or a paucity of evidence for a specific welfare risk factor or standard should not necessarily be construed as a deficiency or knowledge gap. For example, a welfare standard or code that states that an animal should not be hit excessively with solid objects during handling does not require underpinning science to support it as the requirement is clearly self-evident from a moral and ethical perspective.

It is also worth noting that the majority of the research examining pre-slaughter and slaughter risk factors has been focused on quantifying their effects on meat quality traits (see reviews by Warriss (1990); Ferguson and Warner (2008)) rather than animal welfare per se. Some inference however, can still be drawn from some of these studies. For example, in studies examining the meat quality defect known as dark cutting, which is caused by pre-slaughter depletion of muscle glycogen reserves, the actual loss in muscle glycogen can be used as an indicator of the level of exposure to fear-eliciting events (e.g. handling). However, muscle glycogen concentration can also be influenced by other pre-slaughter factors including, nutrition, physical activity and exposure to weather extremes (Ferguson and Warner 2008).

Also when reviewing the relevant science, it is often difficult to draw definitive conclusions and this can be for a variety of reasons. Often there is insufficient evidence or the difficulty arises because of the variability in the methodologies and welfare measures used between studies. Another critical reason is that for many of the measures used to assess welfare status, there is rarely a definitive threshold that defines acceptable and unacceptable welfare. Therefore, when drawing a conclusion about a particular welfare risk factor, it is ultimately a subjective decision based on the consideration of the facts against some ethical framework. For example, if we accept that increasing frequency of vocalisations are an indicator of animal's response to stress (Grandin 2001), then what is the appropriate threshold of acceptability in a group of animals: < 3%, 5% or 10%? The decision ultimately requires some application of an ethical context to establish what is reasonable. Therefore, in the derivation of welfare standards and codes, science and ethics are inextricably linked and this important point has been compellingly argued by Sandoe et al (2003, 2004).

4.2.1 Design and construction of animal handling and holding facilities

The requirement for handling facilities that facilitate efficient and easy movement of livestock with minimal risk of injury is self-evident, from production efficiency, product quality and operator safety perspectives alone. This is paramount particularly in modern abattoirs given the higher line speeds and slaughter capacities (Gregory 2003). However, this requirement equally applies even in those slaughterhouses that may only slaughter 10 – 30 head/day.
Our understanding of the impacts of poorly designed or constructed handling facilities on the welfare of livestock has been greatly advanced by the significant body of work by Temple Grandin and her colleagues (Grandin, 2003) Grandin 2010; see also www.grandin.com). She has applied the fundamental principles of animal ethology to improve the design and operations of abattoir lairage and handling facilities. For example, provision of non-slip floors, even lighting throughout the movement areas and elimination of distractions such as mechanical air drafts or reflecting surfaces have been shown to improve the efficiency of animal movement in abattoirs (Grandin 1990; Grandin 1996; Grandin, 2003). Further gains can be achieved through the installation of curved or serpentine races and long narrow lairage pens (Grandin 1990, Grandin, 2003). Reducing the angle on corners turned by animals as they flow through the facility to 60-80° also improves movement (Grandin 1990) and this may also facilitate reduced bruising and injury.

It is important to recognise that the lairage affords the animal an opportunity to rehydrate and rest and recover from transport. Therefore, it is quite important to ensure that the lairage pens and conditions are conducive for this. In a study where cattle behaviour in lairage was monitored overnight, Eldridge et al. (1989) reported that cattle situated near a noisy environment (next to unloading facilities) exhibited more movement and had a higher incidence of bruising than cattle held in pens in quieter locations. In cattle, the desire to rest in lairage will also be influenced by other factors such as distance travelled, marketing method (direct versus saleyard), group size and time of day and time in lairage (Cockram 1990, 1991; Jarvis et al 1996).

In general, animals have the opportunity to rehydrate after arrival at the abattoir as they typically have access to water whilst in lairage, although it is recognised that even with access to water, not all animals will drink. Limited access to and unfamiliarity with watering facilities or water flavour or quality will contribute to the variability in drinking behaviour in novel environments. Failure to drink when water is available is a particular problem in young calves (Gregory 2003) and lambs (Jacob et al 2006). Jacob et al. (2006) measured urine specific gravity (SG) as an indicator of hydration status and observed that up to 50% of lambs slaughtered in two abattoirs over one year had urine SG values indicative of some dehydration.

It is generally recognised that the most prevalent physical injury that occurs during the pre-slaughter phase is bruising. The factors that predispose to increased bruising have been reviewed by Gregory (2003) but prominent amongst these are design aspects of the loading and handling facilities at the abattoir and the quality of handling. In a survey, McCausland and Millar (1982) concluded that more than 50% of the bruises occurred after arrival at the abattoir, based on histological ageing of bruised tissues taken from beef carcasses.

4.2.2 Animal handling and management

The evidence based on blood physiological measures of stress responses (e.g. plasma cortisol concentration) demonstrates that the pre-slaughter environment is stressful to cattle and sheep (Pearson et al 1977; Cockram and Corley 1991; Tume and Shaw 1992; Shaw and Tume 1992; Hemsworth et al 2011). Hemsworth et al (2001) also reported that a significant proportion of the variance in cortisol concentration at slaughter in cattle and sheep could be accounted by differences between abattoirs. The stress response can however be modulated by abattoir-specific factors such as capacity and operations. The cortisol levels in cattle (Tume and Shaw 1992) and sheep (Pearson et al 1977) were lower in blood samples collected at slaughter in small or experimental slaughterhouses compared to those form larger commercial abattoirs. This may be relevant in the context of live export as typically the importing country slaughterhouses are not large operations. The stress associated with the pre-slaughter environment can be markedly exacerbated through poor handling. Often the quality of handling is directly associated with the design of the handling facilities (Grandin, 2003) where poor handling practices are more likely to be observed in poorly designed facilities where animals frequently baulk or do not move easily. Nevertheless, the human factor must not be dismissed. In a study examining human-animal interactions in cattle and sheep abattoirs, Hemsworth et al (2011) examined the relationships between specific behaviours of stockpersons and cortisol concentration at slaughter. In sheep, handling factors such as dog use score and the frequencies of touches, pushes and whistles by stockpeople were included in the best predictive model for cortisol concentration. Similarly for cattle, frequency of electric goad use was a significant predictor.

The use of electric goads particularly during the pre-slaughter handling of animals has received considerable attention (see Grandin (2003)). Their use causes elevation in vocalisation scores, a behavioural indicator of stress (Grandin 2001). Warner et al (2007) showed that their application 15 minutes prior to slaughter elicited a profound acute stress response based on the near doubling of plasma lactate which is an indicator of sympatho-adrenal mediated increase in muscle glycogenolysis. Interestingly, Pettiford et al (2008) did not find that the use of electric goads on cattle modified the physiological response to loading prior transport. In this study, it is likely that the specific effect of the electric goad was overridden by the significant stress response that occurred during loading and handling. Furthermore, the absence of an effect here does not imply that the use of such devices is desirable from animal welfare perspective. Grandin (2003) has demonstrated that electric goads can be replaced by less aversive handling aids (flags or flappers) without compromising the efficiency of animal movement.

4.2.3 Specific management practices

Mixing
Mixing of unfamiliar groups of animals resulting in agonistic behaviours and therefore increased risk of injuries and stress, should be avoided. The increased aggression and strenuous demands associated with the re-establishment of the social hierarchy particularly in bulls has been shown to have a profound effect of muscle glycogen loss and therefore, the incidence of dark-cutting (Warriss et al 1984). However, in another study examining the effects of mixing unfamiliar groups of feedlot steers 4, 2 and 1 week before slaughter, there was no effect on physiological stress response measures (Colditz et al 2007).

Lairage duration
The time in lairage prior to slaughter is ultimately determined by a number of factors notably; capacity and operations of the abattoir and duration of transport. In many European countries and in North America it is common to slaughter animals on the day of arrival whereas in Australia, New Zealand and other countries, animals are more typically slaughtered the day after arrival. Increased time spent in lairage tends to result in reduced muscle glycogen concentration and therefore an increased risk of dark-cutting in beef cattle (Warner et al 1988). Conversely, a reduction in lairage time had either little impact or resulted in improved meat quality parameters in grain finished cattle (Jeremiah et al 1988[ab]; Ferguson et al 2007). Although it is difficult to extrapolate these results in terms of animal welfare, it is reasonable to assume that the impact of a shorter time in lairage would be negligible particularly for animals that have not been transported for long durations (e.g. < 6 h).

Swim-washing
Due to food safety requirements, cattle and sheep are often washed in lairage to remove hide or fleece contaminants such as excreta and dirt. The process of handling and washing the animals has been shown to be one of the more stressful pre-slaughter events and has been shown to have deleterious consequences to the incidence of dark cutting in lambs (Geesink et al 2001).

4.2.4 Welfare issues related to consciousness at the time of exsanguination

The issue of consciousness at the time of slaughter or exsanguination has been extensively reviewed by the Scientific Panel on Animal Health and Welfare of the European Food Safety Authority (EFSA, 2004) and as part of the European project “Dialogue on Religious Slaughter” (DIALREL) (Von Holleben et al 2010). This review will not attempt to re-iterate the entirety of those reports, but to highlight key findings and provide available fresh information in the context of humane slaughter standards and practices. When considering consciousness at the time of slaughter, two main welfare issues emerge:

- Lack of or failure of stunning: the animal is conscious at the time of the bleeding incision
- Sustained consciousness during exsanguination: the animal does not rapidly lose consciousness as a result of blood loss

4.2.5 The importance of consciousness

An animal that is conscious will perceive pain, and the infliction of pain onto an animal is a welfare concern. It is accepted that if an animal can be rendered unconscious and insensible to pain, the welfare of that animal will not be compromised during the painful procedure. There has been considerable debate as to whether or not the actions leading to exsanguination (variously referred to as ‘bleeding’; ‘sticking’; ‘neck cutting’) in the conscious animal are indeed painful, or perceived as such by the animals concerned. For example, Rosen (2004) claimed that the neck cut for Kosher slaughter is painless because a very sharp knife is used and brain function is lost immediately. However, some studies have shown delays in loss of sensibility of up to 2 minutes, during which time, one would assume that the animal perceives pain.

Recently, a team in New Zealand (Gibson et al 2009[abcd]) used a minimally anaesthetised model to demonstrate electroencephalogram (EEG) evidence of pain in calves subjected to unstunned slaughter. They showed that ventral neck cutting leads to EEG patterns consistent with pain, and that post-cut mechanical stunning can eliminate those patterns.

Identifying unconsciousness in animals is difficult. Behavioural indicators such as collapse and uncontrolled movement indicate that the cortex and cerebellum are not functioning normally, and can be used as indicators of unconsciousness (Muir, 2007). The electrical activity within the brain, recorded using electroencephalogram (EEG) or electrocorticogram (ECoG) can give an indication of brain function, and the absence of evoked responses suggests unconsciousness. Evoked responses, also known as ‘evoked potentials’, are spikes in electrical activity within the brain that result from an external stimulus. For example, a light flashed into the eye of a conscious animal will result in a “visually evoked response (VER)”, or a needle prick in the nose, ear or foot will result in a “somatosensory evoked response (SER)”. Conversely, the presence of evoked responses does not necessarily confirm consciousness as visually evoked responses can be elicited in anaesthetised animals (EFSA 2004; Gregory 2007; Zeman 2001). Kallweit et al (1989) recorded visual (VERs) and somatosensory (SERs) evoked responses in cattle that were either stunned by captive bolt; or were exsanguinated without prior stunning. The evoked responses were immediately eliminated by captive bolt stunning, suggestion immediate loss of consciousness, whereas in the unstunned slaughtered animals, the responses continued for some time after neck cutting (SERs 32-126s; VERs 20-102s), although they did gradually reduce, suggesting a slow loss of consciousness..

4.2.5.1 Issues associated with unstunned slaughter

If an animal is not stunned prior to slaughter, it will be fully conscious at the time of the neck cut, and so could be expected to suffer pain as a result of this insult. The issue of pain, fear and distress resulting from the slaughter incision is extensively discussed by von Holleben et al (2010), with the general conclusion that these adverse welfare effects are present in conscious animals at the time of slaughter. However, the argument then turns to the duration of these effects following the incision. Some (Grandin 1994; Levinger 1995; Rosen 2004) argue that if the incision is carried out properly, the animal does not feel the incision, and loses consciousness extremely rapidly after the incision. Hence, it will not have time to register the noxious stimuli received and therefore it will ‘not suffer’ prior to lapsing into unconsciousness and then death. They cite lack of flinching and lack of defence behavioural responses as indications of painlessness, and also use the analogy of a surgical incision, arguing that the sharpness of the *Chalaf* (the knife used for Kosher slaughter) is akin to “the frequent experience of surgeons who have cut themselves in the course of an operation and only noticed it well after the event” (statement not supported by evidence).

Gregory et al (2010) reported that 8 per cent of non-stunned Halal-slaughtered cattle slaughtered in the standing position take longer than one minute to collapse (fall down) post neck cut, while Cranley (2011), observing 100 calves, reported an average interval between the ritual cut and insensibility of 120 seconds, although some animals took 3-6 minutes to collapse. Cranley suggested that differences between the types of restraint used could have contributed to the different findings in these two studies: while the cattle observed by Gregory (2010) were slaughtered in the standing position, the calves observed by Cranley (2011) were manually held down on a slaughter cradle. Cranley observed that struggling against restraint accelerated death. Gregory et al (2012) summarised observations on unstunned slaughter in eight European countries. Of over 1500 cattle, following neck cutting, 14% were seen to collapse and then stand up again; 8% took longer than 60 seconds to collapse; and 1.5% took longer than 4 minutes to collapse. The average time from neck cut to collapse was 20 seconds, during which time the authors considered that animals to be at least partially conscious.

Daly et al (1988) used ECoGs, VERs and SERs to evaluate brain function of 8 adult cattle after unstunned slaughter in a Weinberg casting pen. Immediately after stunning, the waveform in the ECoG remained unchanged for a period of 7.5 ± 2 seconds. This phase was then followed by a period of low amplitude high frequency (HALF) activity of highly variable duration (9 to 85 seconds), which in turn was followed by the isoelectric state (flat EEG trace, indicating no electrical activity in the brain, i.e. cessation of brain function), which occurred as early as 19 seconds and as late as 113 seconds (mean 28 ± 28). Evoked responses gradually decreased in amplitude until they were lost completely over a period of 20-102 seconds (VERs mean 55 ± 32) or 32-126 seconds (SERs mean 77 ± 32). After loss of evoked responses, there was no evidence of return.

When compared with captive bolt stunning in the same study, the principal difference was in the evoked responses. In each unstunned animal, the duration of the VERs was similar to the duration of the SERs, and similar to the duration of spontaneous electrical activity as measured by ECoG, whereas the captive bolt abolished evoked responses immediately. In the unstunned animals Daly et al (1988) stated, “this close similarity in the durations of the evoked responses and the spontaneous activity … strongly suggests that the spontaneous activity recorded was real, and not artefact”.

Levinger and Appel (1966) reported large variation in the duration of brain activity between animals following schechita (the Kosher method of slaughter) (20 to 113 seconds). The authors proposed that this variation may be underpinned by differences in the proportion of total cerebral blood flow which occurs through the vertebral arteries, citing the finding that there was considerable variation in the size of the anastomoses (linking blood vessels) between the vertebral arteries and the rete mirabilis (Levinger and Appel 1966). In animals with large anastomoses, a greater rate of blood flow could pass from the vertebral arteries into the rete mirabilis, and thus maintain brain function to a greater extent than in animals with narrow or small anastomoses. They also suggested that the anastomoses tended to degenerate with age, so it may be that older animals have less chance of sufficient blood flowing into teh brain through hese anastomoses. Another suggestion (Daly et al 1988) is that the amount of blood reaching the brain via the vertebral arteries is actually very close to the minimum required to sustain electrical activity. In primates, cortical function fails when the blood flow drops to 15-20% of normal, while the threshold for subcortical regions seems to be lower, at 10-15% (Branston et al 1984; Lopes Da Silva et al 1985). So, small individual variations in the capacity of the vertebral arteries, around this threshold level, could make a substantial difference to sustenance of cortical function. This theory is supported by the fact that the variation in time to loss of brain function in anaesthetised animals is much less (Gregory and Wotton 1984[ab]): the lowered blood pressure resulting from anaesthesia is likely to be sufficient to drop the blood flow through the vertebral arteries below the threshold level.

Gregory et al (2006) quantified the occurrence of 'carotid ballooning' in 987 cattle, calves and lambs at slaughter. 'Carotid ballooning' is sometimes also called 'false aneurysm', and occurs when the elastic wall of the artery springs back inside the connective tissue sheath as the cut is made. The loose sheath then collects blood in a similar manner to a water balloon; this blood clots, and prevents rapid exsanguination. When this occurs, the blood pressure can be maintained, and the blood flow is diverted around the blockage, via the vertebral arteries to the rete mirabilis and through the brain. No ballooning was present in 62.4%, 58.5% and 99.9% for cattle, calves and lambs, respectively, while swellings of greater than 3 cm diameter were observed in 15.9%, 24.5% and 0.0% in cattle, calves and lambs, respectively. The proportion of animals with ballooning at this size in both arteries was 5.4%, 12.2% and 0.0% in cattle, calves and lambs, respectively. The largest diameter ballooning was 10 cm, and it occurred in one of the cattle. This is important because some studies have demonstrated that the formation of false aneurysms and large blood clots in the severed carotid arteries and jugular veins may lead to prolonged sensibility, due to increased blood flow in the vertebral arteries (Anil et al 1995[ab]). However, other authors have reported that increased vertebral artery blood flow does not necessarily prolong brain activity (Shaw et al 1990; Bager et al 1992). The actual positioning of the neck cut may impact on rate of loss of consciousness: Gregory et al (2012) reported that cutting at the level of C1 (immediately behind the jaw) markedly reduced the development of false aneurysms in comparison with cutting at the level of C2-C4 (slightly further down the neck).

From the above, it can be seen that the duration of sensibility following the neck cut in a fully conscious animal may be prolonged. What is not clear is the proportion of animals that do suffer prolonged sensibility under commercial conditions, and what actions, other than implementation of immediate post-cut stunning, could be taken to reduce that proportion.

4.2.5.2 Issues associated with improper or failed stunning

Where there is improper or failed stunning, as well as the potential for the animal to suffer the pain and distress of receiving an exsanguination cut, and potential prolonged sensibility as described above, two other considerations must also be evaluated:

- The animal may suffer pain and distress as a result of the failed stun application – e.g. a physical injury from a mechanical stunner; or an electric shock from an electrical stunner. The animal may be fully conscious, but paralysed.
- Where stunning is the normal process, there is likely to be a delay between the application of the stun, and the delivery of the exsanguination cut (EFSA 2004) – during which time the animal may be shackled and hoisted. This in turn prolongs the duration of any pain resulting from the misapplied stun; but is also considered to be extremely distressing to a conscious animal (EFSA 2004).

International standards on humane treatment of animals at the time of slaughter specifically prohibit the shackling and hoisting of conscious animals: OIE Terrestrial Animal Health Code (OIE 2005); AMIC animal welfare standards (AMIC 2009); EC 1099/2009 (EC 2009).

A number of studies have attempted to quantify the incidence of failed stuns and identify possible contributing factors, such as a lack of a proper head restraint system, a lack of shooting accuracy and poor gun maintenance (Grandin 1994; Cockram and Corley 1991; Gracey and Collins 1995; EFSA 2004).

Gouveia et al (2009) found that only 68.2% of 2800 captive bolt stuns in a Portuguese cattle slaughterhouse were effective, and that the efficiency decreased with age of animal ranging from 89.1%, in cattle younger than 12 months of age, to 50.3% in animals over 30 months of age. They also found that stunning was more effective in males than females. The abattoir concerned used a conventional stunning g box without head or body restraint. In the US, Grandin (2002) reported 0.16% of steers/heifers and 1.2% of bulls/cows to be improperly stunned in premises using penetrating mechanical stunners. The 21 abattoirs audited were federally inspected premises, and although the stun restraint was not described, it can be assumed that head restrainers were in use according to USDA requirements. She attributed the failures to poor maintenance and storage of equipment, incorrect shooting position and heavy skulled animals. In France, Marzin et al (2008) reported 7% of cattle requiring re-stun, which was attributed to poor shooting position; while in the same study 8% of cattle (and 15% of young bulls) showed signs of returning sensibility during bleed-out. Endres (2005) reported 6% stun failure in heavy cattle, while von Holleben et al (2010) estimate up to 15% ineffective stunning with penetrative mechanical stunning. Gallo et al (2003) demonstrated that instigation of training and correcting equipment failures can dramatically reduce the incidence of failed stuns. Using a traditional stun box with no head restraint, 27.2% of cattle required multiple shots; 46.9% vocalised after stunning, and 66.9% had positive corneal reflexes. A new stun box with a head restraint was installed, and the incidence of multiple shots reduced to 10.4%; vocalisation to 2.2% and corneal reflex to 0.8%. A training programme was then instigated including correct positioning of shot and signs of sensibility, and this further reduced these incidences to 2.2%; 0% and 0.2%.

It would appear that non-penetrating mechanical stun devices are more likely to produce mis-stuns: using non-penetrating percussive stunning, Lambooij et al (1983) induced immediate unconsciousness in only 15 out of 19 veal animals, while Blackmore (1979) achieved only an 80% success rate in bobby calves of 1-2 weeks old. Under commercial conditions, in two separate studies, 12-20% of cattle stunned using non-penetrating percussive equipment required re-stun (Hoffmann 2003, cited in von Holleben et al, 2010; Endres 2005), most of which were associated with inappropriate positioning of the device; whereas laboratory studies are usually able to demonstrate good effectiveness (Finnie 1995; Gibson et al 2009[c]). It is likely that in laboratory studies there can be much greater care taken over positioning of the animal's head and application of the device.

Poor head restraint is often cited as a causal factor for failed stuns (Bertoloni and Andreolla 2010; Grandin 1994; Gracey and Collins 1995), but there is little research into 'ideal' head restraint for stunning. Bertoloni and Andreolla (2010) compared a standard knocking box without head lift with an automated restraint system that included a head lift, and found that the automatic restraint system resulted in greater shot accuracy and significantly ($P<0.0001$) reduced the number of animals requiring re-stun. A tightly clamped head would be expected to allow very accurate shot placement; however, tight head capture is likely to be very stressful to the animal, and struggling while restrained is considered to be an indication of excessive pressure (Grandin and Regenstein 1994). EFSA (2004) recommends that "all restraining devices should use the concept of optimal pressure".

Ineffective stunning by non-penetrating devices has also been demonstrated in sheep. Occipital (back of the head) application of the stunner was found to be more effective than frontal application, but even so it resulted in 5- 16% of failed stuns in 3-4 month old lambs (Blackmore 1979; Blackmore and Newhook 1982); while a study involving 6 adult sheep demonstrated return of rhythmic breathing after as little as 7 seconds (range 7-43 s)(; Schutt-Abraham et al 1983).

Electrical stunning also is not necessarily 100% effective: von Holleben et al (2010) quote two dissertations: one by Aichinger (2003) in which 10% of cattle stunned using a 4-second head current were seen to be re-stunned by staff in a German beef plant; and a second by Stueber (2000) in which 9 of 23 cattle were considered to be improperly stunned. In sheep, poor placement of stunning tongs, and increased resistance due to long wool and dry skin conditions have been cited as factors contributing to ineffective electrical stunning (Velarde et al 2000). Furthermore, Von Holleben et al (2010) report anecdotal evidence of up to 20% of sheep being mis-stunned due to poor electrode placement, poor restraint, insufficient duration of current application and delayed exsanguination.

4.3 Knowledge Gaps

4.3.1 Lairage facility design and pre-slaughter animal handling and management

There is sufficient scientific evidence to demonstrate that pre-slaughter stress and the risk of physical injury can be minimised by ensuring the animal handling and lairage facilities are well designed to enable smooth and efficient movement of livestock and that the stockpersons understand and apply the principles of animal behaviour and best practice handling. Although there are limitations in the science, there are no major gaps in our knowledge in this context.

However, it is recommended that efforts should be directed (if not already) towards the extension of existing knowledge on low stress stock handling to those responsible for the handling and slaughter of Australian livestock in overseas abattoirs.

4.3.2 Consciousness at the time of exsanguination

There is a general expectation that animals are rendered insensible at the time of exsanguination, with the exception of animals processed for religious rites. However, there is little consensus on the most appropriate indicators of insensibility, and also uncertainty on the duration of insensibility, particularly with head-only electrical stunning in cattle.

There is also doubt over the efficacy of the stunning methods used, and the incidence of failed stuns in commercial practice. Poor head restraint is often cited as a causal factor for failed stuns (Bertoloni and Andreolla 2010; Grandin 1994; Gracey and Collins 1995), but there is little research into ‘ideal’ head restraint for stunning. A tightly clamped head would be expected to allow very accurate shot placement; however, tight head capture is likely to be very stressful to the animal, and therefore, EFSA (2004) recommends that “all restraining devices should use the concept of optimal pressure”.

In unstunned slaughter, there is a lack of clarity on the issue of prolonged sensibility. There is evidence that some animals show prolonged sensibility during exsanguination, but the incidence of this occurrence is only recently being investigated. It is understood that prolonged sensibility is related to perfusion of the brain via the vertebral anastomoses with the rete mirabile. However, there seems to be no research as yet into potential ‘risk factors’ or animal characteristics that may be associated with good perfusion through this route.

Therefore it is recommended further research and development be initiated to explore the optimization of head restraint to maximise blood flow following neck cutting and the identification of risk factors associated with prolonged sensibility during exsanguination.

4.4 Welfare standards and codes

The documents reviewed included enforceable regulations, welfare standards, codes of practice and guidance documents (summarised in humane_slaughter_standards_comparison.xls). As such, the intention of each of these documents varied and this was reflected in the specific standards or requirements. Typically standards can be either input-based such as the desired space allowance in lairage pens or animal outcome-based such as indicators of effective stunning. In some instances, the specific standards or requirements were quite prescriptive (e.g. the slope of the loading ramp should be no steeper than 1 in 3) or conversely, nebulous or non-specific (e.g. the desire of some animals to control their personal space should be taken into account in designing facilities). Given this, it was difficult to meaningfully compare and contrast the various standards and codes etc. The documents compared were:

- OIE Terrestrial Animal Health Code Chapter 7.5
- European Regulation EC 1099/2009
- PISC Model Code of Practice for the Welfare of Animals: Livestock at Slaughtering Establishments (SCARM 79)
- AMIC Animal Welfare Standards
- Malaysian Standard MS 1500/2009
- USDA Humane Handling Guidebook
- USDA 9 CFR ChIII Part 313

According to de Witte (2010), the four main principles against which welfare standards should be tested are:

1. Are they desirable for livestock welfare?
2. Are they feasible for industry and government to implement?
3. Are they important for the livestock-welfare regulatory framework?
4. Will they achieve the intended outcome for livestock welfare?

We would also support the application of these principles in the identification of or development of standards that can be applied in foreign abattoirs slaughtering Australian livestock. However, we recognise that the primary complexity in this process is that there needs to be bilateral acceptance of any welfare standards between Australia and the importing country and this may be difficult to achieve in practice. Nevertheless, ongoing efforts to achieve this are recommended given the potential gains in animal welfare.

4.4.1 Lairage design/construction and pre-slaughter animal handling and management

With the exception of the Malaysian standards, all of the documents reviewed specified welfare standards/codes/requirements for the design and construction of the lairage and handling facilities and animal management/handling practices (Table 1).

Of these, the OIE and AMIC standards and the PISC model code of practice were reasonably comprehensive but the latter was somewhat prescriptive. The AMIC standards offered further utility through the provision of suggested performance indicators to test compliance against the standards. When considering the various standards/codes/requirements against the four principles advocated by de Witte (2010) it is important to also consider the operating context. That is, either state- or privately-owned slaughterhouses in importing countries. Therefore, the obvious impediments are primarily in relation to the second and third principles. Specifically, it may be very difficult or not practical to implement such standards and/or there may not be a welfare regulatory framework in place. Notwithstanding this significant challenge, ongoing bilateral negotiations to explore the identification of and implementation of standards at slaughter is still strongly encouraged.

As discussed earlier, there is also sufficient scientific evidence to support the need for standards pertaining to the physical pre-slaughter environment and conditions and the manner in which cattle and sheep are managed and handled prior to slaughter.

Table 1: Standards that address specific risk factors associated with design/construction of the lairage and handling facilities and animal management and handling

Risk factor	OIE Terrestrial Animal Health Code	EC 1099/2009	Australian PISC Model Code (SCARM 79)	AMIC Animal Welfare Standard	Malaysian Standard MS 1500/2009	USDA Humane Handling Guidebook
Lairage design/construction Including: Pen/race/floor design & construction Unloading facilities (eg.ramps) Exposure to harmful environmental conditions Holding pens/paddocks	Standards 7.5.1, 7.5.3 & 7.5.4	Ch. II Art. 3 Annex II	Sections 2.1, 2.2 & 2.5	Standards 2.1-9, 2.12	None	Ch. III Part 313
Animal Management Including: Lairage duration Contingency planning (eg. breakdowns) Inspection Management of special cases (eg. sick/injured/lactating females)	Standards 7.5.1 & 7.5.4	Ch. II Art. 3 Annex III	Sections 2.3, 2.4 & 2.5	Standards 1.5, 5.1-10	None	
Animal handling Including: Appropriate handling Electric goad use	Standards 7.5.1 & 7.5.2	Ch. II Art. 3 Annex III	Sections 2.2 & 2.5	Standards 5.1-10	None	Ch. III Part 313

OIE – World Organisation for Animal Health & Welfare; EC - European Community; PISC – Primary Industries Standing Committee; AMIC – Australian Meat Industry Council; USDA – United States Department of Agriculture

4.4.2 Stunning and Slaughter

Pre-slaughter stunning is widely accepted as a means of rendering the animal insensible to pain, and the desire is that the insensibility (if not a stun-kill) is maintained for sufficient time as to allow the animal to die as a result of blood loss prior to recovery of sensibility. However, the standards and guidelines in general describe pre-slaughter stunning as "recommended" rather than mandatory; or as mandatory, but with exemptions for particular cultural groups e.g. Muslim (Halal) or Jewish (Kosher) slaughter. Conversely, Halal and Kosher standards tend to describe pre-slaughter stunning as "not recommended", and go on to discuss specific parameters required for stunning only "when stunning has to be carried out" (e.g. the Malaysian Standard for the Halal Production of Food MS 1500/2009 (Anon. 2009)).

The European regulation EC 1099/2009 (EC 2009) states clearly:
"Animals shall only be killed after stunning in accordance with the methods and specific requirements related to the application of those methods set out in Annex I. The loss of consciousness and sensibility shall be maintained until the death of the animal.
"The methods referred to in Annex I which do not result in instantaneous death (hereinafter referred to as simple stunning) shall be followed as quickly as possible by a procedure ensuring death such as bleeding, pithing, electrocution or prolonged exposure to anoxia.
"In the case of animals subject to particular methods of slaughter prescribed by religious rites, the requirements of paragraph 1 shall not apply provided that the slaughter takes place in a slaughterhouse."

In comparison, the Australian model code of practice (PISC 2002) does not give clear instruction on stunning, merely stating that "an animal has been stunned effectively when it is unconscious and insensible to pain. It should not regain consciousness or sensibility before dying", and that "stunning for religious slaughter should be encouraged using either effective 'mushroom' percussion stunning or electrical stunning methods", and similarly, the OIE Terrestrial Animal Health Code (OIE, 2005) does not clearly mandate pre-slaughter stunning, but seems to imply that stunning is expected. The AMIC animal welfare standards (AMIC 2009) do however require that "Livestock are effectively stunned with appropriate equipment for the species and class of livestock."
The four key principles against which standards should be tested (deWitte 2010) are:

1. Are they desirable for livestock welfare?
2. Are they feasible for industry and government to implement?
3. Are they important for the livestock-welfare regulatory framework?
4. Will they achieve the intended outcome for livestock welfare?

When the standards pertaining to stunning and slaughter are examined against these principles, it is clear that the majority of standards achieve the first (desirable for animal welfare), third (important for the livestock-welfare regulatory framework) and fourth (achieve the desired welfare outcome) principles, in that they encourage or mandate pre-slaughter stunning. However, principle 2 (feasible for industry and government to implement) is more difficult to meet in light of the difficulties in ascertaining insensibility in animals. Many standards rely heavily on equipment based performance indicators as a means of assessing compliance, but animal based indicators would be assumed to be a better measure of performance as discussed below.

4.4.3 Monitoring of stunning and slaughter

Within the standards reviewed, there are a variety of suggested approaches to ensuring appropriate control, ranging from a vague indication that monitoring should be carried out and procedures in place for corrective actions to be taken, to a detailed description of an auditing or monitoring system that should be used (see AMIC, 2009 and PISC, 2002). The parameters described range from prescriptive requirements regarding settings for equipment used, to animal based indicators of insensibility. EFSA (2004), for example, discusses a variety of equipment parameters that are expected to produce an effective stun, but when discussing monitoring aspects, focuses entirely on animal based indicators of insensibility. AMIC (2009) list a combination of animal-based and equipment based parameters to be used when monitoring and auditing animal welfare at slaughter.

Animal based performance indicators focus on the effectiveness of stun. For example, the AMIC Animal Welfare Standards (AMIC 2009) suggest that processors monitor:

- Correct stun on first shot (critical limit <95% of animals)
- Insensibility on the bleed rail (critical limit <100% of animals)
- Vocalisation at stun (critical limit >3% of animals)

In a commercial situation, it is impossible to utilise techniques such as EEG or ECoG to monitor the effectiveness of stunning. Therefore, behavioural indicators and responses to certain stimuli are used as surrogates. A summary of the indicators suggested by the standards reviewed is presented in Table 2 (mechanical stun) and Table 3 (electrical stun). It is important to note that regulatory documents, such as EC 1099/2009, FSIS directive 6900.2 and MS 1500/2009 do not give such detailed information – this is contained in the related codes of practice, industry standards and guides to good practice. For example, effective captive bolt stunning is evidenced by:

- Immediate collapse, hind legs tucked in then slowly extend, forelegs rigidly extended,
- Immediate and sustained absence of rhythmic breathing
- Fixed, staring eye with no corneal of palpebral reflex
- No righting reflex, no response to ear or nose pinch, no vocalisation

However, there is no consensus as to which of these signs are the most reliable indicators of insensibility. For mechanical stun, Gracey and Collins (1995) cite ‘no rhythmic breathing’ as the cardinal sign of insensibility, while Grandin (2002) advises processors to focus on “limp head, extended tongue and blank stare”, as described in the USDA Humane Handling Guidebook (USDA-FSIS 2009). Gouveia et al (2009) monitored 2800 cattle in a commercial slaughterhouse in Portugal, using the behavioural indicators suggested in the EFSA report on welfare aspects of animal stunning and killing methods (EFSA 2004). Animals were restrained in a conventional stunning box without head or body mechanical restrainers, and stunned using a contact-firing, 0.22 calibre, captive-bolt gun. The most common signs of ineffective stunning, as described by EFSA (2004), were muscle tone of the ears (17.8%), absence of muscle spasms in the back and legs (11.5%), presence of rhythmic breathing (9.4%), and vocalisation (7.9%). However in animals that demonstrated signs of recovery, the behavioural indicators recorded were most commonly lack of immediate collapse (100%), eyes rotated rather than fixed (91.3%), rhythmic breathing (91%) and response to nose or ear pinch (84.6%).

For electrical stunning, only the EFSA Scientific Opinion (EFSA 2004) and the AMIC Animal Welfare Standards (AMIC 2009) list behavioural indicators:

- Immediate collapse, hind legs tucked in, forelimbs rigidly extended
- Immediate onset of tonic (stiff) seizure that lasts for several seconds, followed by clonic (convulsing) seizure
- No rhythmic breathing
- Eyes rotated upwards, dilated pupils
- No response to nose prick

Table 2: Signs of effective stun in cattle or sheep listed in standards and codes of practice – mechanical stun

Behavioural sign	OIE Terrestrial Animal Health Code	EC 1099/2009	EFSA Scientific Opinion 2004	Australian PISC Model Code	AMIC animal welfare standard	Malaysian Standard MS 1500/2009	USDA Humane Handling Guidebook**
None listed		☑		☑		☑	
Immediate collapse	☑		☑		☑		
No attempt to stand up*	☑						☑
Body and muscles immediately rigid (tonic)	☑		☑		☑		
Lack of normal rhythmic breathing	☑		☑		☑		
Eye open and staring straight ahead / glazed expression	☑				☑		
No attempt to raise head					☑		
Ears relaxed and drooping					☑		
Tongue loose and flapping / hanging out					☑		☑
Corneal reflex absent			☑		☑		
No spontaneous eye blinking					☑		
Straight back and floppy head							☑
No vocalisation of any kind							☑
No response to painful stimulus			☑				
Gradual pupillary dilation			☑				

*The USDA Humane Handling Guidebook describes: “Absence of righting reflex, including an arched back”.
** The USDA Humane Handling Guidebook also lists indications that an animal is NOT properly stunned: Vocalisation, eye blinks, eye reflexes in response to touch, rhythmic breathing, curled tongue.

Table 3: Signs of effective stun in cattle or sheep listed in standards and codes of practice – electrical stun

Behavioural sign	OIE Terrestrial Animal Health Code	EC 1099/2009	EFSA Scientific Opinion 2004	Australian PISC Model Code	AMIC animal welfare standard	Malaysian Standard MS 1500/2009	USDA Humane Handling Guidebook
None listed	☑	☑		☑		☑	☑
Immediate collapse			☑		☑		
Epileptiform seizure (described in detail)			☑		☑		
Lack of normal rhythmic breathing			☑		☑		
No spontaneous eye blinking					☑		
Gasping (breathing in without breathing out) sometimes occurs					☑		
Upward rotation of eyes			☑				
Dilated pupils			☑				
No response to nose prick (painful stimulus)			☑				

EFSA (2004) considered that vocalisation during the induction of unconsciousness is indicative of pain or suffering: however, it must be noted that absence of vocalisation does not guarantee absence of pain or suffering. Similarly, the corneal reflex does not distinguish accurately between consciousness and unconsciousness, but if there is no corneal reflex, it is likely that the animal is unconscious (Anil and McKinstry 1991; Gregory and Grandin 2007). The response to painful stimuli, such as nose prick, is a good indicator of consciousness. Anil and McKinstry (1991) demonstrated that an animal that perceives pain will draw back from the nose prick, and this can be followed by return of the righting reflex. The return of rhythmic breathing suggests that the brainstem is resuming normal control over respiration, and therefore the animal is returning to consciousness. In electrically stunned pigs and sheep, the clonic phase appears to comprise two stages, the first stage being convulsive movements with no rhythmic breathing; and rhythmic breathing returning in the second stage (Anil 1991; Anil and McKinstry 1991; Velarde et al 2002).

A number of standards require equipment-based measures of performance, or an expectation that prescribed settings for equipment is used. For example, The AMIC animal Welfare Standards (AMIC 2009) suggest audit of electrical stun parameters:

- Minimum current flow: Cattle – 1.5A, Calves – 1.0A, Pigs – 1.3A, Sheep and Goats – 1.0A, Lambs 1.0A.
- Minimum stun duration should be 3 seconds.

The minimum currents are derived from research, and are supported in a number of papers (Cook et al 1991; Cook et al 1995; Gregory and Wotton 1984[a]; Gregory et al 1996; Lambooy and Spanjaard 1982; Velarde et al 2000; Velarde et al 2002). There appears however, to be little scientific evidence for the stipulated minimum duration, and industry feedback is that a 3-second application of stun to lambs is resulting in high levels of blood splash or ecchymosis in carcasses. Other standards and guidelines merely state that the equipment used should be appropriate for the species, size and class of animal, to achieve the outcome of insensibility. An over-reliance on equipment parameters in a welfare monitoring system is ill-advised, as it does not address the important issue of application. A misapplied stunning apparatus will still result in poor animal welfare outcomes despite the fact that the equipment parameters recorded were as per the recommendations in the standards and guidelines.

It is clear that animal-based indicators (Table 4), as opposed to equipment parameters (Table 5), are most likely to give an indication of maintained or returning sensibility, and are therefore the most logical indicators to use in monitoring the welfare status of the animals processed. However, it is also evident that no single parameter exists that would provide total confidence in the system, and, as such, a combination of indicators must be monitored. The suite of indicators identified by EFSA (2004) are probably the most comprehensive and practical to apply.

When referring to unstunned slaughter, monitoring procedures are absent or ill defined, and consist largely of the requirement not to carry out any further dressing procedure after exsanguination until the animal is insensible (FSIS 2011) or dead (OIE 2005).

Table 4: Animal based performance indicators listed in standards and codes of practice

Performance Indicator	OIE Terrestrial Animal Health Code	EC 1099/2009	EFSA Scientific Opinion 2004	Australian PISC Model Code	AMIC animal welfare standard	Malaysian Standard MS 1500/2009	USDA Humane Handling Guidebook
None listed							
Vocalisation					☑		☑
Correct stun first shot			☑		☑	☑	☑
Insensibility on the bleed rail			☑		☑		☑
Signs of unconsciousness	☑	☑		☑			☑

Table 5: Equipment or process based performance indicators listed in standards and codes of practice

Performance Indicator	OIE Terrestrial Animal Health Code	EC 1099/2009	EFSA Scientific Opinion 2004	Australian PISC Model Code	AMIC animal welfare standard	Malaysian Standard MS 1500/2009	USDA Humane Handling Guidebook
None listed			☑				
Electrical stun settings	☑ Specific parameters listed	☑ Specific parameters listed		☑	☑ Specific parameters listed	☑	
Mechanical stunner settings		☑ 'appropriate'			☑ 'appropriate' or 'manufacturer's recommendations.'	☑	
Equipment maintenance	☑			☑			☑
Stun to stick interval	☑			☑	☑		
Monitoring and corrective action procedures		☑		☑	☑		
Competent or trained employees	☑	☑		☑	☑		☑

5 Success in achieving objectives

The project objectives have been successfully completed.

This review has critically evaluated current scientific knowledge pertaining to the welfare risks to cattle and sheep that prevail during the immediate pre-slaughter period and slaughter. In addition, the welfare standards/codes and requirements from national and international sources were comparatively assessed. Based on this, recommendations were made to: (i) address identified knowledge gaps or deficiencies in the science and (ii) improve the identification of and development appropriate welfare standards at slaughter.

6 Impact on meat and livestock industry – now and in five years' time

The results of this review will assist the live export industry to determine where further research and development is required to optimise animal welfare at slaughter. Furthermore, the recommendations are designed to facilitate the identification and development of standards that better address and manage the welfare risks at slaughter particularly in importing countries. The main impact should occur in five years' time, when these knowledge gaps have been addressed and more effective standards have been implemented. This will enable the ongoing demonstration of improved animal welfare at slaughter in countries importing Australian livestock.

7 Conclusions and Recommendations

It is concluded that a significant body of research exists regarding the effects of pre-slaughter and slaughter factors on the welfare of cattle and sheep. To that end, there are no major theoretical knowledge gaps, but translation of that theory into commercial solutions warrants further development. One area where further R&D is warranted is slaughter without stunning and specifically, the significant welfare concern of prolonged loss of consciousness, particularly in cattle. Therefore, it is recommended further research be initiated to explore the optimization of head restraint to maximise blood flow following neck cutting and the identification of risk factors associated with prolonged sensibility during exsanguination (e.g. neck cut position). Effective stunning prior to slaughter is still seen as the best means for mitigating this risk and therefore, industry endeavours to increase adoption of stunning prior to slaughter in importing countries of Australian livestock are strongly encouraged. Optimisation of stunning also warrants R&D: translating the ‘concept of optimal pressure’ into reality could minimise the incidence of ineffective stuns.

The standards and guidelines reviewed present a range of requirements or recommendations to industry, in a variety of formats. Some are predominantly outcome based (e.g. the AMIC Animal Welfare Standards (AMIC 2009); others are more prescriptive in their requirements. Many demonstrate a combination of outcome based and prescriptive statements. Science underpins a large part of the standards and guidelines, but there are number of areas in which an ethical judgement must be made, in the absence of clear understanding of the effects of a particular situation on animal welfare. This ethical judgement considers not only the possible impact on animal welfare, but also the social mores of the community in which the judgement is made.

In terms of managing animal welfare risks within an international supply chain, significant differences can exist between the social and cultural expectations of the communities involved, and therefore, these moral and ethical judgements are difficult to make. Furthermore, implementing standards across a supply chain encompassing a number of different regulatory frameworks is fraught with difficulty. Enforcement of a non-legislative requirement is not possible, so the standards within a management system must be implementable by all stakeholders, and acceptable to all stakeholders. In developing such a management system for an inter-community supply chain, it is likely that no single existing standard or guideline meets these criteria, and it is suggested that the management system developed incorporates appropriate components from a variety of standards.

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