Rural Affairs and Transport Legislation Committee.

Animal Welfare Standards in Australia's Live Export Markets.

Submission by Dr Temple Grandin, World Leader in the Study of Animal Behaviour, Design of Facilities and Humane Slaughter.

The cattle handling shown on the videos from Indonesia shows animal abuse.

Cutting tendons and hitting cattle is not acceptable.

My website www.grandin.com has lots of information on basic cattle handling principles.

I recommend that Australian managers maintain ownership of the cattle until after they are slaughtered.

This would require building several slaughter houses in different parts of the country which would be staffed with Australian management.

The existing trip boxes are not acceptable. They should be replaced with one of three options:

1. Preslaughter stunning
2. Halal in an upright box with a head holder
3. Halal in a tilting box

Nonslip flooring is essential.

The OIE standard allows casting because in some parts of the developing world, it is the only practical method. However, when cattle are being brought in from a modern developed country, such as Australia, the standards should be higher.

The Australian industry needs to build and manage modern facilities in Indonesia.

Submitted by Dr Temple Grandin

Temple Grandin Ph.D

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Consultant and designer of livestock handling facilities, Grandin Livestock Handling Systems Inc.

EDUCATION:

B.A. (Psychology), Franklin Pierce College, 1970
M.S. (Animal Science), Arizona State University, 1975
Ph.D. (Animal Science), University of Illinois, 1989

AWARDS:

1984, Meritorious Service, Livestock Conservation Institute (now National Institute of Animal Agriculture)
1990, National Provisioner, Processing Stars of 1990
1990, Who's Who of American Women
1994, Golden Key National Honor Society, Honorary Member
1994, Industry Innovator's Award, Meat Marketing and Technology Magazine
1995, Industry Advancement Award, American Meat Institute
1995, Animal Management Award, American Society of Animal Science
1995, Harry C. Roswell Award, Scientists Center for Animal Welfare
1995, The Brownlee Award for International Leadership in Scientific Publication Promoting Respect for Animals, their Nature and Welfare, Animal Welfare Foundation of Canada, Vancouver, BC
1997, CAS/Miller Com 97 Campus Wide Lecture at the University of Illinois
1997, Profiled in Who's Who in America
1997, Alpha Zeta Centennial Honor Roll
1998, F.W. Presant Memorial Lecture, University of Guelph, Guelph, Ontario, Canada
1998, Forbes Award, National Meat Association
1998, Geraldine R. Dodge Foundation - Humane Ethics in Action, Purdue University, West Lafayette, IN
1999, Woman of the Year in Service to Agriculture, Progressive Farmer Magazine
1999, Humane Award, American Veterinary Medical Association
1999, Honary Doctorate, McGill University, Montreal, Quebec
1999, Named as one of the 26 Industry Influentials by Meat Marketing and Technology Magazine
1999, Animal Welfare Award, Animal Transportation Association
1999, Founders Award, American Society for the Prevention of Cruelty to Animals
2000, Temple Grandin profiled in The New York Times, Scientists at Work, McGraw Hill Books, New York, NY. pp. 48-57. Profile by Anne Raver
2001, Joseph Wood Krutch Medal - The Humane Society of the United States
2001, Knowlton Award for Innovation, Meat Marketing and Technology
2001, Wood Gush Memorial Lecture, International Society of Applied Ethology
2002, Richard L. Knowlton Innovation Award from Meat Marketing and Technology Magazine

2002, British Society of Animal Science, Yorkshire England, Animal Welfare Award Royal Society for the Prevention of Cruelty in Animals
2002, University of Illinois Alumni Illini Comeback Award. Five distinguished alumni are invited back each year during homecoming. Other comeback Illini for 2002, were an astronaut, university president, the inventor of Microsoft Office, and an administrator of a scholarship program
2003, Western Section American Society of Animal Science
2004, Honorary Doctorate of Science, University of Illinois
2004, President's Award, National Institute of Animal Agriculture
2004, The Beef Top 40: The 40 most influential people in the beef industry. Awarded on the 40th anniversary of Beef Magazine
2004, The Organic Style Magazine's Environmental Power List
2006, Animals in Translation was a Top Science Book of the Year in Discover Magazine, January 2006 p.74
2006, Frank H.T. Rhodes Class of 1956 Visiting Professor at Cornell University
2007, Autism Society of America Founder's Award
2007, Dept. of Health and Humane Services, Secretary's Highest Award, Washington D.C.
2008, Franklin Pierce College, Alumni Association: Leader of Conscience Award
2009, Honorary Doctorate - Swedish University, University of Agricultural Science, Uppsala, Sweden, Faculty of Veterinary Medicine, Degree in Animal Welfare
2009, Sharp Cleaver Award - Colorado and Wyoming Association of Meat Processors
2009, Meat Industry Hall of Fame, Chicago, Illinois
2009, Headliner Award, Livestock Publications Council, Fort Worth, Texas
2010, Fellow - American Society of Animal Science
2010, Inducted into the National Cowgirl Hall of Fame in Dallas, Texas
2010, Honorary Doctorate, Duke University
2010, Honorary Doctorate, Lakehead University
2010, Colorado Cattlemen's Assocation, Honorary Life Member
2010, National Cattlemen's Beef Association - Lifetime Achievement Award
2010, Oklahoma State University created an endowed professorship in animal behavior in honor of Temple Grandin

PROFESSIONAL MEMBERSHIPS:

American Society of Animal Science
American Society of Agricultural Engineers
American Society of Agricultural Consultants
American Registry of Professional Animal Scientists
National Institute of Animal Agriculture (formerly Livestock Conservation Institute)

BOOKS ON LIVESTOCK SUBJECTS:

Grandin T. 1993-2000, 2007. (Editor). Livestock Handling and Transport, CAB International, Wallingford, Oxon, United Kingdom. 2nd Edition, 2000. 3rd Edition, 2007.
Titles of chapters written by T. Grandin:

- Introduction: Management and economic factors of handling and transport.
- Behavioral principles of handling cattle and other grazing animals under extensive conditions.
- Handling facilities and restraint of range cattle.
- Handling and welfare of livestock in slaughter plants.

Grandin, T. 1995. Thinking in Pictures. Vintage Press (Division of Random House), New York, NY.
Grandin, T. 2000. Beef Cattle Behavior, Handling and Facilities Design. Grandin Livestock Handling Systems Inc., Fort Collins, CO.
Grandin, T. 1998 (Editor). Genetics and the Behavior of Domestic Animals. Academic Press, San Diego, CA.
Titles of chapters written by T. Grandin and M. Deesing:

- Behavioral genetics and animal science.
- Genetics and behavior during handling restraint and herding.
- Genetics and animal welfare.

Grandin T. and Johnson C., 2005. Animals in Translation. Scribner (Division of Simon and Schuster), New York, NY.
Grandin T. and Deesing M. 2008. Humane Livestock Handling. Storey Publishing, North Adams, Massachusetts.
Grandin T. and Johnson C. 2009. Animals Make Us Human. Houghton Mifflin Harcourt, New York, NY.
Grand in, T. 2009. Slaughter plants behavior and welfare assessment, Encyclopedia of Animal Behavior (online) ANBY: 00083 Elsevier (ln press, accepted for publication).
Grandin, T. 2010. Improving Animal Welfare: A Practical Approach, CABI Publishing, Wallingford, Oxfordshire UK. (ISBN-13-978-1-84593-541-2).
I wrote seven (7) chapters for this book and edited the chapters of eight (8) invited contributors. The chapters written by Temple Grandin include:

- Chapter 1 — The importance of measurement to improve the welfare of nmlivestock, poultry, and fish, pp. 1-20
- Chapter 3 — Implementing effective standards and scoring systems for assessing animal welfare on farms and slaughter plants, pp. 32-49
- Chapter 5 — How to improve livestock handling ad reduce stress, pp. 64-87
- Chapter 7 — Welfare during transport of livestock and poultry, pp. 115-138
- Chapter 8 — Improving livestock, poultry, and fish welfare in slaughter plants with auditing programs, pp. 160-185
- Chapter 11 — The effects of economic factors on the welfare of livestock and poultry, pp. 214-226
- Chapter 12 — Successful technology transfer of behavioral and animal welfare research to the farm and slaughter plant, pp. 274-289

VIDEOS OF LECTURES BY TEMPLE GRANDIN:

Cattle Handling Principles to Reduce Stress
Animal Handling in Meat Plants
Low Stress Handling of Pigs
Preventing Behavior Problems in your horse

Dr Temple Grandin Bio

Temple Grandin is Professor of Animal Science at Colorado State University, and is one of the world's leaders in the design of livestock handling facilities. She has designed livestock facilities throughout the United States and in Canada, Europe, Mexico, Australia, New Zealand and other countries. In North America, almost half of all cattle processing facilities include a center track restrainer system that she designed for meat plants. Her curved chute (race) systems are used worldwide and her writings on the flight zone and other principles of grazing animal behavior have helped many producers to reduce stress during handling. Dr. Grandin also designed an objective scoring system for assessing handling and stunning of cattle and pigs at meat plants. This system is being used by many large corporations to improve animal care.

Dr Grandin is a consultant for McDonalds and together they have transformed animal welfare in the entire beef industry across the USA.

Dr. Grandin has consulted with many different ranchers, feedlot owners, packers, and industry organizations for many years. At Colorado State University she maintains a limited number of graduate students and conducts research that assists in developing systems for animal handling and, in particular, with the reduction of stress and losses at slaughter plants. She has published several hundred industry publications, book chapters and technical papers on animal handling plus 62 refereed journal articles in addition to ten books. She maintains an appointment at Colorado State University where she has been active in making presentations to ranchers and farmers as well as those interested in the packing industry. She developed her own website (www.grandin.com) which contains her research papers and additional information on livestock behavior, cattle handling, humane slaughter, stunning methods, effects of stress on meat quality, and design information.

Dr Grandin has received numerous industry achievement awards and is recognized by many humane groups as the voice of reason. In 2010 HBO premiered a movie about Temple's early life and career with the livestock industry. The movie received seven Emmy awards, and she is also one of Time Magazines 100 most influential people.

ANIMAL WELFARE AND HUMANE SLAUGHTER

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(Updated November 2004)

Gary Smith and I originally wrote this paper in 1999. Since 1999, there have been many improvements in animal handling and stunning. Animal welfare audits by restaurant and supermarket companies have resulted in big improvements in many countries. Audits started by McDonald's Corporation and Wendy's International caused plant management to implement their own internal audits and do a better job training employees and operating equipment. Surveys done in both Europe and the U.S. that are outlined in this paper indicated that some plants had very poor animal welfare. More recent data in Grandin (2000) and data posted in the survey section of www.grandin.com shows that many plants have improved since this paper was written. Auditing of animal welfare in slaughter plants has greatly increased since 1999 in the U.S., Australia, New Zealand, and Europe. The USDA in the the U.S. has also increased enforcement of the Humane Slaughter Act. Animal welfare in slaughter plants in South America is also improving due to audits from restaurants and supermarkets.

Manteca (1998) says concern for animal welfare is a major consideration in meat production and is based upon the belief that animals can suffer. Welfare may be considered (Manteca, 1998) in terms of the subjective experiences of animals (measured using preference testing) or in terms of biological functioning (measured using reactions to stress including plasma levels of glucocorticoids, catecholamines, prolactin and endorphins as well as heart rate and brain levels of neurotransmitters). Meat consumers are increasingly demanding that animals be reared, handled, transported and slaughtered using humane practices (Appleby and Hughes, 1997). Public pressure for increased protection and welfare of animals comes primarily from people in largely urbanized populations, is inversely related to the proportion of a population that is engaged in agriculture and is increasing in importance throughout the world (Appleby et al., 1992). Concern about the welfare of animals is contingent on people believing that animals, if improperly cared for or mistreated, can experience pain and suffering (Dawkins, 1990). Research now clearly shows that mammals and birds feel pain and fear.

The most important factor determining whether a packing plant has good or bad animal welfare practices is the attitude of management personnel. Grandin (1998c) has said that, during her 25- year career, the plants that have good handling and stunning practices have a top manager who “cares” about animal welfare; as upper-management personnel change, handling and stunning improve or decline, depending largely upon the attitude of the new person. Purnell (1998) quotes Temple Grandin as saying “The best facilities and the latest technology make handling cattle easier but they don’t make the manager; and until the owner or manager is convinced that proper handling practices pay off economically, it’s unlikely that employees will follow procedures day-in and day-out. The manager that is most effective in maintaining high humane standards is involved enough in day-to-day operations to know and care, but not so involved that he or she becomes numb and desensitized (Grandin, 1994).

McGlone (1997), Grandin (1987) offers the following tips for handling swine: (a) Pigs will follow other pigs, so it's best to move small groups of pigs rather than single pigs. (b) Large groups (more than 15 pigs) are more difficult to direct and move than several small groups. (c) Plan ahead to allow appropriate time and set the route before you begin, making sure there is only one way for the pigs to go. (d) Move pigs in a slow, steady and calm manner. (e) Use paddles and sorting panels to move pigs rather than using electric prods. (e) Use the animal's flight zone to your advantage; because pigs can see in a wide range on either side, solid walls keep the animal's focus in front. (f) Pigs will explore as they go; they will investigate unique lighting, smells, surfaces, sounds and other animals. (g) On a day-to-day basis, touching pigs is a good idea but make sure each experience is positive. (h) Some genotypes of pigs tend to be more fearful of humans than others; so, genetics (selection for calm, easy-going types) is important. Grandin (1998e) said ultra lean hybrid pigs tend to display higher incidences of blood-splash and broken backs during slaughter and that those problems are especially evident in large, double-muscled pigs. Solving the problem will require changing genetics (Grandin, 1998e).

Grandin (1998d) believes that some cattle handling systems work like well-oiled machines, while others bog down with cattle that constantly balk and turn around. There are usually (Grandin, 1998d) three basic problems in crowd-pens and chutes: (a) Distractions, such as a chain hanging down in the chute entrance, that cause balking. (b) Poor handling methods, like overloading the crowd-pen with too many cattle. (c) Layout mistakes in the crowd-pen and chute.

When an animal welfare problem occurs in a plant, the cause of the problem must be determined. If the cause of the animal welfare problem is properly diagnosed, it will be easier to correct the problem. Critical to the process is identifying which of the following items is causing the problem: (1) Lack of supervision and training of employees. (2) Poor maintenance of stunning equipment, restraint systems, gates and other animal handling equipment (slick floors are a common maintenance problem). (3) Distractions that make animals balk and refuse to move (for example, inadequate lighting, air blowing toward approaching animals or animals being able to see people up ahead; Grandin, 1996a). (4) Condition of animals arriving at the plant. (It is difficult to humanely handle weak debilitated animals that are non-ambulatory. Pigs with an overly excitable temperament, that balk at minor things, create handling problems; these problems are often worse in very lean pigs. Producers should walk in their finishing pens and induce pigs to flow around them every day. This trains the pigs to quietly get up and move in the desired direction; only 10 or 15 seconds per pen per day, for the entire finishing period, is required to accomplish such training.) (5) Design problems with equipment. (Before going to the expense of changing equipment, items 1, 2, 3 and 4, above should be ruled-out as causes of the problem). A common design problem, that can create problems with animal handling, is a beef stunning box that is too wide.

Facco Silveira et al. (1998) reported that preslaughter stunning should render animals insensible to pain and that welfare perspectives have also made it imperative to ensure that animals do not suffer needlessly during slaughter; stunning methods must provide assurance that adverse effects (blood-splash, fractures and PSE meat) are avoided. Shaw and Jones (1988) used Fourier techniques to evaluate pre-stun and post-stun electroencephalograms (EEG) of adult cattle stunned with electricity or by use of a captive-bolt device and concluded that such procedure can be used to provide objective evidence of changes in the EEG signals following stunning to assess the effectiveness and humaneness of various stunning procedures. Numerous scientific studies show that properly done captive bolt and electrical stunning induce instantaineous insensibility (Gregory, 1998).

COMPARISONS OF ELECTRICAL STUNNING AND CO2 STUNNING

In the European Union, there is a legal requirement that all captive bolt and electrically stunned animals destined for meat consumption must be rendered insensible instantaneously and remain insensitive to pain until there is a complete loss of brain responsiveness due to exsanguination (Council Directive 93/119/C). Insensibility is not instantaineous with gas stunning. All animals stunned with gas must remain insensible until exsanguination (bleeding) has eliminated brain responsiveness. This is the main concern when the suitability of a stunning method is analyzed from an animal welfare point of view (Velarde et al., 1998). Internationally, the two most commonly used methods for commercial pre-slaughter stunning of pigs are electrical stunning and CO2 anesthetization. CO2 stunning is used more and more but electrical stunning is still widely used with the arguments for choice of method related to animal welfare and meat quality (Henckel, 1998).

MEAT QUALITY AND STUNNING

The physiological effect of the two most commonly used methods of pig stunning differs. CO2 anesthetization results in a lowering of the blood pH which leads to loss of consciousness (Eisele et al., 1967) and the electric current used in electrical stunning produces an epileptiform activity in the brain leading to unconsciousness without a simultaneous lowering of the blood pH (Hoenderken, 1978). Electrical stunning will, on the other hand, be followed by an acute fall of the muscle pH due to the powerful activation of the glycolysis in the muscles (Henckel, 1998). Individual differences, among animals, in the stress response are important in welfare issues; slaughter poses particular problems and neurophysiology has provided objective criteria to assess the effectiveness of electrical stunning (Monteca, 1998).

The current methods of stunning such as electroanaesthesia and CO2 exposure, are designed to induce physiological changes in the animal’s brain so as to render it insensitive before slaughter (Faucitana et al., 1998). From a meat quality standpoint, both electrical stunning and CO2 stunning affect the rate of postmortem muscle glycolysis in pigs due to increased muscle activity and elevated release of catecolamines into the blood (Troeger and Woltersdorf, 1990; Troeger, 1991). PSE incidence increases after use of electrical stunning (Van der Wal, 1978; Troeger and Woltersdorf, 1990) whereas CO2 stunning reduces incidence of PSE pork (Larsen, 1983).

Facco Silveira et al. (1998) compared unstunned/unrestrained slaughter to both electrical stunning and CO2 stunning of pigs and concluded that: (a) Any stress placed upon pigs immediately before slaughter should be avoided. (b) The relatively high glycolytic rate of unstunned/unrestrained animals highlights the need for care in handling swine in the period immediately prior to slaughter. (c) Muscle pH was higher and water-holding capacity was most desirable when pigs were CO2 stunned, intermediate when pigs were electrically stunned, and least desirable when pigs were unstunned/unrestrained. Henckel (1998) compared electrical stunning and CO2 stunning of market hogs and found that for pigs with similar genetic background (free from the Halothane gene) and with the same environmental exposure prior to stunning, electrical stunning resulted in twice the drip loss from the longissimus muscle with the same muscle pH and meat color.

EFFECT OF ABATTOIR MANAGEMENT ON STUNNING

Velarde et al. (1998) found a significant abattoir effect on all indicators of effectiveness of stunning, whereas the stunning method had a significative effect only on the percentages of animals: (a) showing no corneal reflex or (b) showing either the absence of corneal reflex or the absence of rhythmic breathing were absent ($P<0.10$). In Spanish plants, the proportion of animals showing absence of corneal reflex was lower on exiting the CO2 stunner than after electrical stunning (61.8 vs. 98.9%). For the combined onset of corneal reflex and rhythmic breathing, one abattoir had a lower index than others while one abattoir was intermediate and significantly lower than the remaining two plants equipped with the electrical stunning system. In well managed North American abattoirs using head to back cardiac arrest electric stunning less than 1 in 1,000 pigs exhibited a corneal reflex (Grandin, 1997b). Under commercial conditions, CO2 stunning was less effective in terms of the rapid onset of insensibility in pigs which may have been due to the stop/start manual nature of the system which can lead to a certain variability in the time of exposure to the gas of the pigs in the different positions in the well. Of the hoisted animals, 12.8% in one plant and 33.3% in another plant had signs of recovery from the stun (arched-back righting reflex caused by running the system beyond rated capacity, floppy head and rhythmic breathing) whereas the pigs stunned electrically did not show any signs of recovery on the bleeding rail (Velarde et al., 1998). Velarde et al. (1998) concluded that the administration of an electrical current with 220 V and 800 Hz spanning the brain, in combination with an electrical current with 110 V and 50 Hz passing through the heart, was more effective than the CO2 stunning system effectiveness, the exposure to the gas and the stun to stick interval must be considered carefully in order to prevent the animals from regaining sensitivity after stun. The differences in the efficiency of the two CO2 stunners evaluated underlines the importance of correct handling of the system (Velarde et al., 1998). The problems found be Velarde et al (1998) have been corrected in North American plants. See the survey section of www.grandin.com.

Faucitana et al. (1998) surveyed four commercial pig abattoirs, two of which used the Midas Stunning System (chest belt with an automatically applied, head only electrical stunner, followed by head-to-chest electrical stunner) and two of which used a Compact Carbon Dioxide Stunning Unit (filled with 83% CO2) and reported that the higher degree of muscle activity during the epileptic attack of electrically stunned pigs compared to gas-stunned pigs led to a higher incidence of PSE meat in their carcasses. The Faucitano et al. (1998) results agreed with the findings of Barton-Gade (1993) who observed an increased incidence (10 to 19%) of PSE in plants equipped with electrical stunning than in plants using CO2 stunning (PSE incidence of 2 to 6%).

ELECTRICAL STUNNING

Berghaus and Troeger (1998) reported that while most existing equipment for use in electrical stunning of pigs is based on the 50 Hz sinusoidal voltage available from the main power, producers of electrical stunning equipment now offer units with up to 800 Hz stunning frequencies. Use of the higher stunning frequencies for electrical stunning of pigs is purported to lessen problems with blood-splash and broken backs. The presence of an epileptic state is considered to be a guarantee of an effective electrical stun (Hoenderken, 1978, 1983); Simmons (1995) demonstrated that the minimum current required to induce epilepsy depends on the stunning frequency.

Velarde et al. (1998) reported that the electrical system is the most widely used stunning method in the European Union, and that it consists of passing electricity through the brain to produce instantaneous insensibility; stunning is achieved by inducing a tonic/clonic epileptic fit, before any pain stimulus associated with the application itself is detected and transmitted to the central nervous system (15 milliseconds). Velarde et al. (1998) said that due to its adverse effects on meat quality and on animal welfare (recovery of sensibility) in many Spanish abattoirs the traditional head-only electrical stunning has been replaced by the head-to-chest electrical stunner combined with the chest-belt restrainer (Midas system). The application of the cardiac arrest cycle has a major animal welfare advantage in that it promotes the start of death at the point of stun and relegates sticking to a method of removing blood from the carcass (Wotton and Gregory, 1986).

Velarde et al. (1998) reported that, in agreement with Wotton and Gregory (1986), the utilization of the head-to-chest device for pig stunning led to the instantaneous and irreversible onset of insensibility in 98.7% of the animals, although in s out 16% of the cases studied it was observed that the electrical tongs were not exactly positioned between the eyes and ears on the pig's head. It seems, therefore, that if a high voltage current is applied on the head, the accuracy of the electrode placement on the head is not so important (Velarde et al., 1998). Grandin 1997a,b, 1994 emphasizes the importance of never applying the electrodes to the animal's neck. In most well managed North American plants, the stunning tongs are placed correctly on over 99% of the pigs. See the survey section on www.grandin.com. Grandin (2001) found that placing the tongs in the wrong location was a major cause of return to sensibility. An article in Pork '98 (1998) quotes Nicola Simmons, a New Zealand animal scientist, as saying electrtical stunning of swine has negative effects in the form of high amounts of carcass damage (broken bones and blood-splash) and negative meat-quality effects (decreased tenderness, increased drip loss and paler muscle color) but it is the most economical form of stunning and it is the most favorable from an animal welfare standpoint of all commercially available pig-stunning systems. To minimize the negative effects of electrical stunning on the incidence of PSE in pork, an automatic head-only and head-to-chest electrical stunner has been developed which induces a cardiac-arrest cycle and eventually produces a reduction of the clonic convulsions of the animal at sticking due to the inhibition of the spinal nerve function (Gilbert et al., 1984). The lower degree of muscule activity during the clonic phase would impede the onset of the PSE condition (Grandin, 1985).

Berghaus and Troeger (1998) evaluated animal welfare implications of higher frequency (500 or 800 Hz) electrical stunning in comparison to "normal" (50 Hz) stunning and concluded that: (a) All stunning frequencies tested (50, 500, 800 Hz) caused an effective stun (epileptic fit) within a minimum current flow time (1.3 ampere constant) of 0.3 seconds. (b) The minimum electrical charge (ampere x seconds) to induce epilepsy under laboratory conditions can be calculated within 0.4 Coulomb; this is less than 1/10 of the amount resulting after usual stunning operations (current flow time of 4 seconds). (Troeger and Woltersdorf, 1998, reported that a higher electrical charge during stunning causes deterioration in meat quality characteristics.) (c) The use of higher stunning frequencies did not result in a reduction of time of unconsciousness under laboratory conditions, as was described by Anil and McKinstry (1992). On the contrary, the duration of the tonic phase was longer with 800 Hz stunning frequency than with 50 Hz stunning and the recovery of breathing was delayed after 500 Hz stunning as compared with 50 Hz stunning. (d) All stunning frequencies tested were in conformance with animal welfare demands. The difference may be explained by the fact that Anil and McKinstry used very high frequencies of over 1,500 hz.

To insure that animals are instantly rendered insensible, electrical stunning must be applied correctly. Electrical stunning equipment must operate within electrical parameters which have been verified by scientific research to induce instantaneous insensibility (Grandin, 1997a). Scientific research has shown that an electrical stunner must have sufficient amperage to induce a grand mal seizure to insure that the animal will be made instantly insensible. Insufficient amperage can cause an animal to be paralyzed without losing sensibility. For market-weight pigs, a minimum of 1.25 amps is required (Hoenderken, 1983). For sheep, a minimum of 1.00 amp is required (Gregory and Wooton, 1984; Gilbert et al., 1991). These amperages must be maintained for one second, during stunning, to induce instant insensibility. The Council of Europe (1991) recommends use of the afore-mentioned minimum amperages during electrical stunning for pigs and sheep.

There must be sufficient voltage, during electrical stunning, to deliver the recommended minimum amperage; 250 volts is the recommended minimum voltage for pigs to insure insensibility (Troeger and Woltersdorf, 1989). Research has also shown that too high an electrical frequency will result in failure to induce insensibility. Warrington (1974) found that insensibility was most effectively induced at frequencies of 50 cycles. Frequencies at 2000 to 3000 hz failed to induce instant insensibility and may cause pain (Croft, 1952; Van der Wal, 1978). However, in pigs weighing under 200 lbs (80 kg), Anil and McKinstry (1992) found that high frequency, 1592 hz sinewave or 1642 hz square-wave, head-only for stunning at 800 ma (0.80 amp) would induce seizure activity and insensibility in small pigs. One disadvantage of stunning under the aforementioned conditions, is that the pigs regain sensibility more quickly than do pigs stunned using frequencies of 50 to 60 cycles. The pigs in the latter experiment (Anil and McKinstry, 1992) weighed one-third less than comparable U.S. market pigs and this probably explains why the lower amperages were effective.

Some plants stun animals using amperages below those recommended as the minimum by the Council of Europe (1991) in an attempt to reduce blood spots in the meat. Stunning market-weight pigs with less than 1.25 amps should not be permitted (Hoenderken, 1983; Grandin, 1994a) unless use of different electrical parameters are verified by either electrical or neurotransmitter recordings from the brain. Grandin (1997a) believes that, because only a 1 second application at 1.25 amps is required to induce instant insensibility in market-weight pigs, plants should be permitted to use circuits which lower the amperage setting after an initial, 1 second stun, at 1.25 amps for pigs or at 1 amp for sheep. Plants should also be encouraged to use electronic-constant amperage circuits which prevent amperage spiking (Grandin, 1997a, 1985). Both practical experience and research have shown that the aforementioned types of circuits greatly reduce petechial hemorrhages (blood spots) in carcass muscles (Grandin, 1985; Blackmore and Peterson, 1981).

Because U.S. market pigs are slaughtered at heavier weights than are European pigs, an electrical stunner must deliver the minimum amperage recommended by the Council of Europe (1991) to insure instantaneous insensibility. Grandin (1997a) believes that high-frequency stunning (at frequencies higher than those tested by Anil and McKinstry, 1992) should not be permitted in the U.S. until research is conducted to prove that such stunning is capable of inducing an instantaneous grand mal seizure in heavier, U.S. market-weight pigs. In the Anil and McKinstry (1992) experiment, the pigs were stunned with a head-only applicator. High frequency stunning has never been verified to induce instant insensibility when applied with a head-to-body, cardiac arrest, stunning electrode (the type of electrode used in almost all large U.S. pork slaughter plants). In the Velard et al., 1998 study the pigs were stunned with a high frequency 800 hz current through the brain and then a second 50 hz current was passed through the heart to induce cardiac arrest. The high frequency 800 hz current was effective with this “split stun procedure.” In most U.S. plants, a single current is passed from head to body, and frequencies of over 50 to 60 hz are still not verified when used with an electrode where a single current is passed from the head to the body. Grandin (1997a) recommends that when a single current is passed from head to body the first 1 second should be a minimum of 1.25 amps at 50 to 60 hz. Therefore, Grandin (1998c) recommends that higher frequencies should only be used when they are passed through two electrodes on the head. Research is still needed to verify insensibility when frequencies over 60 hz are passed from head to body.

Electrical stunning of cattle requires a two-phase stun whereas pigs and sheep are electrically stunned by use of a single-phase application of current. Due to the large size of cattle, a current must first be applied across the head to render the animal insensible before a second current is applied from the head to body to induce cardiac arrest (Gregory, 1993). A single 400 volt, 1.5 amp current passed from the neck to the brisket failed to induce epileptic form changes in the brain (Cook et al., 1991). To insure that the electrodes remain in firm contact with the bovine animal’s head for the duration of the stun, the animal’s head must be restrained in a mechanical apparatus. The Council of Europe (1991) requires a minimum of 2.5 amps applied across the head to induce immediate epileptiform activity in the EEG of large cattle. A frequency of 50 or 60 cycles should be used unless higher frequencies are verified by either electrical or neurotransmitter measurements taken from the brain. More recent research has shown that 1.2 amps for 2 seconds is effective (Wotton and Gregory, 2000). For more information on electric stunning of cattle, see the humane slaughter section of www.grandin.com.

For all species, electrodes must be cleaned frequently to insure that a good electrical connection occurs between stunner and animal. The minimum cleaning schedule is once a day; and, for safety, the electrode wand must be disconnected from the power supply before cleaning. Adequate electrical parameters for cardiac arrest stunning cannot be verified by clinical signs, because cardiac arrest masks the clinical signs of a seizure. Measurement of brain function is required to verify any new electrical parameters which may be used in the future (Grandin, 1997a).

If head-only stunning is used, the tongs must be placed so that the current passes through the brain (Croft, 1952; Warrington, 1974). Tongs may be placed on both sides of the head or one tong can be placed on the top and the other tong placed on the bottom of the head. Another scientifically verified location for head-only stunning is with one electrode placed under the jaw, and the other electrode placed on side of the neck right behind the ears. For cardiac-arrest stunning of pigs and sheep, one electrode must be placed on the head and the other electrode may be placed at any location on the body to induce cardiac arrest. The head electrode may be placed on the forehead, side of the head, top of the head, under the jaw, or in the hollow behind the ear, but must never be placed on the neck because this would cause the current to bypass the brain. Electrodes must not be applied to sensitive areas such as inside the ear, in the eye or in the rectum.

When head-only reversible stunning is used, the animal must be bled promptly to prevent return to sensibility. Hoenderken (1983) states that pigs must be bled within 30 seconds, whereas Blackmore and Newhook (1981) recommend that they be bled within 15 seconds, to insure that they remain insensible throughout bleed-out. Grandin (1994) observed that in some small locker plants which used a slow hoist for elevating electrically stunned pigs, proper bleed- out was not accomplished within 30 seconds.

CAPTIVE-BOLT STUNNING

The most common cause of low efficacy scores for use of captive-bolt stunning in the USDA Survey was poor maintenance of the captive-bolt stunner (Grandin, 1998b). Captive-bolt stunners must be cleaned and serviced, following the manufacturer's recommendations, to maintain maximum hitting power and to prevent misfiring or partial-firing. High bolt velocity causes a concussion that induces instantaneous insensibility (Daly and Whittington, 1989; Blackmore, 1985). Each plant should develop a system of verified maintenance for captive-bolt stunners. Pneumatic-powered captive-bolt stunners must be operated at the air pressure recommended by the manufacturer. A major cause of failure to render animals insensible with one captive-bolt shot is poor ergonomic design (some pneumatic stunners are so bulky it is very difficult to achieve correct stunner placement on the animal's forehead). Ergonomics can sometimes be improved by use of a handle extension and improved balancers.

Aversive methods of restraint which cause 3% or more of the cattle or pigs to vocalize must not be used as a substitute for improvements in ergonomics of captive-bolt stunners. Electrical immobilization must never be used as a method for restraining sensible animals prior to or during stunning. Several scientific studies have shown that electrical immobilization is highly aversive (Lambooy, 1985; Pascoe, 1986; Grandin et al., 1986; Rushen, 1986). Assessment of animal discomfort by counting vocalizations is impossible to achieve in electrically immobilized animals because paralysis prevents vocalization. Electrical immobilization must not be confused with electrical stunning. Properly done, electrical stunning passes a high amperage current through the brian and induces instantaneous insensibility. Electrical immobilization holds a sensible animal still, by paralyzing its muscles, and does not induce epileptiform changes in the EEG (Lambooy, 1985).

A third cause of missed captive-bolt stunner shots is an overloaded or fatigued operator. Assessment of stunning efficacy at the end of the shift will pinpoint this problem. In some large plants, prevention of the overloading/fatigue problem may require employment of two captive- bolt stunner operators or frequent rotation of cross-trained operators.

Research has shown that, for cattle, the most effective position for captive-bolt placement, to induce instantaneous insensibility, is in the middle of the forehead (Daly and Whittington, 1989). The hollow behind the poll should be avoided as a site for captive-bolt stunning except in large Bos indicus cattle which have a bony ridge in the forehead which makes captive-bolt stunning more difficult.

Observations of cattle stunning indicate that, under field conditions, penetrating captive- bolt stunners are more effective than non-penetrating captive-bolt stunners that have a mushroom-type head; observations in many plants indicate that there is less margin for error with non-penetrating captive-bolt stunners and the shot must be exactly on target to render the animal instantly insensible.

The use of a mechanical head restraint will improve the accuracy of captive-bolt stunning, but it can increase stress if it is improperly used (Ewbank and Parker, 1992). To minimize stress, the animal should be stunned within five seconds after its head is restrained. If more than 3% of the cattle vocalize (moo or bellow), the head restraint device will have to be modified to reduce stress. Animals should enter the head restraint easily, with a minimum of prodding.

CARBON DIOXIDE STUNNING

There has been controversy about the humaneness of carbon dioxide (CO2) stunning. Velarde et al. (1998) reported that, as in other countries, the use of CO2 stunning has recently increased in popularity in the European Union but its acceptability on welfare grounds has been questioned by several researchers. Gregory et al. (1987) examined the effectiveness of a compact stunner and suggested that insensibility is not instantaneous and narcosis began 30 to 39 seconds after the start of immersion procedure. Additionally, the exposure to the gas stimulates breathing frequency and may lead to respiratory distress (Raj and Gregory, 1995). On the other hand, from the study of the changes occurring in the EEG patterns of pigs, Forslid (1987) observed that pigs reach insensibility before the onset of the violent motor activity. Some people who are interested in animal welfare claim that CO2 stunning is extremely aversive to pigs while other people claim it is humane. Both practical experience and scientific studies indicate that genetic factors play a large role in determining the aversiveness of CO2 gas to pigs. For some genetic types of pigs, use of CO2 stunning is probably very humane and for other genetic types of pigs it may be very stressful.

Ring (1988) concluded that because pigs stunned with N2 in his study, in spite of lower PaO2 than the CO2-stunned pigs, did not show any signs of restlessness, choking attacks, collapsing or flight reflexes for two minutes, stunning with CO2 cannot be considered to be caused by hypoxia. Furthermore, Ring (1988) observed that, during the time before the stage of analgesia was experienced, the pigs were fully conscious; so, during this stage, unpleasant feelings cannot be excluded, but obvious signs of unpleasant feelings were not noticed. After the stage of excitation, the animals passed the stage of asphyxia when they were exsanguinated. Barfod and Madsen (1988) concluded that the loss of consciousness during CO2 anesthetization is rapid and is similar to other forms of narcosis and, therefore, it appears to be an acceptable method for preslaughter stunning. Forslid (1988) reported that determinations of plasma cortisol, adrenalin and noradrenalin did not provide any direct evidence that the inhalation of CO2 imposed any emotional strain in addition to that induced by the mere transport of the swine to the intermediate pre-exposure situation.

Dutch research indicated that the excitation phase which occurs during CO2 stunning starts prior to the onset of unconsciousness (Hoenderken et al., 1983); this study raised the question of potential distress in pigs during the induction of CO2 anesthesia. More recently, research by Forslid (1987) indicated that unconsciousness occurred prior to the onset of the excitation phase, therefore, CO2 stunning is definitely humane. All of the research conducted by Anders Forslid at the Swedish Meat Research Institute has been on Yorkshire pigs (Forslid, 1991). In Yorkshire X Landrace crossbred pigs, exposure to CO2 was less aversive than were electrical shocks (Jongman et al., 1998). Aversion was measured by determining the time required to enter and re-enter a CO2 machine after being exposed to the gas or to an electrical shock. Other studies have shown that there is large variation among pigs with regard to their reaction to CO2 (Dodman, 1977; Grandin, 1988a). Grandin (1988a) observed, in a commercial slaughter plant in the U.S., that white crossbred pigs (with Yorkshire breedtype characteristics) had a much milder reaction to CO2 than black, white-striped crossbred pigs (with Hampshire breedtype characteristics).

Grandin (1988a) concluded that the effect of genetic stress susceptibility on reaction to CO_2 needs to be studied because, possibly, CO_2 may be acceptable from an animal welfare standpoint for some breeds or genetic lines within a breed and not acceptable for other breeds or genetic lines within a breed. Excitement and rough handling prior to entry into the Compact plant may also affect the animal's reaction; so, there is a possibility that rough handling may have a large effect on pig reaction in one breed and little effect on pig reaction in another breed or genetic line within a breed (Grandin, 1998a).

Many of the Hampshire-type pigs, when stunned in a Wernberg Compact plant, started to react in the first few seconds after they contacted the gas. Hampshire-type pigs rode quietly in the gondola until they contacted the gas; they then attempted to rear up to avoid the gas while they were fully conscious (Grandin, 1988a). Grandin (1998c) observed that Danish pigs (which have a very low incidence of the Halothane gene) remained calm when they breathed CO_2, but that Irish pigs (which have a high incidence of the Halothane gene) became highly agitated within seconds after sniffing the gas.

Experiments with Pietrain X German Landrace pigs indicated that Halothane-positive pigs had a more vigorous reaction to CO_2 than Halothane-negative pigs (Troeger and Woltersdorf, 1991). These pigs had little or no reaction during initial contact with the gas; the reaction started about 20 seconds after the animals contacted the gas. Seventy percent of the Halothane-positive pigs had strong motoric reactions while only 29% of the Halothane-negative pigs reacted in this manner. Troeger and Woltersdorf (1991) expressed concern that reactions in Halothane-positive animals may possibly be of animal welfare concern but concluded that the use of high CO_2 concentrations (80% or greater) reduced the incidence of vigorous reaction.

An earlier German study with pigs of unspecified genetics indicated that the animals were anesthetized before the excitation phase (Ring, 1988). It is likely that some Halothane-positive pigs were tested in the Ring (1988) investigation but further studies with both Halothane-positive and Halothane-negative Hampshire pigs are still needed. The effect of the Napole gene in the Hampshire breed also needs to be researched because many of the bad reactors in the Ring (1988) study had Hampshire coloration (Grandin, 1998a).

Human beings also vary in their reaction to CO_2. People who have panic attacks which have a strong genetic basis will react very badly to CO_2; the gas may induce panic attacks in these people (Griez, 1990; Bellodi et al., 1998). Lambooy (1990) reported that Neville Gregory from the Meat Research Institute in England reviewed a number of studies that indicated that most people find the smell of CO_2 gas to be pungent when it is breathed at a concentration of 50% (Lambooy, 1990).

In conclusion, CO_2 stunning is probably very humane for use with certain genetic types of pigs and stressful for pigs of other genetic types. The use of a mixture of CO_2 and argon gas may create an improved gas stunning system for poultry (Raj and Gregory, 1994). It is possible that a combination of CO_2 and argon might make CO_2 stunning less stressful for genetic types of pigs which react badly to CO_2. Any research studies conducted to determine animal welfare aspects of gas stunning should use populations of pigs that include those that are both positive and negative for the Halothane gene and for the Napole gene.

ASSESSING INSENSIBILITY

Blackmore (1988) concluded that reflexes used to judge the depth of chemical general anesthetics are inappropriate to assess the state of sensibility of an animal during slaughter; thus, it is impossible to assess whether or not a slaughter process is humane by examination of individual animals at the abattoir. He believes, though, that sufficient information is now available to be able to construct specifications of a slaughter process which can be considered, with a high degree of confidence, to be humane (Blackmore, 1988). However, if an animal shows any signs of return to sensibility this is an indication of an obvious problem that must be corrected.

To assess insensibility in a meat plant one should look at the stunned animal's head and ignore the reflexes occurring in the body. Reflexive movements and kicking will occur in insensible animals that have been properly stunned with electricity or a captive-bolt stunner. The mistake many people make is to look at leg kicking. Random limb movement can create a safety hazard when large cattle kick, and, this activity can occur in an unconscious animal.

When cattle or sheep are shot with a captive bolt, the animal should instantly drop to the floor if it is stunned in a box. In a conveyor restrainer, the head should drop down. It is normal for the head to go into a spasm for a few seconds before it drops. Insensibility in cattle can be evaluated immediately after the head spasm. In electrically stunned cattle, sheep or pigs, stunning induces a grand mal seizure which causes instant unconsciousness. This seizure causes rigid spasms which last for at least 30 seconds; these spasms can mask signs of insensibility. Under commercial conditions, the animal should not be evaluated for insensibility until 30 seconds after electric stunning. For more information on solving return to sensibility problems, refer to Grandin (2001) or the humane slaughter section of www.grandin.com.

At no time, either during or after stunning should the animal vocalize (squeal, moo or bellow). Vocalization is a sign that a sensible animal may be feeling pain. It is easy to evaluate insensibility after an animal is hanging vertically on the bleed rail; it should hang straight down and have a straight back, and the head should be limp and floppy (Grandin, 1994, 1997a). If the stunned animal has kicking reflexes, the head should flop like a limp rag. If the animal makes any attempt to raise its head, it may still be sensible. An animal showing a righting reflex must be immediately re-stunned. There should also be no rhythmic breathing and no eye reflexes in response to touch. Blinking is another sign of an animal that has not been properly stunned and thus may still be sensible. Gasping is permissible; it is a sign of a dying brain (Gregory, 1994). If the tongue is hanging straight down and is limp and floppy, the animal is definitely stunned; if the tongue is curled, this is a sign of possible sensibility.

INSENSIBILITY IN POULTRY AND GAS-STUNNED ANIMALS

Do these same principles for determining insensibility apply to poultry or animals stunned by use of gas? The answer is definitely "yes." The principles of determining insensibility are the same in all animals and birds. The heads of chickens or turkeys that have been stunned with electricity or gas should hang straight down after stunning. Birds which have not been properly stunned will show a strong righting reflex and raise their heads. Both mammals and birds which have been stunned with $CO2$ should be limp and floppy. Gas-stunned mammals and birds should not have reflexive movements and should not display kicking actions. The entire body and head should be flaccid and floppy. Any animal which shows eye reflexes or a righting reflex is not properly stunned.

RITUAL SLAUGHTER

Ritual slaughter is performed according to the dietary codes of Jews or Muslims. Cattle, sheep or goats are exsanguinated by a throat cut without first being rendered unconscious by pre- slaughter stunning. Ritual slaughter is exempt from the Humane Methods of Slaughter Act of 1978 in order to protect religious freedom in the U.S.; in Europe and Canada, however, ritual slaughter is covered by humane slaughter regulations. Because ritual slaughter is exempt in the U.S., some plants use cruel methods of restraint, such as suspending a conscious animal by a chain wrapped around one hind-limb. In more progressive plants, the animal is placed in a restrainer that holds it in a comfortable, upright position.

The latest guidelines for ritual slaughter, published by the American Meat Institute (Grandin, 1997a), strongly recommend the use of upright restraint devices. Most large cattle slaughter plants are using more comfortable methods of restraint, but there are still some plant managers who have no regard for animal welfare. They persist in hanging large cattle and veal calves upside down by one hind-leg. There is no religious justification for use of this cruel method of restraint. The plants that suspend cattle/calves by one hind-leg do so in order to avoid paying the cost of installing a humane restraint device. Humane restraint devices can often pay for themselves by improving employee safety (Grandin, 1995, 1991a).

When ritual slaughter is being evaluated from an animal welfare standpoint, the variable of restraint method must be separated from the act of throat cutting without prior stunning. Distressful restraint methods mask the animals' reactions to its throat being cut. Four state-of-the-art restraint devices have been designed, built and operated that hold cattle and calves in a comfortable upright position during kosher (Jewish) slaughter (Grandin, 1994; Grandin and Regenstein, 1994). To determine whether cattle feel the act of having their throat cut, Grandin (1994), at one plant, deliberately applied the head restrainer so lightly that the animals could pull their heads out; none of the 10 cattle moved or attempted to pull their heads out. Observations of hundreds of cattle and calves during kosher slaughter indicated that there was a slight quiver when the knife first contacted the throat (Grandin, 1994). Invasion of the cattle's flight zone by touching its head caused a bigger reaction (Grandin, 1994, 1993b) than did the act of having its throat cut. The animal's head must be restrained in such a manner that the incision does not close back over the knife. Cattle and sheep will struggle violently if the edges of the incision touch during the cut (Grandin, 1994).

The design of the knife and the cutting technique are critical for preventing the animal from reacting to an incision of its throat. In kosher slaughter, a straight, razor-sharp knife that is twice the width of the throat is required, and the cut must be made in a single continuous motion. For halal (Muslim) slaughter, there is no knife-design requirement. Halal slaughter performed with short knives and multiple hacking cuts results in vigorous reactions of cattle being treated in this manner. Fortunately, many Muslim religious authorities accept preslaughter stunning. Muslims should be encouraged to stun the cattle or to use long, straight, razor-sharp knives that are similar to the knives used for kosher slaughter.

Investigators agree that throat-cutting without stunning does not induce instantaneous unconsciousness. In some cattle, consciousness is prolonged for over 60 seconds (Blackmore, 1984; Daly et al., 1988). Grandin (1994) observed that near-immediate collapse can be induced in over 95% of cattle if the ritual slaughterer makes a rapid, deep cut close to the jawbone. Further observations indicated that calm cows and bulls lose sensibility and collapse more quickly than do cattle with visible signs of agitation (Grandin, 1994). Cattle that fight restraint are more likely to have prolonged sensibility; gentle operation of restraint devices facilities rapid loss of sensibility.

To provide the best possible animal welfare, restraint devices must be operated correctly. The most common problems in restraining animals involve applying excessive pressure to the body. If more than 5% of the cattle vocalize or struggle in the restraint device, it is either poorly designed or it is operated too roughly. A survey done in plants performing kosher slaughter in an upright restraint system indicated that under 5% of the cattle vocalized when the system was operated correctly (Grandin, 1997b). Dunn (1990) found that significantly more cattle vocalized when they were inverted onto their backs for ritual slaughter as compared to the number of cattle that vocalized when they were held in a restrainer that kept them in an upright position. Higher cortisol levels were also correlated with higher rates of vocalization (Dunn, 1990). Plants that shackle and hoist large cattle often have loud bellowing by more than 50% of the animals treated in that manner. In some cases, those vocalizations can be heard outside the building. Instructions for proper operation and design of comfortable upright restraint devices can be found on the internet at www.grandin.com and in papers by Grandin (1991b, 1992, 1993b, 1994, 1995). The use of comfortable restraining equipment complies with the religious principles of both halal and kosher slaughter. Kosher and halal slaughter were originally developed to spare the animal pain (Grandin and Regenstein, 1994).

OBJECTIVE SCORING OF ANIMAL WELFARE

The American Meat Institute Guidelines (Grandin, 1997a) outline objective scoring methods which can be used to assess animal welfare. The advantage of objective scoring is that different people will be able to provide comparable assessments of animal welfare (Grandin, 1998b). Those guidelines are a supplement to the 1991a Recommended Animal Handlilng Guideline for Meat Packers; the main emphasis of such guidelines is with regard to use of animal-welfare performance standards which can be objectively scored as an alternative to specifying equipment design or specific practices. Scoring procedures for assessing animal welfare, and recommendations which will help improve animal welfare are described in the Guidelines. The recommended scoring procedures are simple enough to be conducted easily under commercial conditions, and they should be conducted a minimum of once a week. Scoring should be done at both the beginning and the end of a shift to determine the effect of employee fatigue. If a score falls below the acceptable range specified in the Guidelines, plant management personnel should take steps to correct the problem. The results of the Survey of Stunning and Handling in Federally Inspected Beef, Pork, Veal and Sheep Slaughter Plants (sponsored by USDA's Animal and Plant Health Inspection Service) indicated that the recommended minimum acceptable levels specified in this guide can be achieved easily and at a minimal of expense (Grandin, 1998b). Objective scoring should be done in those areas of the plant that are critical control points for good animal welfare. The minimum acceptable percentage scores used in the survey (Grandin, 1997a, 1997b) were determined by the survey's author based on more than 20 years of practical experience in over 100 different slaughter plants. In conducting the survey, Grandin (1998b) considered the following: (1) Percentage of pigs or sheep on which the electrical stunner was placed in the wrong position. (2) Percentage of cattle that had to be shot more than once with the captive-bolt stunner. (3) Percentage of sensible and partially sensible animals on the bleed rail. (4) Percentage of animals falling down or slipping. (5) Percentage of cattle vocalizing in the stunning chute area (the stunning chute area includes the stunning box, restrainer, lead-up chute and crowd pen). (6) Percentage of pigs vocalizing in the stunning pen or on the restrainer conveyor. (7) Percentage of animals subjected to an electric prod. (8) Percentage of non-ambulatory animals and procedures used to move such animals to the stunning/sticking area (scoring procedures need to be developed at this critical control point).

- (I) Electrical Stunning And Electrode Placement Efficacy Criteria—(Score a minimum of 100 pigs or sheep in large plants). (a) Excellent. 99.5 to 100% correct placement of stunning wand or tongs. (b) Acceptable. 99.4 to 99% correct placement of stunning wand or tongs. (c) Not Acceptable. 98% to 95% correct placement of stunning wand or tongs; or, 4% or more of the pigs vocalizing due to energizing the electrodes before they are firmly positioned. (d) Serious Problem. Less than 95% correct placement of stunning wand or tongs; or, more than 4% vocalizing in response to improper electrode placement.
- (II) Captive-Bolt Stunning Efficacy Criteria—(Score a minimum of 100 animals in large plants). (a) Excellent. 99 to 100% instantly rendered insensible with one shot. (b) Acceptable. 95 to 98% instantly rendered insensible with one shot. (c) Not Acceptable. 90 to 94% instantly rendered insensible with one shot. (d) Serious Problem. Less than 90% instantly rendered insensible with one shot. If one-shot efficacy falls below 95%, immediate action must be taken to improve the percentage. If the first shot fails to induce instantaneous insensibility, the animal must be immediately re-stunned.
- (III) Considerations For Penetrating Captive-Bolt Stunning, Bleed-Out Interval—Does not have to be measured for animal welfare evaluations unless a non-penetrating captive-bolt is used. Additional study is needed to determine the recommended interval for time to render the animal insensible for non-penetrating captive-bolt stunning. All of the plants surveyed by Grandin (1998b) used penetrating captive-bolt stunners.
- (IV) Considerations For Electrical Stunning Bleeding Interval And Cardiac Arrest— Bleeding should occur within 60 seconds. All of the large plants surveyed by Grandin (1998b) were achieving cardiac arrest in less than 60 seconds.
- (V) Considerations For Head-Only, Reversible Electrical Stunning. Fifteen seconds is strongly recommended (Blackmore and Newhook, 1981) and 30 seconds is the maximum recommended (Hoenderken, 1983) to maintain insensibility. Scientific research clearly shows that pigs will start returning to sensibility after 30 seconds when stunned by use of the head-only reversible electrical stunning procedure.
- (VI) Bleeding Rail Insensibility Efficacy Criteria—(Score a minimum of 100 animals in large plants). (a) Excellent. Sensible cattle occurring at less than 1 per 1,000; sensible pigs occurring at less than 1 per 2,000. (b) Acceptable. Sensible cattle occurring at less than 1 per 500; sensible pigs occurring at less than 1 per 1,000. Animals showing any sign of return to sensibility MUST be immediately restunned BEFORE any other slaughter procedures. Procedures such as skinning, scaulding, leg removal or other slaughter procedures MUST NEVER be performed on an animal that shows any sign of return to sensibility.
- (VII) Considerations For Slipping And Falling—Good animal welfare and quiet calm handling is impossible if animals slip or fall on the floor. All areas where animals walk should provide non-slip footing. Animals should be observed

during all phases of handling and, if slipping or falling is observed, steps should be taken to correct it. Slipping on scales, unloading ramps and stunning boxes can often be corrected by installing a grating built from steel bars. A concrete-grooving machine can be used to roughen an existing floor. Since results of the plant survey for USDA (Grandin, 1998b) indicated that the greatest problems with slipping and falling were in the stunning chute area, scoring for that characteristic should be done there.

- (VIII) Slipping And Falling In The Stunning Chute-Area Efficacy Criteria (All Species)—(Score a minimum of 50 animals in large plants). The stunning chute area includes restrainer entrance, stunning box, lead-up chute and crowd pen. Scores assigned should consist of (a) Excellent. No slipping or falling. (b) Acceptable. Slipping of less than 3% of the animals. (c) Not Acceptable. 1% of the animals falling down (body touches floor). (d) Serious Problem. 5% falling down or 15% or more slipping.
- (IX) Considerations For Vocalization Scoring Of Cattle—Vocalization (moos or bellows) is an indicator of cattle discomfort. Dunn (1990) reported that significantly more cattle vocalized when they were held in a restraint device that inverted them on their backs than when cattle were subjected to upright restraint. Research by Bridgett Voisinet at Colorado State University demonstrated that the number of times that cattle vocalize during a stressful husbandry procedure is related to cortisol (stress hormone) levels (Voisinet et al.,). Vocalization is correlated with physiological measures of stress in both cattle and pigs (Dunn, 1990; Warris et al., 1994).

  Results of the plant survey for USDA indicated that the percentage of cattle which vocalized in the stunning chute area ranged from 3% or less of the cattle in the three best plants, to 12 to 32% in the two worst plants (Grandin, 1997b, 1998a). Cattle vocalizations in the stunning chute area were caused by use of an electric prod, slipping in the stunning box, missing with captive-bolt stunners or excessive pressure applied by a restraint device. USDA survey results (Grandin, 1997b, 1998b) showed that plants with a high percentage of vocalizing cattle could easily reduce this percentage; the average vocalization percentage in the two plants with the roughest handling was reduced from 22% of the cattle to 4.5% of the cattle by reducing electric prod usage.

  Results of the plant survey clearly demonstrated (Grandin, 1998a) that cattle seldom vocalize during handling or stunning unless an easily observed, aversive event occurred. A total of 1,125 cattle were scored for vocalization (Grandin, 1998a) and 112 of those animals vocalized; only two animals vocalized which were not responding to an aversive event such as electric prodding, slipping, falling, missed stuns, or excessive pressure from a restraint device. Other aversive events which can cause vocalization are hitting cattle with gates or pinching an animal in a restraint device which indicates that vocalization is an indicator of discomfort.

- (X) Vocalization Scoring Of Cattle In The Crowd Pen, Lead-Up Chute, Stunning Box Or Restraining Device Efficacy Criteria—(Score a minimum of 100 animals in large plants). (a) Excellent. 0.5% or less of the cattle vocalizing. (b) Acceptable. 3% or less of the cattle vocalizing. (c) Not Acceptable. 4% to 10% of cattle vocalizing. (d) Serious Problem. Over 10% of the cattle vocalizing.

When vocalization is being evaluated, cattle from more than one feedlot or ranch should be observed. To make scoring simple, each animal should be classified as either a vocalizer or a non-vocalizer. Cattle vocalizations should be tabulated during handling in the crowd pen, lead- up chute, restrainer or stunning box. Vocalizations occurring in the yards should not be tabulated because cattle standing quietly in the yards will often vocalize to each other. In one plant (Grandin (1997b) observed that hungry Holstein-Friesian cattle vocalized and turned to face a man bedding a pen with sawdust; it appeared that they perceived the sawdust as feed.

Observations at one of the sheep slaughter plants during conduction of the survey indicated that vocalization during handling is absolutely useless as a measure of handling problems in sheep. Sheep walking quietly up the stunning chute often vocalized to each other while sheep which balked, and had to be pushed by a person, never vocalized (Grandin, 1997b). There is a species difference between cattle and sheep with respect to the circumstances in which they vocalize.

- (XI)Considerations For Vocalization Scoring Of Pigs—Research conducted in commercial pork slaughter plants indicated that the intensity with which pigs squealed (measured with a sound meter) in the stunning chute area was correlated with physiological measures of stress and with poorer meat quality (Warriss et al., 1994). White et al. (1995) also found that the intensity of pig squeals is correlated with pig discomfort.

  Because it is impossible to count individual pig squeals when a group of pigs is being handled, vocalization scoring of individual pigs can only be conducted in the restrainer. Results of the survey (Grandin, 1997b, 1998b) indicated that there were two major causes of pig vocalizations: (a) misapplied electric stuns, and (b) pinching in the restrainer. Survey results further indicated that vocalization in the restrainer ranged from 0% to 14%, with 72% (8 of the 11 plants) having no pigs squealing due to misapplied electric stuns; in two of the plants 2 to 4% of the pigs squealed during stunning (Grandin, 1997b). The use of sound-level meters should be investigated as a means for monitoring pig vocalizations during handling.

- (XII)Vocalization Scoring Of Pigs In The Restrainer Or During Stunning—(Scores minimum of 100 pigs in large plants). (a) Excellent. 0% or less of the pigs vocalizing due to use of the restrainer; no vocalizing due to a misapplied stunning device. (b) Not Acceptable. 2% or more of pigs vocalizing in the restrainer for any reason. (c) Serious Problem. 5% or more of the pigs vocalizing in the restrainer for any reason.
- (XIII)Restraint Device Principles Which Reduce Stress On Animals And Help Reduce Vocalization—The behavioral principles of low-stress animal restraint and handling (Grandin, 1991b, 1993, 1994, 1995, 1996, 1998d and www.grandin.com) have been outlined in several publications and on the worldwide web. Pigs and cattle should enter a restraint device easily with a minimum of balking. Correcting problems with animal- restraint devices can help reduce bruises and meat quality defects (e.g., blood-splash). The basic principles of low-stress animal restraint which will minimize vocalization and agitation are: (1) For cattle, block the animal's vision with shields so that they do not see people or objects that move while they are entering the restrainer. Install metal shields around the animal's head on box-type restrainers to block the

animal’s vision. Alley-ways leading up to restraint devices should have solid sides. (2) Block the animal’s vision of an escape route until it is fully held in a restraint device (Grandin, 1995). This is especially important on restrainer conveyors. A flexible curtain of conveyor belts at the discharge end of the conveyor works well. Cattle often become agitated in a conveyor restrainer if they can see out from under the solid hold-down cover before their back feet are off the entrance ramp. Extending the solid hold-down cover on a conveyor restrainer will usually have a calming effect on animals and most animals will ride quietly. Solid hold-downs can also be beneficial for pigs on conveyor restrainers. (3) Eliminate air hissing and other distractions such as clanging and banging. (4) The restraint device must be properly lighted. Animals will not enter a dark place or enter a place where direct glare from a light is blinding them. To reduce balking at the entrance of a conveyor restrainer, install a light above the entrance. The light should be above the lead-up chute; it should illuminate the entrance of the restrainer, but it must not glare into the eyes of approaching animals. Light coming up from under a conveyor restrainer should be blocked with a false floor to prevent animals from balking at the “visual cliff effect.” (5) Provide non-slip flooring in box-type restrainers and a non-slip cleated entrance ramp on conveyor restrainers. Animals tend to panic when they lose their footing. (6) Parts of a restraint device operated by pneumatic or hydraulic cylinders that press against the animal’s body should move with slow steady motion. Sudden jerky motion excites animals. On existing equipment, install flow controls to provide smooth steady movement of moving parts which press against the animal. (7) Use the concept of optimum pressure. The restraint device must apply sufficient pressure to provide the feeling of being held, but excessive pressure that causes pain should be avoided. Install a pressure regulator to reduce the maximum pressure that can be applied. Very little pressure is required to hold an animal if it is fully supported by the device. If an animal bellows or squeals in direct response to the application of pressure, the pressure should be reduced. (8) A restraint device must either fully support an animal or have non-slip footing so the animal can stand without slipping. Animals panic if they feel like they may fall. Restraint devices should hold fully sensible animals in a comfortable, upright position. (9) Equip restraint devices with controls that enable the operator to control the amount of pressure that is applied. Animals of different sizes may require different amounts of pressure. Hydraulic or pneumatic system should have controls which enable a cylinder of the device to be stopped in mid-stroke. (10) Never hold an animal in a head restraint device for more than a few seconds. The animal should be stunned or ritually slaughtered immediately after the head holder is applied. Head restraint is much more aversive than body restraint. Animals can be held in a comfortable body restraint for longer periods if they are comfortable. The animal’s reaction should be observed. If the animal struggles or vocalizes, this is an indication that the device is causing discomfort. (11) Restraint devices should not have sharp edges that dig into an animal. Parts that contact the animal should have smooth rounded surfaces and be designed so that uncomfortable pressure points are avoided. (12) On V-conveyor restrainers, both sides should move at the same speed.

With regard to animal restraint, it is possible, in most plants, to modify existing restraint devices to lower vocalization and agitation scores. Balking at the entrance is also easy to reduce. Most of the modifications that would reduce animal agitation and vocalizations can be installed at a minimum expense—usually between $200 to $2,000.

- (XIV)Considerations For Use Of Electric Prods—Reducing the use of electric prods will improve animal welfare. Many well-managed plants have eliminated use of electric prods in the holding pens. In beef plants with well-trained handlers, the survey (Grandin, 1997b) showed that 90 to 95 percent of the animals could be moved through the entire plant without the use of an electric prod. USDA regulations require that electric prods have a voltage of 50 volts or less. An easy way to test an electric prod to determine if it delivers too intense a shock is to touch an animal with the prod for one second; if such contact causes the animal to vocalize, the power should be reduced. Electric prods which have sufficient power to knock an animal down or paralyze it must not be used. Electric prods must never be applied to sensitive parts of the animal such as the eyes, ears, nose or anus.
- (XV) Use Of Electric Prods Efficacy Criteria—Below are two tables that characterize the method to be used for scoring plants for appropriate incidence of animals subjected to electric prods:

Table 1. Electric prod scoring criteria for cattle (percentages of animals prodded).

	Crowd pen to chute	**Entrance of stunning box or restrainer**	**Total percentage of cattle prodded**
Excellent	None	5% or less	5% or less
Acceptable	5% or less	20% or less	25% or less
Serious problem	---	---	50% or more

Table 2. Electric prod scoring criteria for pigs (percentages of animals prodded).

	Crowd pen to chute	**Entrance of restrainer**	**Total percentage of pigs prodded**
Excellent	None	10% or less	5% or less
Acceptable	---	---	25% or less
Serious problem	---	---	80% or more

- Electric prods should never be used on sheep.
- (XVI) Handling Recommendations To Reduce Electric Prod Use And Maintain Efficient Handling—Recommendations are as follows: (1) Remove or correct distractions which cause balking—Distractions caused by air hissing, shadows, reflections from shiny metal, ventilation drafts blowing in the faces of

approaching animals, and seeing either moving people or moving machinery up ahead (Grandin, 1996) should be corrected. The evaluator can enter the chutes and observe those things that cause the animals to balk. Shields or strips of conveyor belting can be installed to prevent animals from seeing movement up ahead as they approach the restrainer or stunning box. Reflections can sometimes be eliminated by moving an overhead lamp. Ventilation drafts blowing down the chutes toward the animals may make it impossible to reduce electric prod use. The plant ventilation system may need to be adjusted. (2) Provide adequate lighting – Animals may refuse to enter a dark place. Entry into a restrainer can be facilitated by aiming a light into the entrance. The light must not shine into the eyes of approaching animals. Animals may be difficult to drive out of the crowd-pen and into the single-file chute if the chute is in the dark and the crowd-pen is brightly illuminated. Lighting problems can make quiet handling almost impossible. A common problem with lighting is that a handling system may work well when lamps are new, but the animals will balk more and more as lamps dim with age. The most efficient lighting can be determined by experimenting with portable lights. Animals may also balk at shiny reflections from a piece of metal or from sparkling water on the floor. (3) Reduce noise – Animals are very sensitive to high-pitched noise. Reducing high-pitched noises generated by motors and/or hydraulic systems can improve animal movement. Clanging and banging metal should be reduced and hissing air should be muffled. (4) Move small groups – When cattle and pigs are being handled, the crowd-pen and the staging areas which lead up to the crowd-pen should never be more than three-quarters full. Half full is best. Crowd gates should not be pushed up tightly against the animals. Cattle and pigs need room to turn. For sheep, large groups may be moved and the crowd-pen can be filled completely. (5) Use other driving-aids – Electric prods should be replaced whenever possible with other driving-aids such as a plastic paddle, a stick with a flag on the end or panels (for pigs). The animals should move easily and handlers should not hit them. Cattle and pigs can often be moved through a chute by having the handler walk by them in the opposite direction of desired movement. When the handler passes the shoulder of each animal, it will move forward. Grandin (1991a) provides more information on animal handling principles. (6) Use genetics and management to reduce incidence of excitable animals – There are some animals which have a very excitable temperament and are difficult to drive. Some lean pigs and cattle are very excitable (Grandin, 1991a, 1993b, www.grandin.com); these animals will often have high vocalization scores. Plant management personnel need to work with producers to solve this problem. Pigs with excitable genetics will be easier to handle at the meat packing plant if producers have walked through the pens every day during the finishing period; only 10 to 15 seconds per pen is needed. Such interaction trains excitable pigs to be more comfortable with human handling. Producers should be encouraged to produce animals—genetically—which will be reasonably easy to handle.

- (XVII)Considerations For Movement To Stunning/Sticking Of Non-Ambulatory Animals—Each plant should develop written guidelines and procedures for handling non- ambulatory animals in a humane manner. Dragging sensible non-ambulatory animals is a violation of The Humane Slaughter Act regulations. Stunned, non-ambulatory animals may be dragged. If a skid loader ("Bob Cat") is used to transport non-ambulatory pigs or sheep, the animal must be rolled into the bucket. Two people are required unless the loader is equipped with a special bucket with a lid; one person operates the loader and the other rolls the animal into the bucket. Loading a non-ambulatory animal into the bucket by shoving it up against a wall or fence is not acceptable. Shoving bare forklift forks under non-ambulatory cattle is not an acceptable method for moving them.

Plant personnel should develop procedures to help reduce the occurrence of non-ambulatory animals on the premises. Non-slip flooring is essential. Mounting activity and animal fights can cause injuries; this is especially a problem with bulls and boars. Bulls which are mounting other animals should be placed in a separate pen. Mounting by bulls is a common cause of bruising and crippling injuries to cows.

- (XVIII) Considerations For Pen Stocking Density. Pens should be stocked using recommendations of the Grandin (1991a) guidelines. A good rule-of-thumb is that all animals must have room to lie down simultaneously. All animals must have access to water to comply with the regulations of the Humane Slaughter Act.
- (XIX) Considerations For Maintenance Of Facilities And Equipment. Pens, alleys, chutes, restraints and other equipment should be kept clean and well maintained. They should be free of protrusions which could injure animals.
- (XX) Conclusion. An acceptable level of animal welfare can be maintained if scores at the critical control points for stunning, animal insensibility, slipping and falling, vocalization and electric prod use are in the acceptable range. Scoring performance for these variables is simple and easy to do under commercial plant conditions. Electrical stunning equipment must have amperage, voltage, and frequency parameters which have been verified by either electrical or neurotransmitter recordings from the brain to reliably induce insensibility. Plant managers must be committed to good animal welfare. Plants which have managers who insist on good handling and stunning practices will usually have animal welfare practices that are superior to those of plants in which management and supervision are lax. Since this paper was written in 1999, handling and stunning in North American plants has greatly improved due to audits by restaurant companies. See the survey section of www.grandin.com.

STUNNING METHOD AND BLOOD-SPLASH

The major negative effect on meat quality of inappropriately administered stunning methods is that they affect the incidence of petechial hemorrhages or blood-splash in the meat. Blood-splash is a cosmetic defect and it occurs when small capillaries in the muscle rupture while the circulatory system is still intact. Blood-splash can appear as small red spots or it can cover a larger area and look like a bruise. Blood splash is a meat quality problem that has no effect on animal welfare.

Lambooy and Sybesma (1988) stunned pigs with 70 volt or 475 volt electricity, in the fattening pen vs. in a restrainer and using electrical stunning vs. CO_2 stunning and reported that: (a) high voltage and stunning in a pen resulted in lower incidences of blood-splash, and (b) CO_2 stunned pigs showed no blood-splash. Grandin (1988b) compared pig-handling treatments that consisted of Control Treatment (4-6 seconds stunning time; electric prods; 10 minutes rest after climbing a long ramp) vs. Special Treatment (3-4 seconds stunning time; no electric prods and overnight rest prior to stunning) and concluded that Special Treatment handling provided the greatest reduction in petechial hemorrhages when low winter temperatures had greater day-to-day variability.

The incidence of blood-splash and hemorrhages is increasing in both beef and pork. The most likely cause of this increased incidence greater emphasis in animal selection on leanness in beef and pork. Leanness is probably associated with increased fragility of the animal's capillaries and, thus, with an increase in the incidence of blood-splash.

Recent audits of pork and beef packing plants by the National Pork Producers Council and the National Cattlemen's Association indicate that blood-splash is costing the pork industry almost 50 cents for every hog marketed (Morgan et al., 1993) and is costing the beef industry about 12 cents for every slaughter steer or heifer marketed (Smith et al., 1994). In the pork industry, damage to loins and hams is costing approximately $43 million annually (Morgan et al., 1993).

Sensitivity of individual animals to blood splash differs greatly. Unstable weather, especially circumstances in which ambient temperatures quickly fluctuate, can make animals more sensitive to such damage. Grandin (1988b) found that fluctuating weather affected the efficacy of electrical stunning in terms of reductions in blood-splash in pigs. Therefore, when a new stunning or handling procedure is studied, for its effectiveness in reducing blood-splash, it must be tested on alternate days, against a control method, for several weeks to remove confounding due to temperature and weather fluctuations. Seasonal differences in blood-splash have also been reported in lambs (Peterson and Wright, 1982).

Research has demonstrated that an automatic stunning system mounted on a center track (double rail) restrainer reduced blood splash by 20 percent compared to a standard V-conveyor restrainer. On V-conveyor restrainers, blood-splash will increase if one side of the conveyor runs faster than the other (Grandin, 1985). Carbon dioxide stunning will produce less blood- splash than does the average electrical stunner (Channon et al., 1998). However, tests run in a single plant with CO2 versus a well-maintained and operated electrical stunner showed no differences in incidence of blood-splash. Electrical stunning is comparable to CO2 stunning from a blood-splash standpoint, if it is done perfectly. The most serious problem with blood-splash incidence is in terms of its association with ultra-lean pigs with very heavy muscling. CO2- stunning probably has little advantage over electrical stunning for use with normal pigs but it is most likely to provide a reduction in blood-splash in ultra-lean pigs. Some pigs with extremely muscling have very weak skeletons which increases the incidence of broken backs and damage to the loins during stunning.

The first step in reducing blood-splash is to stop double-stunning; double-stunning occurs when an animal is given two separate jolts of electricity. Practical experience has shown that blood-splash can be greatly reduced by following the stunning practices that are outlined below. Double-stunning damages the capillaries because it makes the muscles contract twice. To prevent this, the operator must press the wand firmly against the pig before the stunning current is turned on. The wand must remain pressed against the pig until the timer stops the flow of current. If the wand slides during the stun, blood-splash incidence may increase. A stunning switch with dirty contacts or a cord with frayed wires inside may also cause blood-splash, because they can allow fluctuations in the electrical current due to the momentary making and breaking of the circuit. Wiring and switches need to be changed frequently to prevent fluctuations in the electrical current. It is also essential to clean electrode contacts every day and make sure the pigs are wet.

Some plants have attempted to reduce blood-splash by reducing the stunning amperage to 0.5 amps. This is a practice that should be banned. Scientific research has shown that a minimum of 1.25 amps at 250 to 300 volts must pass through the hog's brain to induce instantaneous unconsciousness (Hoenderken, 1983). Use of lower amperages will kill the pig, but the animal may feel the symptoms of a heart attack.

The plants with the lowest incidence of blood-splash in North America use 1.25 amps with an electronic amperage-controlled circuit. Unlike old-fashioned voltage-regulated stunners the amperage in electronic amperage-controlled circuits is kept constant at 1.25 with the electronics and the voltage automatically changing with resistance encountered in individual hog.

A survey of seven large pork plants conducted by a major processed-products firm indicated that the one plant that used an electronic amperage-controlled stunner had a 100 percent reduction in blood-splash compared to use of the old-fashioned, voltage-regulated stunner. The concept is very simple; the amperage should be held absolutely constant at 1.25 amps while the voltage is allowed to vary. There is no reason to stun hogs with 0.5 amps. An electronic system with constant amperage will generate less blood-splash than will use of a voltage-regulated system at 0.5 amps. Electronic amperage-controlled electrical stunners are now available with computer outputs that count double-stuns and misapplied stuns. The printouts show that an operator's performance declines after about two hours; the operators should be rotated every few hours to prevent fatigue from increasing blood-splash.

There has never been a test comparing CO2 stunning to electronically controlled constant amperage electrical stunning in the same plant. The test described previously, in which CO2 stunning and electrical stunning were compared in the same plant, involved use of an old- fashioned voltage- regulated stunner. It is likely that electronically amperage-controlled electrical stunning, if it is perfectly maintained and operated, will generate the same incidence of blood-splash as will CO2 stunning. The principles described above apply to both manual and automatic stunners.

Quick bleeding. It is essential that animals are bled quickly. The animal should be stuck within 15 seconds after stunning. This will reduce blood-splash in all species (Burson et al., 1983; Van de Wall, 1978). Bleeding very quickly reduces blood-splash because quickly lowering the blood pressure helps prevent small capillaries from bursting.

Electrical stunning of cattle. Blood-splash problems are the main reason why electrical stunning has not become more popular for use with cattle. Plant managers in New Zealand have found that blood-splash incidence is low in grass-fed cattle, but when the Australians tried electrical stunning in fed cattle, blood-splash levels were too high to make it commercially viable. Practical experience in New Zealand has shown that very quick bleeding (within 10 seconds) is required to keep blood-splash incidence low.

Resting and handling animals. Practical experience in many pork slaughter plants reveals that pigs should be rested for 2 to 4 hr to reduce incidences of both blood-splash and pale, soft, exudative (PSE) lean. In cattle, long resting periods are not recommended, but it is advisable to allow the animals about 30 minutes to settle-down after unloading. Such rest will help prevent excitement during subsequent handling. Reducing or eliminating electric prod usage also helps to reduce occurrence of blood-splash. Calkins et al. (1980) found that electric prods increased incidence of blood-splash in pigs. Practical experience in many slaughter plants has shown that using very low voltage prods, with 24 volts or less, reduced blood-splash. If pigs squeal when electrically prodded they are receiving a shock that is too strong.

Captive-bolt stunning. Some beef plants have found that a cartridge-fired stunner causes less blood-splash than does use of a pneumatic stunner. There are two possible explanations for these differences. First, some air-operated stunners inject air into the brain. The second explanation is that poor maintenance of captive-bolt stunners or differences in shooting position can cause increases in blood-splash. Some operators using air-operated stunners will shoot cattle behind the poll because the air-powered stunner may be harder to position on the forehead than is the cartridge-fired stunner. A test conducted in one plant with a highly skilled operator using perfectly maintained equipment showed no difference in incidence of blood-splash. Pneumatic guns require careful maintenance and some plants skimp on maintenance resulting in excessive recoil and poor stunning.

There is also concern that pneumatic stunners that inject air could contaminate beef by forcing brain tissue throughout the body. Recent research (Schmidt et al., 1998) showed that air injection sometimes forced pieces of neurological tissue as large as a pencil into the heart and other organs. This problem was not observed when a cartridge-fired stunner was used. For food-safety concern reasons, the use of stunners that inject air into the head is not recommended. One major beef packing company has found that the extra cost of blank cartridges for a cartridge-fired stunner was economically justified because eliminating air injection reduced occurrence of blood-splash.

Ritual slaughter. Cattle and calves slaughtered without stunning (ritual slaughter of Jews—kosher—and Muslims—halal) are more prone to blood-splash than are cattle stunned by use of either type of captive-bolt stunner. Cutting the throat of cattle and calves without first stunning them almost always increases incidence of blood-splash. Blood-splash incidence in cattle stunned with a captive-bolt stunner is almost always under 0.5% percent; but, in ritually slaughtered cattle, blood-splash often occurs in 3% to 10% of cattle.

Keeping cattle calm during ritual slaughter will reduce occurrence of blood-splash because excited cattle often have a bigger spasm when they lose consciousness (Grandin, 1994). Restraint devices should be designed to apply as little pressure as possible to the animal’s body. After the throat is cut, restraining devices should be loosened immediately. Cattle should be ritually slaughtered within seconds after their heads are restrained in the neck yoke; allowing an animal to fight restraint will increase incidence of blood-splash.

The technique used in throat-cutting can also affect the incidence of blood-splash and the speed of bleed-out. Cutting the throat too far back on the neck slows bleed-out and increases blood-splash. The incidence of blood-splash can differ greatly between two different ritual slaughterers. Stunning cattle with a captive-bolt device will greatly reduce incidence of blood- splash caused by ritual slaughter. Some religious authorities will permit post-slaughter stunning of animals. Stunning with a captive-bolt device, immediately after ritual slaughter, will lower blood-splash incidence from 3%, in the best ritual slaughter plant, to about 1%; such incidence will still be slightly elevated as compared to stunning the bovine prior to bleeding.

Gregory et al. (1988), studying bobby calves in Australia, determined that a faster bleed- out was obtained when the thoracic, compared with the neck, sticking protocol was used, and when electrical stunning rather than captive-bolt stunning was used. Bager et al. (1998) reported that the amounts of jugular blood that were collected from calves that were exsanguinated by throat-cutting indicated that cerebral blood perfusion is very severely impaired after gash-cutting while cortical dysfunction occurred at a time when mean arterial blood pressure was sufficiently high to maintain cerebral circulation. They regarded those findings and indirect evidence of a retrograde flow of blood from the vertebral arteries, through the occipto-vertebral anastomis, to the open cephalic ends of the severed carotid arteries.

Due to differences in the anatomy of the blood vessels in cattle and sheep, ritual slaughter will not increase blood-splash in sheep. Almost the entire blood supply to the brain of a sheep is in the front of the neck whereas cattle have some small vessels in the back of the neck. This difference in anatomy causes sheep to bleed-out more quickly.

A full copy of this paper and list of references is available at:

http://www.grandin.com/references/humane.slaughter.html

Animal Welfare in Slaughter Plants

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Abstract

There are five basic causes of animal welfare problems in slaughter plants:

1. Poorly designed or improper stunning and handling equipment.
2. Distractions which impede animal movement, such as sparkling reflections on a wet floor, air hissing, high-pitched noise or air drafts blowing down the race towards approaching animals. These distractions can ruin the performance of a well designed system and cause animals to become excited. When this happens, prodding will be required to make them move.
3. Lack of employee training and poor supervision of employees by management.
4. Poor maintenance of equipment and facilities, such as malfunctioning stunners or worn, slick, floors which cause animals to slip and fall.
5. Poor condition of animals arriving at the plant, such as cripples and sick animals.

Another problem is pigs and cattle from excitable genetic lines which are more likely to become agitated during handling To maintain a high standard of welfare, all five problem areas must be addressed. A survey of 29 Canadian slaughter plants indicated that 27% had excellent non-slip floors and 21% had slick floors which would cause animals to slip. Twenty-four percent had high pitched motor noise or hissing air exhausts that caused animals to balk. Air drafts blowing down the race toward approaching animals were a problem in 9% of the plants. Air drafts will often impede animal movement.

Introduction

There are five basic causes of animal welfare problems in slaughter plants:

1. Stressful equipment and methods
2. Distractions that impede animal movement
3. Lack of employee training
4. Poor equipment maintenance
5. Poor condition of the animals arriving at the plant

To correct an animal welfare problem, one has to determine the cause of it. For example, installation of new stunning equipment will not solve an abuse problem caused by untrained, poorly supervised employees or animal agitation caused by air hissing. This paper will review both the scientific literature and the author's observations in over 200 slaughter plants in the United States, Canada, Mexico, Europe, Australia and New Zealand. Surveys were conducted in plants in the U.S. and Canada to determine the incidence of distractions and equipment problems that impeded animal movement or caused animals to become excited. In the last section, the economic benefits of good animal welfare and public concerns will be covered.

Equipment and methods

Equipment can be divided into two basic categories of stunning equipment and handling systems, such as races, lairages and restraint devices. There have been numerous research studies on stunning methods, but until recently, stress and discomfort during a lairage and movement of the animals to the stunning point was neglected. Ron Kilgour from New Zealand was the first researcher to discuss that there was a need for greater emphasis on procedures that occur prior to stunning or slaughter (Kilgour, 1978).

Stunning

Effective stunning methods are readily available to induce instantaneous insensibility. Good reviews on captive bolt stunning can be found in Leach (1984), Grandin (1994a) and Eikelenboom (1983). Electrical stunning methods used commercially on pigs and sheep are effective and induce instantaneous insensibility. A minimum of 1.25 amps must be passed through a pig's brain to reliably induce insensibility (Hoenderken, 1982). This is especially important for heavy pigs (over 225 lbs / 100 kg). In sheep, 1 amp is required (Gregory and Wotton, 1984). Unlike pigs and sheep, a single current passed from the neck to the brisket failed to induce epileptiform changes in the electroencephalogram of cattle (Cook et al., 1993). In cattle, a split stun procedure is used. A 2.5 amp current must first be applied to the head before a head-to-body current is applied (Gregory, 1993). Reviews by Warrington (1974), Leach (1985), Grandin (1985; 1986) and Gregory (1994) provide further information.

Carbon dioxide stunning is used for stunning pigs in many countries. There have been welfare concerns about CO2 because it is a pungent gas which is irritating to the respiratory tract (Gregory, 1994). Hoenderken (1982) reported that a motorific excitation phase occurs while the pig is still conscious. Forslid (1987) found that the excitation phase starts after the pig is unconscious in purebred Yorkshires. There is a large variation in a pig's reaction to CO2 (Dodman, 1977; Grandin, 1988a). The reaction ranges from none when the pigs first sniff the gas, to violent attempts to escape. Halothane-positive pigs have more excitation (Troeger and Waltersdorf, 1991). Carbon dioxide stunning may be a good method for certain genetic types of pigs and very stressful to others.

Preslaughter handling

Good systems are available for handling cattle and sheep at the abattoir. Cattle and sheep will move quietly through single file races and ride quietly in a well designed conveyor restrainer system. Moving in single file is a natural behavior for cattle.

In the U.S., large stunning boxes which held more than one bovine have been replaced with conveyor restrainers. The V conveyor restrainer was introduced for cattle in the 1970s (Schmidt, 1972; Willems and Markley, 1972). It was replaced in the l990's with the center track double rail restrainer (Giger et al., 1977; Grandin, 1988b; 1991). Cattle and sheep will remain calm in conveyors because they are touching the animal in front and back of them. V conveyors work less well for pigs. The author has observed that slender, lean pigs are not supported properly and heavily muscled pigs are pinched on the hams, whereas round, fat pigs are held in a comfortable position. Lean pigs are properly supported on a center track restrainer.

In England, head restraint devices are required by legislation to hold a bovine's head for captive bolt stunning. The purpose of the legislation was to improve stunning accuracy. In some circumstances, head restraint can increase stress. Ewbank et al. (1992) found that cortisol levels were higher in a head restraint compared to a conventional single animal stunning box. It took an average of 32 seconds to induce the cattle to put their heads in the poorly designed yoke used in this study. Stress can be minimal in a well designed head restraint where the animal is stunned immediately after the head is caught (Tume and Shaw, 1992; Frank Shaw, personal communication). The author has observed electrical stunning of cattle in a head restraint in New Zealand. Each animal quietly entered the stunning box and was stunned within 2 seconds after the head was clamped. Information on the design of head restraint devices can be found in CSIRO (1989) and Grandin (1993; 1994). Stress caused by prolonged restraint will be a severe problem if live animals are subjected to intravenous injections shortly prior to slaughter. Payne and Young (1995) report that intravenous injections of lambs with antifreeze glycoproteins may improve the quality of frozen meat.

Design mistakes in races and forcing pens will cause stress. One of the most serious design mistakes is laying the race out so that its entrance appears to be a dead end. Cattle will move more easily through a curved race compared to a straight race, but it must be laid out correctly (Grandin, 1980; 1990; 1993). Practical experience has shown that an animal standing in the forcing pen must be able to see a minimum of two to three body lengths up the single file race before it curves. Bending the single file race too sharply where it joins the forcing pen will cause animals to balk.

Warris et al., (1994) found that pigs were more stressed in abattoirs with single file races compared to plants where pigs were stunned in small groups on the floor. The intensity of squealing was highly correlated with physiological stress measurements and PSE. Electrical stunning of pigs on the floor is most practical for abattoirs that slaughter under 240 pigs per hour. The author has observed that floor stunning often becomes rough and sloppy at higher speeds. In larger plants, a well designed race will produce less stress than a poor one. Weeding et al., (1993) found that both design and staff expertise affected stress levels in pigs.

Stress caused by forcing pigs to move through a single file race could be eliminated by stunning groups of pigs in CO2 gas. Barton Gade et al., (1993) has developed a low stress driving and lairage system for moving groups of five pigs onto an elevator which descends into CO2 gas. An entire system approach should be used for evaluating CO2 stunning. Some discomfort during the induction of anesthesia may be a small price to pay for great reductions in handling stress.

DISTRACTIONS THAT IMPEDE MOVEMENT

Animals will often balk and stop moving through a handling system if there are distractions such as sparkling reflections, air blowing towards the animals, movement or high pitched noise. A survey of 33 Canadian slaughter operations ranging from small to the very largest revealed that cattle and pigs often balk and have to be prodded excessively due to distractions that can be easily eliminated.

Incidence of Distractions
Which Impede the Movement of Livestock

Type of distraction	Acceptable, move easily	Not acceptable, excessive balking
Lighting problems (too dim or too bright)	28 (85%)	5 (15%)

Ventilation air blowing towards approaching animals	30 (91%)	3 (9%)
Seeing movement or sparking reflections	25 (76%)	8 (24%)
High pitched motor noise or hissing air exhausts	25 (76%)	8(24%)

These distractions will ruin the performance of well designed restrainers and races because animals often have to be prodded when they refuse to move. Sometimes, adding more light or moving a light to eliminate sparkling reflections on floors or walls will improve the movement of pigs or cattle. In two plants a new double rail conveyor system worked well when the plant was new, but balking at the restrainer entrance gradually worsened as the lamps over the restrainer grew dimmer with age. Animals have a tendency to move from a darker place to a more brightly illuminated place (Grandin, 1980; Van Putten and Elshoff, 1978). The light must not shine directly in the eyes of approaching animals.

Air blowing through a stunning box entrance or down a race will make both pigs and cattle stop. Nine percent of the surveyed plants had serious balking problems caused by ventilation blowing air either out the entrance of the stunning area or down a race . Seeing people moving up ahead or jiggling gates will also impede livestock movement. In one plant, cattle balked at a small chain jiggling in the race and in another, cattle balked at a shiny reflection on a vibrating metal wall. When animals are calm, they will stop and look directly at things that make them balk.

In 24% of the plants visited, animals became visibly frightened by sudden air hissing noises or extremely high pitched noises. Observations by the author indicate that high pitched noise causes more agitation than a low pitched rumble of chains and gears . The ears of cattle are most sensitive at 8,000 Hz (Ames, 1974) and they can hear up to 21,000 Hz (Algers, 1984). Clanging and banging noises will make animals flinch or jump. Sheep slaughtered in a noisy commercial abattoir had higher cortisol levels than sheep slaughtered in a quiet research abattoir (Pearson et al., 1977). Sudden noise of a door slamming and banging on a wall increased heart rate in deer (Price et al., 1993). In the eight plants that had balking caused by noise, five were due to air hissing and three were due to high pitched motor noise. At one plant, elimination of a high pitched hydraulic whine resulted in calmer cattle. Stunning box entrance doors had hissing air in three plants. In one plant, installation silencers to stop hissing air resulted in a dramatic reduction of excited cattle. Other distractions which can impede movement are shadows, drain grates and changes of fencing or flooring types.

EMPLOYEE TRAINING AND SUPERVISION

During twenty years of experience, I have observed that plants which have good animal welfare have a manager who trains and supervises his or her employees. Plants with lax management often have animal abuse (Grandin, 1988c; 1994a). Maintaining a high standard of welfare requires constant management attention and vigilance. A good manager constantly works on improving details of procedures. After the distractions and serious design mistakes are eliminated, employees can fully use behavioral principles to move animals easily and quietly (Grandin, 1993; Kilgour and Dalton, 1984).

The author has observed that the most common mistake made by employees is attempting to move too many animals at a time. For all species, forcing pens should not be filled more than three-quarters full. Employees should also be taught how to time bunches of animals. The next bunch should not be driven into the forcing pen until there is space in the race for them to walk into. This procedure utilizes natural following behavior. Most important is that employees need to remain calm and avoid sudden, jerky motions or yelling. Electric prods should be used as little as possible.

EQUIPMENT MAINTENANCE AND WELFARE

The two major maintenance problem areas that the author has observed are poor captive bolt stunner maintenance and slick floors. A survey of 29 Canadian slaughter plants indicated that 21% had slick floors.

Condition of Floors in Slaughter Plants

Number of slaughter systems	Percentage	Flooring condition
8	(27%)	Excellent, non-slip floor
15	(52%)	Acceptable floor
6	(21%)	Slick floor, not acceptable

The majority of slippery floor problems were due to either the rough finish wearing off a concrete floor, or a slick floor in a cattle stunning box. The author has conducted welfare surveys in plants in both the U.S. and Canada. Slick floors which caused animals to fall down was the number one equipment problem. Cockrum, Corley (1991) found that slipping increased stress and also noted that it is a problem area. The author has observed that the second most common equipment maintenance problem in U.S. plants is poor maintenance of pneumatic captive bolt stunner. Stunners require careful maintenance to maintain maximum hitting power.

CONDITION OF ANIMALS

Animals which arrive at the plant in bad condition often suffer. A recent survey of U.S. cow and bull slaughter plants indicated that 1% of the cull beef cows and 1.1% of the cull dairy cows arrive downed and unable to walk (Colorado State University, 1995). Most of these animals were in bad condition before they left the farm. Further information on death losses and metabolic stress can be found in Gregory (1994) and Grandin (1993). There have also been increasing problems with very excitable cattle and pigs which are more difficult to drive and more likely to become excited (Grandin, 1992; 1994b). The author has observed that the increase in excitable cattle and pigs appears to be in the leaner animals. This is an area that needs to be researched because the welfare of excitable animals is sometimes severely compromised.

ECONOMIC ADVANTAGES OF GOOD ANIMAL WELFARE

Careful, quiet handling of livestock by trained people in good facilities will reduce bruising and help maintain meat quality. Bruises cost the U.S. beef industry $ 1.00 per animal on feedlot beef and $3.91 per animal on cows and bulls (Colorado State University, 1992; 1995). In Australia, bruises cost the beef industry $36 million annually (Blackshaw et al., 1987). The U.S. pork industry loses $.34 per pig due to PSE and $.08 per pig due to bruises (National Pork Producers' Association, 1994). Improvements in pig handling and reductions or elimination of electric prods will reduce petechial hemorrhages (Calkins et al., 1980). Improving animal welfare can also improve employee safety because calm cattle are less likely to run over employees or rear up.

PUBLIC CONCERNS

Treating animals in a humane manner is the right thing to do. The public is becoming increasingly concerned about how animals are treated. The treatment of downed, crippled animals has been an issue shown on national television in the U.S. and animal transport is a major issue in England. People unfamiliar with slaughter often ask, "Do animals know they are going to die" and "Are they afraid of blood." Anil and McKinsey (1995) report that pigs watching stunning and slaughter of another pig had little or no change in heart rate, cortisol or B endorphin levels. Observations made by the author indicate that the small distractions discussed previously are more likely to result in excitement or balking than seeing blood or watching another animal being stunned. Cattle will voluntarily walk into a restraint device that is covered with blood (Grandin, 1994a). The author has also observed that it appears that blood from relatively calm cattle has little effect, but if the animals become severely agitated for 10 or 15 minutes, possibly a fear pheromone is secreted. Other cattle will start balking and refuse to walk near the place where the previous animal was stressed. Research with rats and pigs indicates that there may be fear pheromones in blood and urine. Urine from a stressed gilt caused other pigs to avoid a feed dispenser and urine from an unstressed animal had no effect (Vieville-Thomas and Signoret, 1992). Stevens and Saplikoski (1973) reported that blood and muscle tissue from stressed rats was avoided and brain tissue or water had no effect. Blood from guinea pigs and humans had little effect on rats (Hornbuckle and Beall, 1974; Stevens and Gerzog-Thomas, 1977).

RITUAL SLAUGHTER

Slaughter without stunning is an area of concern in many countries. When ritual slaughter is being evaluated from a welfare standpoint, the variable of restraint must be separated from the variable of the actual throat cut. In the U.S., some plants use highly stressful methods of restraint, such as shackling and hoisting fully conscious cattle by one back leg. Suspension of cattle by the back leg causes many animals to bellow and struggle, and their leg is sometimes broken. European and U.S. cattle are held in restraint devices that hold them in an upright position or in devices that invert them onto their backs (Grandin, 1994a; Grandin and Regenstein, 1994). The author has observed that cattle inverted onto their backs often aspirate blood, and stressful methods of restraint mask the animal's reaction to the throat cut.

Dunn (1990) found that investing cattle onto their backs for 103 seconds caused the cortisol levels to be twice as high compared to cattle held in an upright restraint device. The use of devices that hold cattle in an upright position is now required in the United Kingdom. The author has observed that proper design and gentle operation of upright restraint devices can eliminate visible signs of animal discomfort, such as struggling. The restrainer must be equipped with pressure limiting valves to prevent excessive pressure that would cause pain or discomfort from being applied to the animal's body (Grandin, 1994a). Parts of the apparatus which press against the animal should move slowly, because sudden, jerky motion tends to excite the animal. The throat cut should be made immediately after the head is restrained.

The animal's reaction to the throat cut can be observed when the animal is held in a comfortable, upright position. Most researchers agree that cutting the throat without stunning does not induce instantaneous unconsciousness (Daly et al., 1988; Blackmore, 1984). In some cases, consciousness in calves can last for over a minute (Blackmore, 1984). Occlusion of the blood vessels will sometimes delay the drop in blood pressure which is required to induce unconsciousness (Anil et al., 1995a).

Cattle have very little behavioral reaction to a correctly made kosher cut (shechitah) done with a razor-sharp long knife (Grandin, 1994a). Bager et al., (1984) made a similar observation. Behavioral observations and measurements are a major method of pain assessment (Short and Poznak, 1992). Halal slaughter done with hacking cuts with a short knife resulted in vigorous struggling and obvious distress (Grandin, 1994a). Allowing the incision to close back over the knife during the cut caused the animal to struggle, and excited cattle took longer to collapse. One can conclude that a correctly done cut is much less distressful than a poorly done cut.

Head-only electrical stunning is used in many halal slaughter plants on both sheep and cattle. Due to differences in the anatomy of the blood vessels in sheep compared to cattle, head only stunning of cattle must be followed by a chest sticking method to ensure rapid loss of blood pressure (Anil et al., l995b). Minimizing stress and discomfort during ritual slaughter requires a skilled slaughterman and a well designed restraint device which holds the animal in a comfortable, upright position.

CONCLUSIONS

To maintain a high standard of welfare during handling and slaughter management, personnel in the abattoir must be attentive to details of the procedure and supervise and train employees. Lax management is a major cause of poor animal welfare. For good animal welfare, a plant must be equipped with well designed stunning and handling equipment which is kept well maintained by trained, conscientious employees. Small distractions that cause animals to balk and refuse to move through the system must be eliminated. Balking is often caused by sparkling reflections, air hissing, seeing people up ahead or drafts blowing down the race towards approaching animals.
A full copy of this paper and list of references is available at:
http://www.grandin.com/welfare/general.session.html

Euthanasia and Slaughter of Livestock

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ABSTRACT
This paper outlines the basic principles of captive bolt stunning, electric stunning and carbon dioxide anesthesia. It outlines the recommended amperages and currents for electrical stunning and describes how to assess whether or not an animal is rendered insensible. Other subjects that are discussed are preslaughter stress, behavioral principles of handling and ritual slaughter. One of the final conclusions is that the single most important determinant of good animal welfare in a slaughter plant is the attitude of management.

Sufficient amperage must pass through the brain to induce a grand mal epileptic seizure. For large market weight pigs a minimum of 1.25 amps at 250 to 300 volts for 1 second should be used. For sheep a minimum of 1 amp at 375 volts for 3 seconds should be used. Unlike pigs and sheep, cattle must have a stunning current of 2.5 amps passed through the brain before a head to body cardiac arrest current is applied. Available research shows that carbon dioxide stunning is a good euthanasia method for certain genetic types of pigs, and it may possibly cause discomfort in others.

Assessment of insensibility while hanging on the bleed rail in a slaughter plant.

1. The animal hangs straight down and there is no arched back righting reflex. An animal with an arched back is attempting to right itself
2. No rhythmic breathing
3. No eye blinking
4. No eye reflexes in response to touch
5. No vocalizations such as squealing or bellowing
6. Gasping movements are permissible
7. Ignore uncoordinated reflexive limb movements
8. If the tongue is hanging straight down and is limp and floppy the animal is insensible.

These eight signs can be used to insure that slaughtered animals are insensible and they will not be able to feel pain.

When ritual slaughter without stunning is being evaluated from a welfare standpoint the variable of the restraint method must be separated from the act of the throat cut. Distressful restraint methods will mask the animals reactions to the throat cut. Observations of hundreds of cattle and calves which were held in a comfortable upright restraint device indicated that there was a slight quiver when the knife first contacted the skin; Invasion of the animals flight zone caused a bigger reaction. The welfare of animals can be greatly improved during ritual slaughter by holding the animal in a device which holds it in a comfortable upright position.

Basic Causes of Animal Welfare Problems

- Proper livestock handling is extremely important to meat packers for obvious ethical reasons. Once livestock arrive at packing plants, proper handling procedures are not only important for the animal's well-being, but can also mean the difference between profits and losses due to meat quality or worker safety.
- For the best results in animal handling, plant management must make proper handling and stunning a high priority. Top management must play an active role. Plants with the best handling and stunning practices have managers who closely monitor stunning and handling practices. Employees handling hundreds of animals day after day, sometimes need reminders from management that animals must always be handled carefully.
- Healthy animals, properly handled, keep the meat industry running safely, efficiently and profitably.

To correct an animal welfare problem, first determine the cause:

1. **Stressful Pre-Slaughter Handling**

   There have been numerous research studies on stunning methods, but until recently, stress and discomfort during a lairage and movement of the animals to the stunning point was neglected.

2. **Distractions that Impede Animal Movement**

   Animals will often balk and stop moving through a handling system if there are distractions such as sparkling reflections, air blowing towards the animals, movement or high pitched noise.

3. **Lack of Employee Training**

   Maintaining a high standard of welfare requires constant management attention and vigilance.

4. **Poor Equipment Maintenance**

   The two major maintenance problem areas that the author has observed are poor captive bolt stunner maintenance, and slick floors.

5. **Poor Condition of the Animals Arriving at the Plant**

   A recent survey of U.S. cow and bull slaughter plants indicated that 1% of the cull beef cows and 1.1% of the cull dairy cows arrive downed and unable to walk (Colorado State University, 1995). Most of these animals were in bad condition before they left the farm.

Best practices for animal handling and stunning

by Dr. Temple Grandin
Meat & Poultry, April 2000, pg. 76

At the February American Meat Institute Animal Handling and Stunning Conference, the results of the 1999 McDonald's audits were presented ("Managing what you measure," M&P, March 2000, page 58). During visits to 42 beef and pork plants a number of best practices were identified, which were shared with the attendees. Animal handling and stunning greatly improved in 1999 compared to my 1996 U.S. Dept. of Agriculture audit. Following is a list of best practices that will improve animal welfare and help reduce pale, soft, exudative meat; bruises; dark cutters; and blood splash:

- The ergonomics of a heavy pneumatic captive bolt stunner can be improved by adding a handle (Figure 1). On a conveyor restrainer, the stunner should be hung on a 30-degree angle. This will reduce the twisting strain on the wrists.

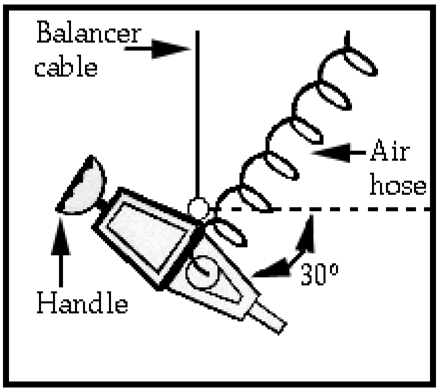

Figure 1. Pneumatic captive bolt stunner with ergonomic improvements for use in a conveyor restrainer.

Figure 2. Pneumatic captive bolt stunner equipped with an ergonomic handle. When this stunner is used in a conveyor restrainer it should be hung at an angle.

- Flags made from a 30 inch by 30 inch (76 cm by 76 cm) square of light, plasticized tarp cloth are good for moving pigs. Pigs move away from the rustling cloth.

- To prevent guillotine gates from bruising on the back, replace the bottom 18 inches (46 cm) of the gate with a piece of conveyor belting. The pigs will think the conveyor belt curtain is solid and they will not go through it.
- Fill the crowd pen leading to the single file chute and the staging area half full. Animals need room to turn.
- Plastic bags work well for moving cattle. A plastic wastebasket liner on a stick works well for turning cattle in the crowd pen. Use the stiff plastic liners that make a crackling noise.
- Illuminate the entrance of the conveyor restrainer. The light must be directed into the entrance of the restrainer. It must *not* shine into the eyes of approaching cattle or pigs. Animals will balk at a dark entrance.
- If animals balk at a reflection on the floor of a chute, try moving the ceiling lights off the centerline of the chute. Moving a light will often eliminate a reflection.
- Conveyor restrainers for both cattle and pigs should have a false floor mounted under the restrainer. This prevents the animal from balking at seeing the "visual cliff effect." The false floor provides the illusion of a solid floor to walk on, but the animal's feet must not touch it.
- On a pneumatic stunner, install an easy to reach water spray to clean the trigger mechanism; Regular cleaning will help prevent misfiring.
- Cartridges for a cartridge-fired stunner should be kept in a dry place. Storage in a damp location can result in misfiring. One suggestion is to shrink-wrap boxes of cartridges held in storage.
- Cartridge-fired stunners must be rotated often to prevent overheating. Build a rack on the wall or side of the chute to hold the stunners to make rotation easier.
- Electric prods should not be used routinely. A flag, paddle stick or a plastic bag should be the primary tool for moving animals. The electric prod should only be used to move an animal that balks.
- If a powered gate is used to move animals, it should be controlled by an operator pushing a switch. Fully automated gates in the crowd pen leading to the single file chute often lead to pile ups. The operator must be able to control the gate.
- Chutes should be designed to reduce clanking and rattling. In a pork plant, the doors for removing downed pigs should be designed so they do not clatter and make noise when pigs bump against them.
- People should stop whistling and yelling. High-pitched sounds from people yelling agitates the animals.
- Pork producers should walk in the pens every day during finishing. This will help make the pigs easier to handle at the plant. This is especially important for lean hybrid pigs with an excitable temperament.
- Eliminate the injection of air into the brain by a stunner.

How to Determine Insensibility in Cattle, Pigs, and Sheep in Slaughter Plants

(Revised December 2010)

by Temple Grandin
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In both captive bolt and electrically stunned animals kicking will occur. Ignore the kicking and look at the head. To put it simply, THE HEAD MUST BE DEAD. When cattle are shot with a captive bolt, it is normal to have a spasm for 5 to 15 seconds. After the animal is rolled out of the box or hung up its eyes should relax and be wide open.

Below are the signs of a properly stunned animal:

1. The legs may kick, but the head and neck must be loose and floppy like a rag. A normal spasm may cause some neck flexing, but the neck should relax and the head should flop within about 20 seconds. Check eye reflexes if flexing continues. Animals stunned with gas stunning equipment should be limp and floppy though they may exhibit slow limb movement.
2. The tongue should hang out and be straight and limp. A stiff curled tongue is a sign of possible return to sensibility. If the tongue goes in and out, this may be a sign of partial sensibility.
3. When the animal is hung on the rail, its head should hang straight down and the back must be straight. It must NOT have an arched back righting reflex. When a partially sensible animal is hung on the rail it will attempt to lift up its head. It will be stiff. Momentary flopping of the head is not a righting reflex.
4. When captive bolt is used the eyes should be wide open with a blank stare. There must be no eye movements. Immediately after electrical stunning the animal will clamp its eyes shut, but they should relax into a blank stare.
5. When captive bolt is used the animal must NEVER blink or have an eye reflex in response to touch. In electrically stunned pigs eye movements can be misinterpreted when untrained people indiscriminantly poke at the eyes. It is often best to observe without touching the eye. If a pig blinks with a natural blink where the eye closes and then re-opens it is not properly stunned. If you are not sure what a natural blink looks like, go and look at live pigs in the yards (lairage) before assessing insensibility.
6. Rhythmic breathing must be absent. Count as rhythmic breathing if the animal's ribcage moves two or more times. Gasping is a sign of a dying brain and is acceptable after gas or electric stunning. It will look like a fish out of water. A twitching nose (like a rabbit) may be a sign of partial sensibility.
7. In captive bolt stunned animals, insensibility may be questionable if the eyes are rolled back or they are vibrating (nystagmus). Nystagmus is permissible in electrically stunned animals, especially those stunned with frequencies higher than 50 or 60 cycles.
8. Shortly after being hung on the rail, the tail should relax and hang down.
9. No response to a nose pinch or pinprick on the nose. The painful stimulus should be applied only to the nose. Animals entering a scauld tub must not make a

movement that is in direct response to contact with the hot water. For all types of stunning this is an indicator of possible return to sensibility.

10. No vocalization (moo, bellow or squeal) after the captive bolt stunning.
11. After electric stunning there maybe a response, but the animal will be insensible if there is no response to a pinprick on the nose. No blink response when a light is shined in the eye. The light should be held 6 inches (15 cm) away.

The above methods can be used for determining insensibility for all types of stunning and for ritual slaughter which is done without stunning. Just remember, kicking reflexes are normal in captive bolt stunned animals, electrically stunned animals and after ritual slaughter. They should be absent or very feeble for $C0_2$. Captive bolt stunning induces instant insensibility by both concussion and physical destruction of the brain. Stunner maintenance is essential to maintain maximum hitting power.

Electrical stunning, renders an animal instantly insensible by inducing a grand mal epileptic seizure. Scientific research has shown, that in order to induce the seizure the electric stunner must be set at a minimum of 1.25 amps for market weight pigs and l amp for sheep. Large sows will require 2 or more amps. If' lower amperages are used the stunner may induce cardiac arrest but the animal will feel the shock because the seizure was not induced. Electrical frequencies up to 800 hz (cycles) can be used. Frequencies over 800 hz should not be used. Research has shown that 1500 cycles failed to induce instant insensibility. Animals that are dehydrated may have high electrical resistance and be difficult to stun.

In some plants, cattle or sheep are immobilized after electric stunning with a small electric current to stop kicking. This immobilizer current completely masks signs of return to sensibility. To assess return to sensibility the immobilizer current MUST be turned off. Electric immobilization is highly distressful to animals and it must never be confused with electric stunning, which induces instantaneous insensibility by passing a high amperage current through the brain.

If an electrically stunned animal blinks within 5 seconds after stunning this is a sign that the amperage is too low. In electrically stunned animals, blinking should be checked within 5 seconds and after 60 seconds. In most plants blinking will not be found immediately after stunning, because the plant is using the correct amperage. After it has been verified that the amperage is set correctly, the most important point to observe for signs of return to sensibility is 60 seconds after electrical stunning. This provides time for the eyes to relax after the epileptic seizure. Checking for signs of return to sensibility after bleeding insures that the animal will not recover.

When stunned animals are viewed from a distance, the most important signs to look for in a properly stunned animal are:

1. A floppy head
2. Tongue hangs straight out and is limp
3. The back and head hang straight down. There is no arched back righting reflex.

Animals that show all three of the above signs will be insensible and blinking and other eye reflexes will be absent.

Order of the events which indicate Return to Sensibility:

1. Single feeble eye (corneal) reflex in response to touch (probably still insensible and not conscious).
2. Return of rhythmic breathing. This is a primary indicator of poor stunning and it may occur before the corneal reflexes.
3. Spontaneous natural blinking without touching (recommended sign for determining return to sensibility for regulatory purposes). In large plants this is easier to assess than rhythmic breathing.
4. Response to a painful stimulus such as pricking the nose with a pin. The stimulus must be applied to the head to avoid confusion with spinal reflexes.
5. Righting reflex and raises it's head.
6. Fully conscious and sensible. Complete return to sensibility can occur within 15 to 20 seconds after eye reflexes appear if an electrically stunned animal is not bled.

The American Meat Institute guidelines require that ALL of the signs of return to sensibility MUST be absent to pass an audit. Even thought an animal is probably insensible if it shows a weak corneal reflex or tongue movement, it is starting the process of return to sensibility. Weak indicators of return to sensibility can be abolished by improved stunning practices. Slaughter plants are not research laboratories where conditions are carefully controlled. Therefore a much greater margin of safety is required to ensure that the animal remains insensible.

An animal showing any of the above signs must be immediately re-stunned before any slaughter procedures are started.

Update October 2008

Due to increased USDA enforcement of the Humane Slaughter Act, thousands of animals have been observed and data collected by USDA inspectors and plant personnel. A tiny percentage of animals still have a weak corneal reflex with no other indicators of return to sensibility present. These animals MUST be immediately re-stunnned before scalding or any invasive dressing procedure such as leg removal or skinning is performed. Scientific research shows that an animal with a weak corneal reflex in response to touching with a pen is insensible if no other indicators of return to sensibility are present (Anil 1991, Knudsen 2005, and Rumpl et al 1982). A corneal reflex must NEVER be confused with natural spontaneous blinking that can be observed in live animals in the yards. Animals with spontaneous natural blinking are sensible. To insure that animals remain completely insensible after stunning and bleeding, good bleeding is essential (Grandin 2001). Increased sampling and measurement is probably detecting faint corneal reflexes that were not detected previously. My previous statement that weak corneal reflexes can be completely abolished in CO_2 and electrically stunned animals may be wrong. Since corneal reflexes are the beginning of the process of return to sensibility, effort must be made to reduce them to a very low level and insure that all other signs of return to sensibility are absent. All animals showing a corneal reflex MUST be immediately re-stunned. There is a need to collect data on thousands of animals to determine the incidence of weak corneal reflexes when no other signs of return to sensibility are present in animals stunned with CO_2 or electricity. In animals stunned with captive bolt corneal reflexes can be abolished.

There is also a possibility that some stunning failures in one of several thousand animals may be due to biological variability or abnormal nervous system development. In one strange case, 1 of 8000 electrically stunned pigs had a stiff arched back righting reflex 45 to 60 seconds after bleeding and there was no corneal reflex, no blinking in response to light, and no response to a nose prick. Most of these pigs were large, 275 lb (124 kg), and extremely heavy muscled. Another possibility is that their physiology was so overloaded by genetic selection or ractopamine (Paylean) that they went into rigor. The plant employees immediately re-stunned the pigs. The righting reflex was not due to poor bleeding because the effectiveness of bleeding was verified with dissection of the throat area. To insure that animals do not return to sensibility while hanging on the line, a plant employee MUST re-stun all animals that have a corneal reflex or any of the signs of return to sensibility listed in this paper. On a 100 animal audit, ALL animals must have no signs of return to sensibility.

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Restraint of Livestock

(Updated March 2000)

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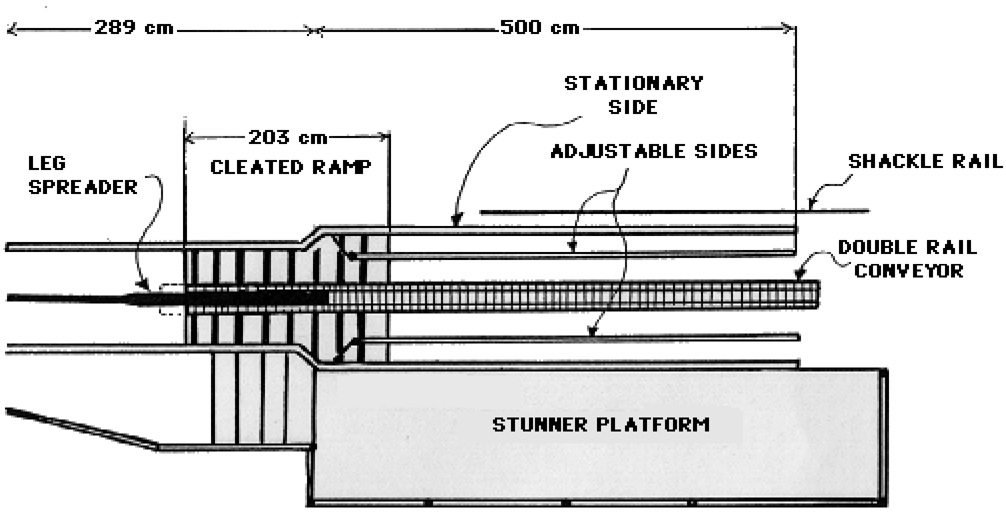
During twenty five years of work on livestock handling and design of restraining devices for animals, I have observed that many people attempt to restrain animals with sheer force instead of using behavioural principles. Improvements in the design of restraining devices enhances animal welfare and will reduce stress and injuries. A series of surveys conducted by the author showed that changing the design of a squeeze chute would reduce injuries to cattle (Grandin 1975). Squeeze chute design has improved. Some of the newer headgate designs may further reduce injuries. The pressure relief valve on a hydraulic chute must be set correctly. An animal restrained in a squeeze chute should be able to breath normally without straining. Under the best conditions, cattle can become bruised or injured in a conventional squeeze chute. A survey of seven major feedlots by Brown et al (1981) indicated that in five of the feedlots 1.6% to 7.8% of the animals were bruised. Even though bruises would heal by marketing time, pain and trauma may reduce weight gain. Research done by Bridget Voisinet at Colorado State University has shown that cattle that become excited and agitated in a squeeze chute will have lower weight gains and are more likely to have dark cutting meat and tougher meat. Cattle can become asphyxiated by excessive pressure on the carotid arteries. In a standard hydraulic stanchion squeeze chute used in most commercial feedyards an inexperienced operator can cause 2% of the cattle to collapse from pressure on the carotid arteries (Grandin 1980). A collapsed animal will die if the operator fails to release it immediately. Excessive hydraulic pressure can cause severe injuries. The animal's diaphragm can be ruptured (Fulton, R. 1973 personal communication). Excessive pressure can break the pelvis (Miles, D. 1992 personal communication). The author has also observed that excessive squeeze pressure can cause a significant reduction in weight gain. Good management can prevent many of these problems but there is still a great need for improved restraint devices for use on ranches and feedlots. I did not realize how poor existing chutes in feedlots were until I developed restraint devices for calf and beef slaughter plants. Quiet handling of cattle will reduce stress and injuries in squeeze chutes. Excited animals are more difficult to handle. It takes up to 30 minutes for an excited animal to calm down. To keep animals calm in a restraint device they must be calm when they enter it. Cattle should walk into a squeeze chute and walk out of it. Feedlot operators have found that calm handling of cattle in squeeze chutes will enable cattle to go back on feed more quickly.

Over the years I have designed several different types of cattle restraint devices for use in meat packing plants. During the course of developing these devices I have learned that the use of behavioural principles will keep both cattle and pigs calm. Many of these ideas could be incorporated into new designs for cattle restraining devices for the ranch farm or feedlot.

Origins of the Double Rail Restrainer System

For the last eighteen years, large beef slaughter plants have been using the V restrainer system for restraining cattle during stunning and shackling. It was invented by Edwards

(1972), Schmidt (1972) and Willems and Markey (1972). The V restrainer was a major humane and safety improvement over old style knocking boxes, but there were still problems with it. Cattle balked at the entrance and the stunner operator had to reach excessively to place the cattle bolt stunner in the animal's forehead. Researchers at the University of Connecticut developed a laboratory prototype double rail restrainer for calves and sheep (Giger et al 1977, and Westervelt et al 1976). They determined that it was a good low stress method for holding an animal. Grandin (1988) developed an improved entrance and animal size adjustment mechanism for this system and installed it in a commercial calf and sheep slaughter plant.



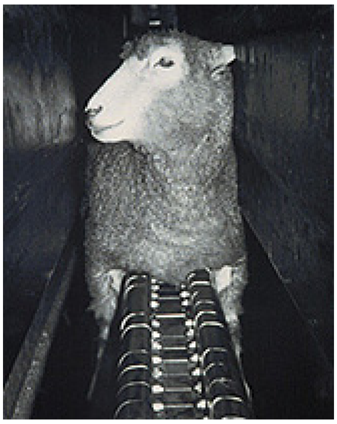
Center Track Conveyor Restrainer for Beef Cattle

Temple Grandin, Grandin Livestock Handling Systems Inc.

Revised July 2011

Note position of the bottom of the adjustable side to prevent pressure on the leg joint.

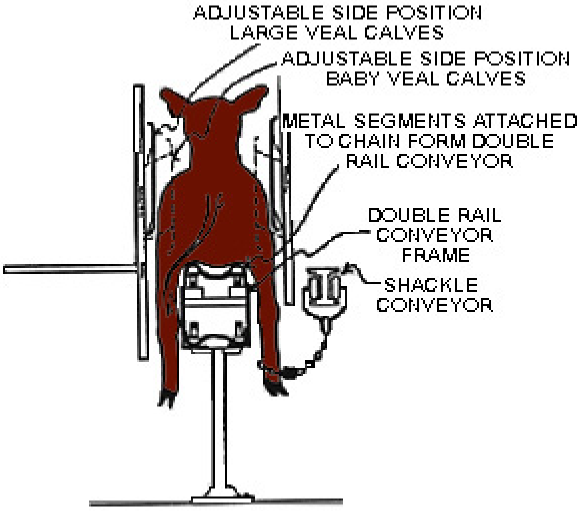
Adult steer on the center track conveyor. Note that the conveyor is shaped to fit the steer's brisket (chest). Another name for this system is a belly restrainer. This restrainer system will work for cattle, pigs, or sheep.



Center track double rail restrainer. This system is available for sheep, calves, pigs, and adult cattle.

A double rail (center track) conveyor restrainer system designed by the author is based on research by Geiger et al. (1977) and it is adjustable for a wide variety of animal sizes. Baby calves, sheep and large 225 kg (500 lb.) calves can all be handled in the same restrainer. For adult cattle, a slightly wider conveyor is used. The width of the moving conveyor that the adult animals straddle is 30cm (12 inches).

Standard V restrainer conveyors may cause petechial haemorrhages during electric stunning (Thornton et al., 1979; Lambooy, 1986). There is a possibility that this system may reduce bloodsplash and speckle in electrically stunned animals (E. Lambooy, 1987, personal communication). With the double rail conveyor animals are supported under the brisket and belly while straddling the conveyor so that even large wild calves will ride quietly. The double rail requires less space than a V conveyor restrainer and it is compatible with existing shackling and bleeding systems.

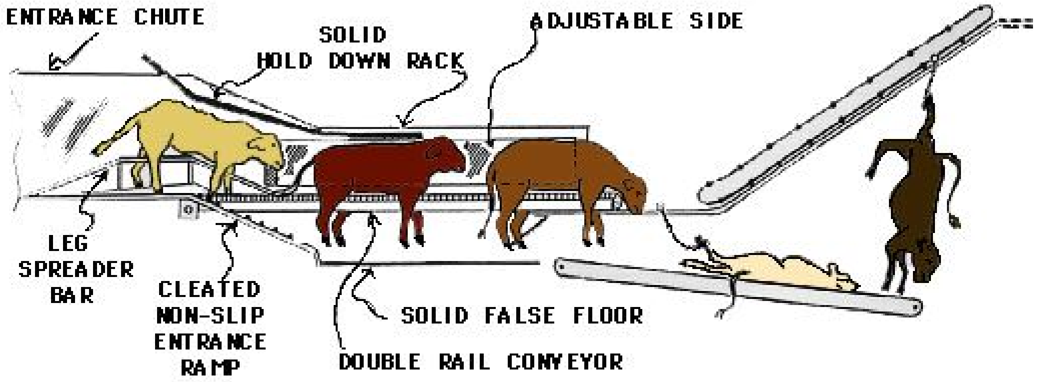


Proper design of the system is essential. The top of the conveyor is level with the floor of the entrance race. The animals walk down a cleated nonslip ramp which is on a 25 degree angle. The principle is that the animal will walk in quietly if it does not slip. A common mistake many people make is to remove the cleats. Making an animal slide down the ramp is wrong. A ramp with a shallower angle, such as 15 to 20 degrees, can be used. An entrance ramp steeper than 25 degrees must never be used.

Veal calf entering the center track restrainer. For all species, it's very important to have a non-slip ramp with cleats. For adult cattle, a belly rail must be added (see diagram of cross section through the restrainer entrance).

This same ramp design is also recommended for V conveyor restrainers. The sides of the ramp must be closed-in and animals must not see light coming up through the bottom of the restrainer. A stationary leg spreader bar over the ramp and in the first section of entrance race guides the animal's legs to the correct position. Calves entered this system with less balking compared to a V restrainer. The conveyor is constructed from metal segments attached to a moving chain. Each segment is bent to form the double rail configuration. Total width of the conveyor frame is 21.5 cm (8 1/2 inches). The moving segments are 19 cm (7 1/2 in.) wide with a 7.6 cm (3 in.) space in the middle to accommodate the animals' brisket. For adult cattle, a slightly wider conveyor is used. The width of the moving conveyor that the adult cattle straddle is 30cm (12 inches). The total inside width of the stationary sides is 107 cm (42 in) and the width of the entrance race which leads up to the conveyor is 86 cm (34 in). The width between the belly rails is 69 cm (27 in) (see diagram).

To induce the cattle to stay still and ride quietly, the solid hold down rack <u>MUST</u> be long enough so that the animal entering the restrainer can <u>NOT</u> see out until it's feet are completely off the entrance ramp.



This system MUST have a solid false floor just below the animal's feet. Cattle will balk and refuse to enter if they see a steep drop off below the conveyor.

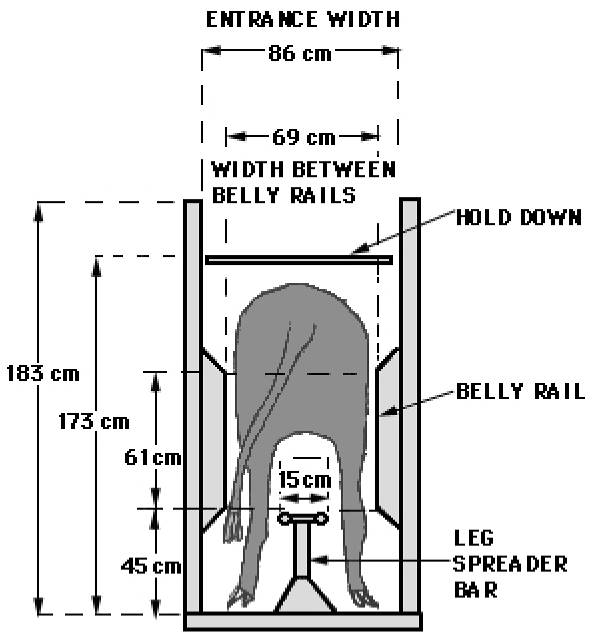
Adjustable sides accommodate different sized animals. The adjustable sides press lightly against the top portion of the animal's body. They are on pivots and the bottom edge of the adjustable side is slightly above the top of the conveyor. This provides room for the animal's leg joints. Pressure on the leg joints causes stress and discomfort. The pivot mechanism simultaneously adjusts the width between the sides and the leg joint space. For calves, the width between the adjustable sides can be varied from 51 cm (20 in.) to 25 cm (10 in.). The space between the bottom of the adjustable sides and the top of the double rail is 5 cm (2 in.) when the sides are spread 25 cm (l0 in.) apart and 12.7 cm (5 in.) when the sides are spaced 45 cm (18 in.) apart.

Full size double rail restrainer for adult cattle.

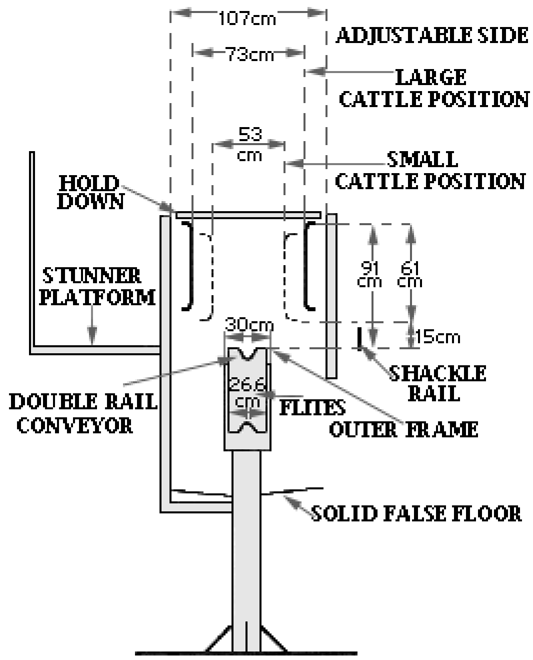
Inner adjustable sides: The position of the adjustable sides in relation to the steer's body can be seen in the first picture on this page. The adjustable sides are on pivots like a parallelogram. For adult cattle, the inside width between the adjustable sides is 53 cm (21 in) for small cattle and 73 cm (29 in) for large cattle.

Another very important design feature is the solid hold down rack and the solid false floor. To keep the animal calm, the hold down rack must be long enough to prevent the animal from seeing out until it's rear feet are off the entrance ramp. The solid false floor prevents the animal from seeing the "visible cliff" effect under the restrainer. This greatly reduces the amount of animals balking and refusing to enter.

The solid false floor is essential to facilitate cattle entry into the restrainer.



Cross Section through restrainer entrance before the animal reaches the conveyor



Cross Section through the conveyor and hold down

These diagrams illustrate dimensions for adult cattle. Dimensions for calves are given in previous text. For adult cattle there must be a belly rail to keep the cattle centered as they enter the restrainer. The belly rail makes the animal straddle the leg spreader bar and it prevents the animal from walking on one side of the leg spreader. The belly rail must not extend all the way to the floor. The animal's feet need space for walking.

Installing a spot light to illuminate the entrance to the restrainer will make animals enter more easily and reduce balking. Good lighting is essential. The cattle will not enter a dark tunnel.

Correcting Common Problems with Conveyor Restraints

Problem: Animal refuses to enter

Solutions:

1. Add lighting. Cattle, pigs, or sheep will not enter a restrainer that looks like a dark tunnel.
2. Block vision of moving people and equipment that an incoming animal can see through the restainer. Animals will not approach visible people.
3. Make sure the false floor is in place. Animals will not enter if they can see the "visual cliff" effect. Install a solid false floor so it is 20 cm (8 in) below the hooves of the largest animals.
4. The entrance ramp must be non-slip. Animals panic when they slip. Cattle will confidently walk down a non-slip entrance ramp. Never remove the cleats. It should work on the same principle as the non-slip dip vat ramp that was shown in the HBO move "Temple Grandin."
5. Raise the solid hold down so incoming animals do not bump their shoulders. Animals will refuse to enter if they bump their backs on equipment.

Problem: Animals become agitated or vocal

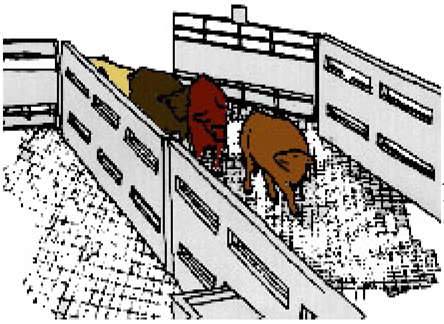
Solutions:

1. Remove sharp edges that may be gouging the animal. Very small sharp edges can be felt.
2. The solid holddown rack must be long enough so that the animal is fully settled down and riding on the conveyor BEFORE it sees out. Experiment with pieces of cardboard to determine the best length.
3. Move people who are standing in front of the restrainer. Incoming cattle should not see people.
4. Reduce use of electric prods and eliminate people yelling and whistling. People should be quiet.

The Principles Of Low Stress Restraint
Cattle and Pigs

Cattle restraining squeeze chute with angled rubber louvres on the side which prevent the cattle from seeing people. The side can be opened for easy access for injections and other veterinary procedures. The louvres block the animal's vision the same way that louvred shutters block vision through windows in a house.

1. Solid sides or barriers around the cattle to prevent them from seeing people deep inside their flight zones. This is especially important for wild or excitable cattle.
2. To prevent lunging at the headgate, the bovine's view of an escape pathway must be blocked until it is fully restrained. This principle does not apply to pigs.
3. Provide non-slip flooring for all species of animals.
4.
5.
6.



A good example of a non-slick surface for livestock.

7. Slow steady motion of a restraint device is calming, while sudden jerky motion excite.
8. Use the concept of optimal pressure. Sufficient pressure must be applied to provide the feeling of restraint, but excessive pressure that causes pain or discomfort must be avoided.
9. The entrance of the restraint device must be well lighted, however, lamps must not glare into the eyes of approaching animals. All species must be able to see a place to go.
10. Livestock will remain calmer if they can see other animals within touching distance.
11. Engineer equipment to minimize noise. High pitched noise is more disturbing to livestock than a low pitched rumble.
12. Restraint devices must be designed to avoid uncomfortable pressure points on the animal's body.
13. Restrain livestock in an upright position.

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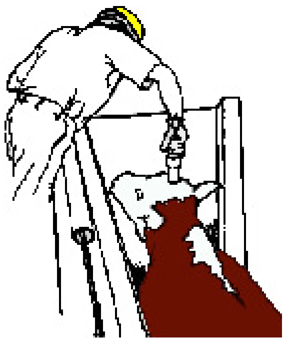
Proper Cattle Restraint for Stunning

Updated April 2010

Cartridge fired captive bolt gun



If a stunning box is used, it should be narrow enough to prevent the animal from turning around. The floor should be non-slip so the animal can stand without losing its footing. It is much easier to stun an animal that is standing quietly. Only one animal should be placed in each stunning box compartment to prevent animals from trampling on each other.

Stationary slanted shelf in the front of the stun box keeps the animal's head raised

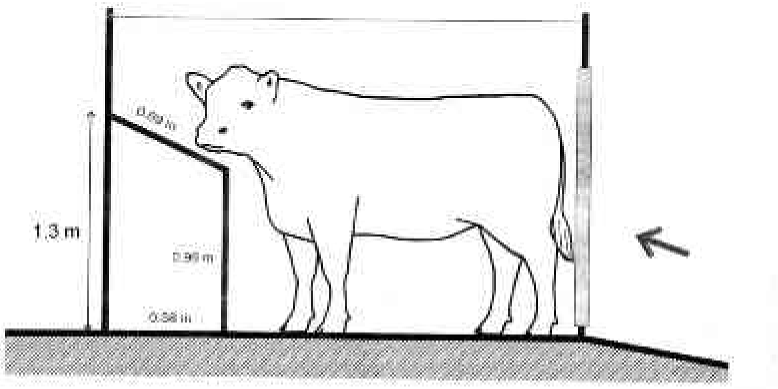


Image courtesy of Humane Slaughter Association

Hinged panel to raise the animal's head

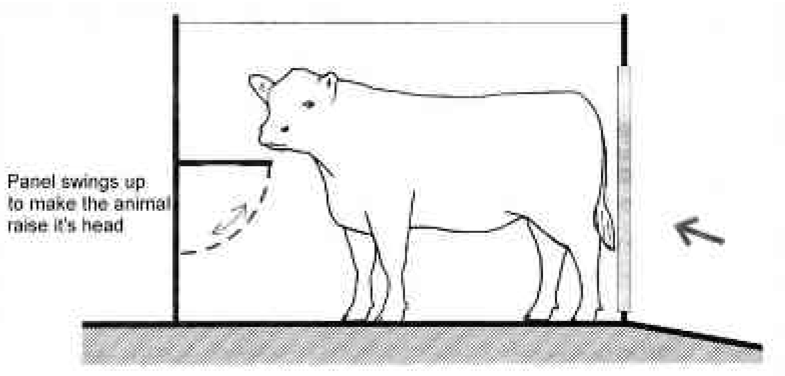
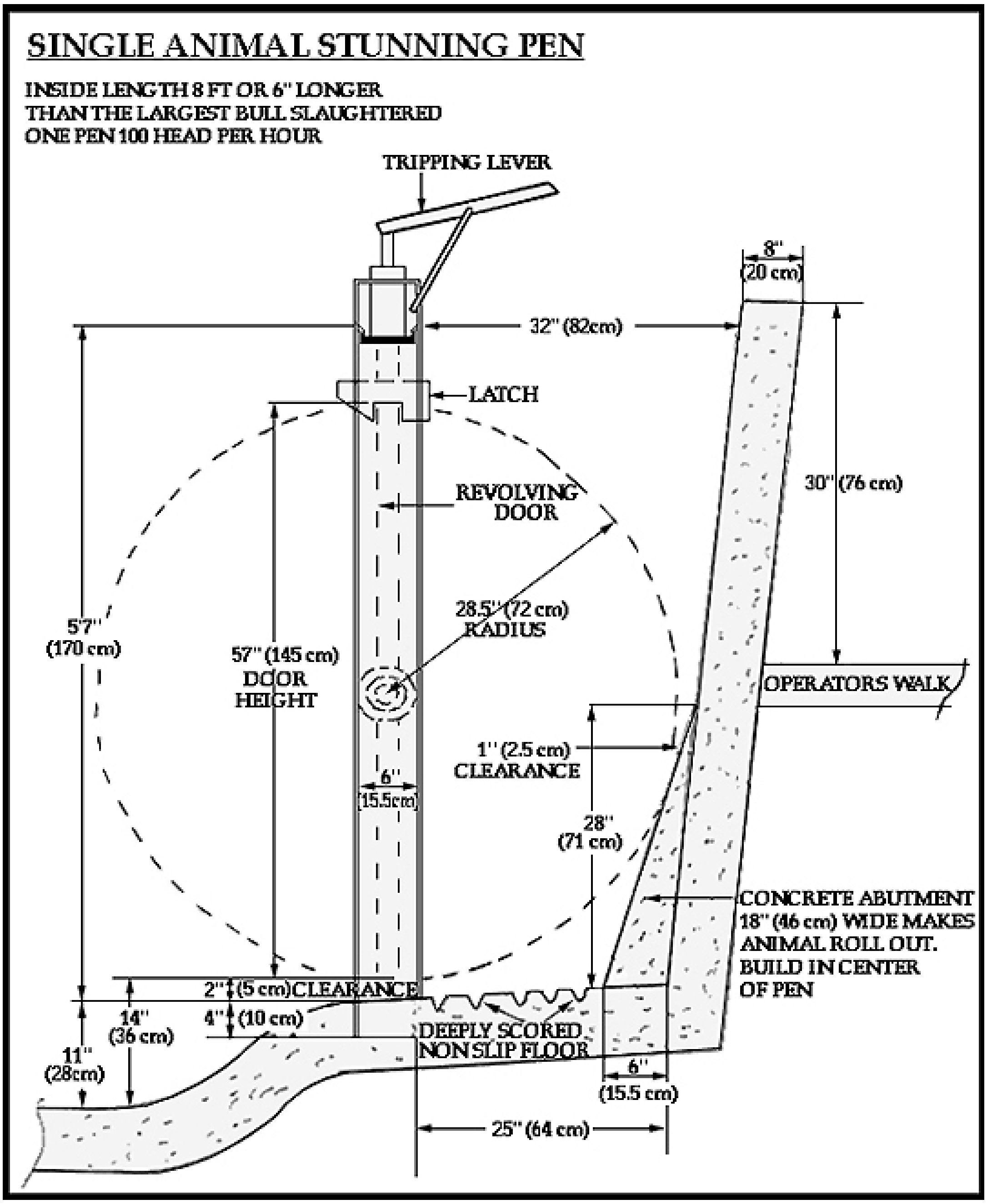


Image courtesy of Humane Slaughter Association

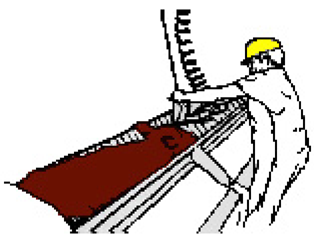
If either electric stunning or mushroom head (non-penetrating) captive bolt stunning is used a head holder like the one in this picture or similar to the headholders used for religious slaughter should be used. When non-penetrating captive bolt is used the aim must be exact. This requires holding the animal's head still. When penetrating captive bolt is used a good stunner operator may not need a headholder or one of the simpler shelf systems can be used.

In this head holder, a neck stanchion closes around the neck and a shlef is raised up under the animal's chin.

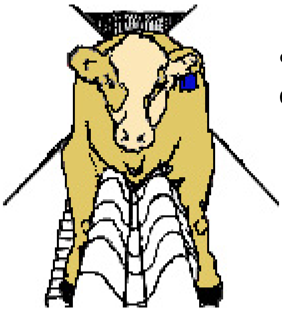


In many new plants a vertical sliding door is used instead of the rotating door to improve safety. A solid vertical sliding door can be placed in the same location as the rotating door. The angled concrete abutment can still be used to facilitate rollout of the stunned animal. When a vertical sliding door is used, there should be a 6 in (15 cm) gap at the bottom when the door is in the full down position to prevent the shackler's hands from getting caught.

Pneumatic captive bolt gun

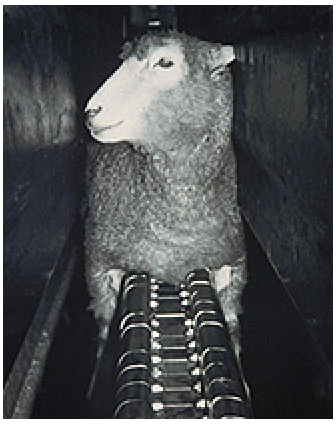


Most large plants restrain cattle in a conveyor restrainer system. There are two types of conveyor restraints, the V restrainer and the new center track system. In a V restrainer system, the cattle are held between two, angled conveyors. In the center track system the cattle ride astride a moving conveyor.



- **A very humane position for cattle. Cattle are restrained in a comfortable, upright position.**

- The center track system provides the advantages of easier stunning and improved ergonomics because the stunner operator can stand closer to the animal. Either type of restrainer system is much safer for workers than a stunning box. Restrainer conveyors are recommended for all plants which slaughter over 100 head per hour. Stunning boxes are difficult and dangerous to operate at higher speeds. In a plant which slaughtered 160 cattle per hour, replacement of multiple stunning boxes with a conveyor restrainer eliminated at least one serious accident each year.



- **Center track double rail restrainer. This system is available for both sheep and cattle.**

- Lighting in the restrainer room over the top of the conveyor will help induce cattle to raise their heads for the stunner. Cattle should not be able to see light coming up from under the restrainer because it may cause balking at the entrance. Restrainer systems should be equipped with a long, solid hold-down rack to prevent rearing. The hold-down should be long enough so that the animal is fully settled down onto the conveyor before it emerges from under it.
- If an animal is walking into the restrainer by itself, do not poke it with an electric prod. Center rack systems require less prodding to induce cattle to enter it. Workers need to break the "automatic prod reflex" habit.

- **Animal entering the center track double rail restrainer.**

Recommended Captive Bolt Stunning Techniques for Cattle

by Temple Grandin

(Updated March 2009)

A captive bolt stunning gun kills the animal and reduces it instantly unconscious **without causing pain.** A captive bolt gun has a steel bolt that is powered by either compressed air or a blank cartridge. The bolt is driven into the animal's brain. It has the same effect on the animal as a firearm with a live bullet. After the animal is shot the bolt retracts and is reset for the next animal. A captive bolt gun is safer than a firearm.

There have been some questions about whether or not a captive bolt actaully kills an animal. Practical experience in slaughter plants indicates that cattle shot correctly with a penetrating captive bolt have irreversible damage to their brain and they will not revive. If a non-penetrating captive bolt is used the animal may revive unless it is bled promptly.

Captive bolt stunning in center track restrainer

Stunner in the correct location.

These photos show correctly applied captive bolt stunning. The animal is instantly rendered insensible to pain.

There has been renewed interest in the use of non-penetrating captive bolt due to concerns about BSE (Bovine spongiform encephalopathy). The elimination of stunners that injected air into the brain greatly reduced the amount of brain or spinal cord tissue that could be spread to other parts of the body. However, research has shown that even when air injection had been removed, small amounts of brain tissue may enter the body and brain tissue may contaminate plant equipment. The effective use of non-penetrating captive bolt requires much more accurate aim than a penetrating captive bolt. This will require the use of equipment to hold the animal's head. Designs for head holders can be found in the religious slaughter section of www.grandin.com and in the restraint for stunning section. Mushroom head non-penetrating captive bolt stunners inflict varying degrees of damage to the skull. Non-penetrating captive bolt that fractures the skull is more effective than a stunner that does not fracture the skull. Effectiveness increases as the degree of skull fracturing increases. It is likely that reducing the spread of at risk brain material is reduced when fracturing is minimized. Unfortunately, effective stunning and reducing skull fracturing are two opposite goals. As the amount of damage to the skull is reduced, placement of the shot must become more and more precise to achieve instantaneous insensibility. Shooting on a slight angle may result in failure to induce instantaneous insensibility. A mushroom head with a larger diameter may be more effective with less fracturing than a mushroom head with a small diameter.

Recent observations of the Jarvis pneumatic mushroom head non-penetrating stunner showed that it was effective on Zebu type cattle with very short hair. The plant had a head holding device to hold the bovine's head. The stunner fractured the skull but did not break the skin. Observations indicate that non-penetrating stunners may be less effective on cattle with woolly heads such as Herefords compared to short haired cattle.

In plants using a non-penetrating captive bolt animal welfare should be evaluated with the American Meat Institute scoring system in the same manner as penetrating captive bolt. The plant must be able to stun 95% or more of the cattle correctly with a single shot. They must be able to attain an acceptable score of 75% of the cattle moved with no electric prod and 3% or less of the cattle vocalizing. If a head restraint is used, a vocalization score of 5% is acceptable.

Heavy mature bulls are more difficult to stun with captive bolt compared to cows or fed beef. Practical experience in plants indicates that heavy bulls are most effectively stunned with either a perfectly maintained cartridge fired penetrating captive bolt stunner, a fire arm with a free bullet, or one of the new powerful pneumatic penetrating captive bolt stunners. Stunning mature bulls correctly has been a continuous problem that has repeatedly shown up in restaurant audits. The stunning of bulls with a non-penetrating stunner will need to be carefully monitored and audited to maintain a high standard of animal welfare.

For large bulls and other heavy livestock such as bison, some plants routinely shoot them twice with a captive bolt. To verify that 95% or more are rendered insensible with one shot, the auditor or inspector should check for signs of return to sensibility BEFORE the second shot is done. A stunner shot that shoots in the air and does not touch the animal does not count. If the bolt of the stunner touches or partially penetrates the animal it is counted as a missed shot.

Some European regulations require that animals be bled within 45 to 60 seconds after captive bolt stunning. This is especially important after non-penetrating captive bolt. There have been questions on how to interpret this regulation that need to be clarified. If the first shot fails to render the animal completely insensible and the animal has to be shot a second time, how should the interval be timed? It should be timed AFTER the second shot. An animal showing signs of return to sensibility must NEVER be hung on the rail. This is a direct violaton of USDA regulations and hanging a sensible animal would cause suffering.

The issue of stunner problems with brain tissue contamination must be kept in perspective. The carcass splitting saw also spreads spinal cord tissue on the carcass (Bowling et al., 2007). Splitting saw contamination may possibly be worse than contamination from a standard penetrating captive bolt.

Studies done under good commercial conditions show that contamination from brain proteins is low. A study done by Rovira et al (2007) at Colorado State University indicated that only one animal out of 360 had a positive GFAP immuno assay for brain protein in the blood after penetrating captive bolt. Thirty cattle were sampled in 12 commercial plants. In 10 out of the 12 plants, the animals were shot with a single shot. The one positive sample occurred in a plant where the kill floor layout made it impossible to verify that the animal was shot with a single shot. A study done at the University of Bristol by Coore et al (2005) showed much higher levels of contamination. They used methods that may have confounded their results. The cattle were anesthetized and a catheter with a balloon was inserted into the jugular vein. There is a possibility that this device may have slowed down bleedout and changed blood flow patterns in the brain. Another study done under commercial conditions had results similar to the Colorado State study (Lucker et al, 2005).

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The Principles Of Low Stress Restraint
Cattle

1. Solid sides or barriers around the cattle to prevent them from seeing people deep inside their flight zones. This is especially important for wild or excitable cattle.
2. 

Cattle restraining squeeze chute with angled rubber louvres on the side which prevent the cattle from seeing people. The side can be opened for easy access for injections and other veterinary procedures. The louvres block the animal's vision the same way that louvred shutters block vision through windows in a house.

3. To prevent lunging at the headgate, the bovine's view of an escape pathway must be blocked until it is fully restrained.
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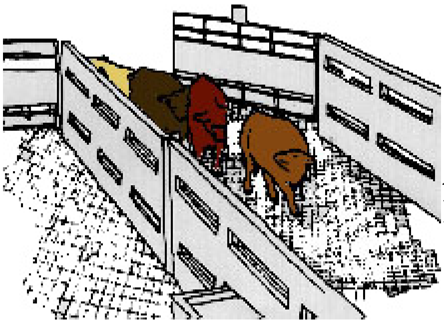
7. 

A good example of a non-slick surface for livestock.

8. Slow steady motion of a restraint device is calming, while sudden jerky motion excite.
9. Use the concept of optimal pressure. Sufficient pressure must be applied to provide the feeling of restraint, but excessive pressure that causes pain or discomfort must be avoided.
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13. Restraint devices must be designed to avoid uncomfortable pressure points on the animal's body.
14. Restrain livestock in an upright position.

Electric Stunning of Cattle

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(Revised April 2011)

Electric stunning of cattle has been successfully used for many years in New Zealand and it is in compliance with strict animal welfare codes. A minimum of 1.2 amps must be passed through the bovine's head for a minimum of 2 seconds. The current must pass through the brain. Commercially available equipment that is used in New Zealand is very effective when it is used correctly. The one possible problem area is the use of electric stunning on dehydrated cattle. Unfortunately the cost of the New Zealand equipment is prohibitive for use in many other countries. Some homemade electric stunning systems are not effective. These systems often consist of a hand held electrode that is held on the head and the current grounds out through the floor of the stun box. These systems are bad for two reasons:

1. Cattle are too big to be stunned effectively by a single current passing from the head to the feet. The current may bypass the brain. Even though the heart is stopped by the electrical current, the animal may feel the shock. To induce instant insensibility, the current must enter the brain and cause a grand mal epileptic seizure.
2. Another problem is that a hand held electrode applied to the head often fails to maintain contact when the animal falls unless it's head is held in a restraing headholder. This may result in the animal feeling the shock.
3. Use of the stun box floor as an electrode is a poor design because the feet may fail to stay in complete contact with the floor for the entire duration of the stun.

An electric stunner for cattle must have the following features to maintain good animal welfare:

1. For head only stunning, two electrodes must be applied to the head and held in firm contact with the head when the animal falls. In the New Zealand system the current passes from a neck stanchion to a nose plate. Another alternative would be modification of a chin lift used for religious slaughter. The electrode position would be forehead to chin. Another possible position would be across the head between the eye and the ear, like head only tongs used for pigs. The tong would have to stay attached to the head when the bovine falls. The neck to neck position must NEVER be used because the current may fail to go through the brain. A headholder that holds the animal's head up when the body falls is stronlgy recommended.
2. To prevent stress on the animal, the current must be applied immediately after the head electrodes are applied. Head restraint devices that cause 5% or more of the cattle to vocalize (moo or bellow) are not acceptable.
3. Water must be applied to the electrode during the stun to reduce electrical resistance. Some systems have failed due to high electrical resistance through

the bovine's hair. This is especially a problem in cattle with long hair. Be careful not to apply excessive amounts of water which may cause the current to be diverted over the surface of the animal instead of passing through the brain.

4. When head only electrical stunning is used the bovine must be bled within 10 seconds. Head only stunning is often used for Halal slaughter.
5. The two stage stun described here has been verified by scientific research. If cardiac arrest stunning is desired to stop the heart, the head stun must be applied first by the two electrodes on the head. After the head stun, a second current can be applied to the body to stop the heart. The design of the cardiac arrest electrode is less critical and a hand held probe would be effective. Hand held probes should NOT be used to apply the initial head stun, unless the animal's head or body is supported to prevent the animal from falling away from the electrode.
6. In some plants, to stop kicking after stunning, an immobilizing current is applied to paralyze the muscles. This current is NOT a substitute for an effective head stun. The first step of the process of electric stunning of cattle must be an initial head stun applied by electrodes which will stay in firm contact with the animal's head when it falls. Immobilization of a conscious animal with a weak electric current is highly aversive. Several scientific studies have shown that immobilization of conscious sensible animals is very detrimental to animal welfare.
7. When electric stunning is assessed for return to sensibility, immobilization devices must be turned off. The animal may kick. This is a normal sign of a grand mal epileptic seizure. An electric immobilization device will mask the normal tonic (ridgid phase) and clonic (paddling leg movements) of an effective head only electric stun that has induced epileptic activity in the brain. Head only stunning that is reversible is often used in Halal slaughter plants. When cardiac arrest stunning is used, the tonic and clonic phase of the epileptic seizure will be partially blocked by the heart stopping current.
8. For the initial head stun, an electrical frequency of 50 to 60 Hz is most effective.
9. Observations in a slaughter plant indicate that a single electrical current passed from the forehead to the side of the body may be effective. The tonic and clonic spasms of a grand mal epileptic seizure were induced by using this position. The body electrode should be isolated from a steel restraining device.
10. To safely wet the electrodes during the stun, a small stream of water should be applied continuously during the stun. This must NOT be applied by a person holding a hose. It must be applied by a separate pipe system that is NOT touched by people during stunning.
11. Electric stunning is much more likely to fail and not produce insensibility in dehydrated cattle. I have observed this problem in three different plants. Even though the New Zealand electric stunner was working perfectly, many animals showed signs of return to sensibility such as blinking and rhythmic breathing. Problems with dehydrated cattle are most likely to occur in cattle that have been trasported long distances. Some animals that have been drinking from ponds or large tanks may refuse to drink from small water troughs with an automatic float. They are afraid of the "shsh" sound when the trough refills, and may refuse to drink in the lairage at the plant.

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- Even though this paper is about pigs and sheep, it will provide useful information on determining whether or not the head electrodes are staying in good electrical contact with the head.

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Cattle vocalizations are associated with handling and equipment problems at beef slaughter plants

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Abstract

Vocalization of cattle in commercial plants is associated with observable aversive events such as prodding with electric prods, slipping in the stunning box, missed stuns, sharp edges on equipment or excessive pressure from a restraint device. A total of 5806 cattle were observed during handling and stunning in 48 commercial plants in the United States, Canada, and Australia during the calendar year of 1999. Each animal was scored as either a vocalizer or a non-vocalizer. In 20 plants (42%), 0-1% of the cattle vocalized, in 12 plants (25%) 2-3% vocalized, in 12 plants (25%) 4-10% vocalized, and in four plants (8%) more than 10% vocalized. In three plants repeated use of an electric prod on 95% or more of the cattle that balked and refused to move was associated with vocalization percentages of 17, 16, and 12%. In five plants, the percentage of cattle that vocalized was reduced by making modfications to plant equipment. Reducing the voltage on a rheostat controlled electric prod reduced the vocalization percentage from 7 to 2% in the first plant. In three other plants, the incidence of cattle backing up and balking was reduced by illuminating a dark entrance or adding a false floor to a conveyor restrainer. A false floor eliminates the visual cliff effect. The percentage of cattle that vocalized was reduced from 8 to 0%, 9 to 0%, and 17 to 2%. Since balking was reduced, electric prod use was also reduced. In the fifth plant, reduction of the pressure exerted by a neck restraint reduced the percentage of cattle that vocalized from 23 to 0%. In the five plants where modifications were made, a total of 379 cattle were observed prior to equipment modifications and 342 after modification. The mean percentage of cattle that vocalized was 12.8% before the modifications and 0.8% after the modifications ($P < 0.001$). Vocalization scoring can be used to identify handling and equipment problems that may compromise animal welfare.

Behavioral Principles of Livestock Handling

(With 1999, 2002, and 2010 Updates on Vision, Hearing, and Handling Methods in Cattle and Pigs)

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Summary

Reducing stress during handling will improve productivity and prevent physiological changes that could confound research results or lower productivity. Handling stresses lower conception rates and reduces both immune and rumen function. Handlers who understand livestock behavior can reduce stress. Livestock have wide angle vision and they are easily frightened by shadows or moving distractions outside of chutes. Solid sides on chutes will reduce agitation and excitement. Noise should be kept to a minimum because animals have sensitive hearing. When wild cattle or sheep are handled the handler should work on the edge of the fight zone to avoid agitation. Cattle, pigs, and sheep are herd animals and isolation of a single individual should be avoided. An animal's previous experience with handling will affect its reaction to handling in the future. Animals which have had frequent gentle contact with people will be less stressed during handling than animals which have had previous aversive treatment. Livestock can be trained to voluntarily enter a restraining device. The restraint device should be gradually introduced and should not cause pain. Feed rewards will facilitate training. Training animals to voluntarily submit to handling procedures would be especially useful for valuable breeding animals and animals used for research.

Introduction

An understanding of the behavior of livestock will facilitate handling, reduce stress, and improve both handler safety and animal welfare. Large animals can seriously injure handlers and/or themselves if they become excited or agitated. Reducing stress on animals has been demonstrated to improve productivity and prevent physiological changes that could confound research results. Recent studies have shown the adverse effects of stress on animals. Restraint, electric prods and other handling stresses lowered conception rates (44, 84, 85). Transportation and restraint stress reduced the immune function in cattle and pigs (4, 53, 65). Rumen function was impaired by transit stress (20). In the studies conducted by Galyean et al., (20), Kelley et al., (53), and Blecha et al., (4), the stress imposed by transit had a greater detrimental effect on the animal's physiology than the stress of feed and water deprivation for the same length of time. Handling sheep with dogs and transport and sorting two to three weeks after mating caused early embryonic losses (12). The purpose of this review is to provide practical livestock handling information. It will cover various factors which affect stress levels in livestock.

Vision and Livestock Motion

Livestock have wide angle vision. Cattle and pigs have a visual field in excess of 300 degrees (75). In sheep, the visual field ranges from 191 to 306 degrees depending on the amount of wool on the head. Loading ramps and handling chutes should have solid side walls to prevent animals from seeing distractions outside the chute with their wide angle vision (22, 24, 79). Moving objects and people seen through the sides of a chute can cause balking or frighten livestock. Solid side walls are especially important if animals are not completely tame or they are unaccustomed to the facility. Blocking vision will stop escape attempts. This is why a solid portable panel is so effective for handling pigs. Sight restriction will lower stress levels (13, 39). The wildest cow will remain calm in a darkened artificial insemination box which completely blocks vision (70, 86).

Even though ruminant animals have depth perception, their ability to perceive depth at ground level while moving with their heads up is probably poor (59). Hutson (50) suggests that there may be an extensive blind area at ground level and moving livestock may not be able to use motion parallax or retinal disparity cues to perceive depth. To see depth on the ground, the animal would have to stop and lower its head. This may explain why livestock often lower their heads and stop to look at strange things on the ground. Cattle, pigs, sheep and horses will often balk and refuse to walk over a drain grate, hose, puddle, shadow or change in flooring surface or texture (22, 24, 62).

Shadows will cause livestock to balk.

Drains should be located outside of the areas where animals walk. A drain or a metal plate running across an alley will cause balking.

In areas where animals are handled, illumination should be uniform and diffuse. Shadows and bright spots should be minimized. Slats on the floor of shearing sheds and other animal facilities, should be eliminated so animals walk across the slats (48). Flapping objects or a coat hung on a chute fence may stop animal movement.

Pigs, sheep, and cattle have a tendency to move from a dimly illuminated area to a more brightly illuminated area, provided the light is not glaring in their eyes (22, 62, 90). A spot light directed onto a ramp or other apparatus will often facilitate entry. The light must not shine directly into the eyes of approaching animals. Recent research by Phillips et al., (74) indicated that pigs reared indoors preferred to walk up a ramp illuminated at 80 lux which was similar to the illumination of the rearing quarters. A dimly illuminated ramp with less than 5 lux was avoided. There was also a tendency to avoid an excessively bright ramp illuminated with 1200 lux.

Moving or flapping objects can also disrupt handling. Fan blades or a flapping cloth can cause balking. Animals may refuse to walk through a chute if they can see motion up ahead (31).

Livestock have color perception. Numerous investigators have now confirmed that cattle, pigs, sheep and goats all possess color vision (9, 10, 19, 40, 58, 68). Handling facilities should be painted one uniform color. All species of livestock are more likely to balk at a sudden change in color or texture.

1999 Vision Update

The latest research on color vision in farm animals shows that they are dichromats with cones (color sensitive retina cells) most sensitive to yellowish-green (552-555 nm) and blue pruple light (444-445 nm)[2]. Humans are trichromats and see the full color spectrum. Dichromatic vision may make the animal more sensitive to seeing sudden movement[4,5]. It may explain why grazing animals such as cattle balk at drain gates, shadows, and anything that has high contrast of light and dark. The brain's fear center which is called the amygdala is activated when an animal sees sudden movement[3]. One of the most common causes of balking in a handling facility is a small loose chain end that makes a rapid movement. Loose chain ends must be removed from races, chutes, and alleys. This is why people working with livestock should have slow deliberate movements. Grazing animals have a visual system that provides excellent distance vision but relatively weak eye muscles inhibit the ability to focus quickly on nearby objects. This may explain the tendency of a horse to spook at nearby sudden movement. Grazing animals also have a split shaped pupil and a visual system that is designed to be most efficient at scanning at a distance while they are grazing[8]. Animals will often refuse to enter a building that looks dark. This is most likely to be a problem on a bright sunny day. There are some handling facilities in buildings that work well at night or on a cloudy day, but on a sunny day the cattle may refuse to enter the building. Animals will enter a building more easily if they can see daylight in the building. Opening a door may help. Another option is to install white plastic transluscent panels which will let in lots of shadow free light. The ideal illumination should resemble a bright cloudy day.

2002 Vision Update

Well designed curved single file chute with solid sides to block the animal's vision. White translucent skylights provide good lighting with no shadows. The black strip along the top of the chute (race) is flexible rubber conveyor belting. The belting blocks the animal's vision and handlers can easily reach under the belting to move cattle.

Noise

Cattle and sheep are more sensitive than people to high frequency noises (2, 56). The auditory sensitivity of cattle is greatest at 8000 hz and sheep at 7000 hz (1). The human ear is most sensitive at 1000 to 3000 hz. Unexpected loud or novel noises can be highly stressful to livestock. Sheep exposed to exploding firecrackers or noise in a slaughter plant had increased thyroid hormone levels and elevated cortisol (16, 72). A loud clanging bell from an outdoor telephone will raise a calf's heart rate 50 to 70 beats per minute (T. Camp USDA Experimental Station, College Station, Texas, personal communication). Physiological changes induced by sudden noises could alter the results of experiments. Animals will readily adapt to reasonable levels of continuous sound, such as white noise, instrumental music, and miscellaneous sounds. Continuous exposure to sounds over 100 dB reduced daily weight gain in sheep (1). However, continuous background sound can actually improve weight gain in some cases. Ames (1) found that sheep exposed to 75 dB of miscellaneous sounds (roller coasters, trains, horns, etc.), white noise, or instrumental music gained weight faster than controls without continuous background sound.

Livestock producers and researchers have learned from practical experience that continuous playing of a radio with a variety of talk and music will reduce the reaction of pigs to sudden noises. Providing controlled amounts of continuous but varying background sound may help prevent weight gain losses caused by unexpected noises.

In facilities where livestock are handled, loud or novel noises should be avoided because they distress livestock (31). It may be advisable to have the same radio station or background sound that is provided in the living quarters. Research is needed to determine if exposing animals to sounds such as truck noise would help reduce stress.

The sound of hanging metal can cause balking and agitation (31). Rubber stops on gates and squeeze chutes will help reduce noise (26). The pump and motor on a hydraulic squeeze chute should be located away from the squeeze. Exhausts on pneumatic powered equipment should be piped away from the handling area. Small amounts of noise can be used to move livestock. Cattle and sheep will move away from a rustling piece of plastic. If sheep become excited they will not respond to this stimulus (87).

1999 Hearing Update

Research by Jennifer Lanier in our research group has shown that cattle that have a flighty temperament are more likely to flinch or jump in response to sudden movements and intermittent high pitched sounds. In the auction ring, flightly cattle were more likely to startle when the ring man suddenly swung his arm when he yelled out a bid. Intermittent sounds caused piglets to react more than a steady sound[6] and high pitched sounds increased a piglets' heart rate more than low pitched sounds[7]. Researchers in Canada found that sounds from people such as yelling or whistling had a greater effect on the heart beat of cattle than equipment sounds such as gates clanging[9]. Handlers can keep animals calmer if they avoid the visual and auditory stimuli that scare them. Sudden intermittent sounds and sudden jerky movement should be avoided. Handlers should use low pitched sounds to calm animals.

2002 Hearing Update

Horses, cattle, and other grazing animals will point their ears towards things that concern them. The zebra and the horse are both pointing an ear at each other. The horse has one ear pointed at me when I was taking the picture and the other ear focused on the zebra. This "ear radar" can provide an indication of stimuli that have attracted the animal's attention. Calm cattle can help you locate distractions in a cattle handling facility that can cause balking. Calm animals will point both their ears and eyes towards distractions that should be removed such as a swinging chain.

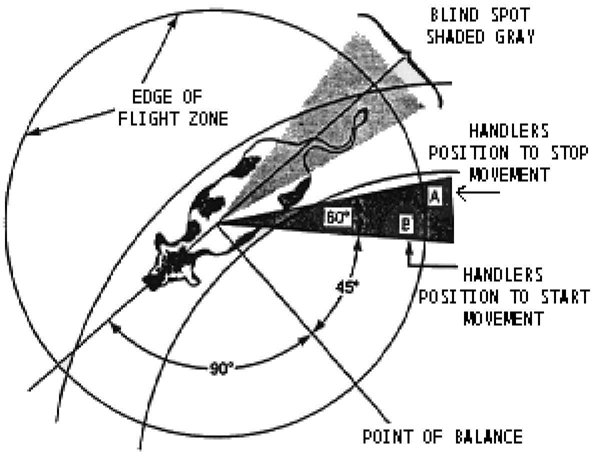
2002 Hearing Update

People should be quiet and all yelling and whistling should be stopped. Research has shown that yelling at livestock is very stressful. High pitched loud noise close to animals is very stressful. Research done by Joe Stockey and his colleagues at the University of

Saskatchewan showed that the sounds of people yelling increased the animal's heartrate more than the sound of a gate slamming. The animals differentiated between equipment noise and threatening noise from people that was directed at them. People need to keep thier mouths closed except for a gentle "sshh" or talking softly to their cattle. A loud noise such as a horn is sometimes used as a signal to call cattle in from pasture. This is acceptable because the sound of the horn is associated with a reward such as feed or switching pastures, instead of something threatening such as being forced into a chute (race).

Flight Zone

An important concept of livestock handling is flight zone. The flight zone is the animal's "personal space". When a person enters the flight zone the animals will move away (22, 31). Understanding of the flight zone can reduce stress and help prevent accidents to handlers. The size of the flight zone varies depending on the tameness or wildness of the livestock (22). The flight zone of extensively raised cows may be as much as 50m (164 ft) whereas the flight zone of feedlot cattle may be 2m (6 ft) to 8m (26 ft) (22). The size of the flight zone will slowly diminish when animals receive frequent, gentle handling.



The edge of the flight zone can be determined by slowing walking up to the animals. The circle represents the edge of the flight zone (22).

Extremely tame livestock are often difficult to drive because they no longer have a flight zone. These animals should be led with a feed bucket or halter. The size of the enclosure the livestock are confined in may affect flight zone size. Sheep experiments indicated that animals confined in a narrow alley had a smaller flight zone compared to animals confined in a wider alley (49). Approaching an animal head on will increase flight zone size (Bud Williams, personal communication).

When a person enters an animal's flight zone it will move away. If the handler penetrates the flight zone too deeply, the animal will either bolt and run away, or turn back and run past the person. When the flight zone of a group of bulls was invaded by a mechanical trolley, the bulls moved away and maintained a constant distance between themselves and the trolley (54). The best place for the person to work is on the edge of the flight zone (22). This will cause the animals to move away in an orderly manner. The animals will stop moving when the handler retreats from the flight zone. To make an animal move forward, the handler should stand in the shaded area marked in the flight zone diagram (22). To cause the animal to back up, the handler should stand in front of the point of balance (57). A flag on the end of a stick can be used to sort cattle by moving it back and forth across the point of balance (57).

Many people make the mistake of deeply invading the flight zone when cattle are being driven down an alley or into an enclosed area such as a crowd pen. If the handler deeply penetrates the flight zone, the cattle may turn back and run over him (3). If the cattle attempt to turn back, the person should back up and retreat from inside the flight zone. The reason why the livestock attempt to turn back is because they are trying to escape from the person who is deep inside their flight zone.

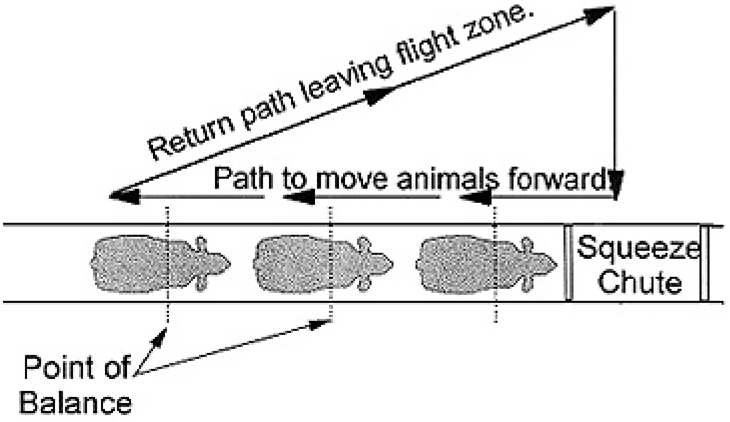
When the handler is **outside the flight zone the animals will turn and face the handler, and maintain a safe distance.**

When the handler **enters the flight zone the animals will turn away.**

Cattle sometimes rear up and become agitated while waiting in a single file chute. A common cause of this problem is a person leaning over the chute and deeply penetrating the flight zone (25). The animal will usually settle back down if the person backs up and retreats from the flight zone. Inexperienced handlers sometimes make the mistake of attempting to push a rearing animal back down into a chute. The animal will often react to this by becoming increasingly agitated. Both the handler and the animal have a greater likelihood of being injured. This also explains why livestock will balk if they see people standing in front of the squeeze chute. The provision of shields for handlers to stand behind will improve animal movement (17, 54).

2002 Update - Point of Balance Diagram

Handler movement pattern to keep cattle moving
into a squeeze chute or restrainter



Walking quickly past the point of balance at the animal's shoulder in the opposite direction as desired movement is an easy way to induce an animal to move forward. The principle is to walk inside the flight zone in the opposite direction of desired movement and to return to the starting position by walking outside the flight zone. The cattle have to be able to see you to make this movement pattern work. In chute (race) systems with completely solid sides you may need to make a small slit at cow eye level along the inner radius. In curved systems the handler should work along the inner radius and the outer radius should have a completely solid fence. In systems with catwalks alongside the chute the cattle will be able to see you and the chute (race) sides should be completely solid.

Herd Animals

All livestock are herd animals, and they are likely to become highly agitated and stressed when they are separated from their herd mates. Physiological changes which occur during isolation may affect productivity or research results.

Isolation is a strong stresser. Restraint and isolation in a small box reduced immune response in pigs (65). In sheep and cattle isolation was highly stressful (15, 55, 80). A dairy cow left alone in a stanchion had increased leucocytes in her milk (62).

During handling, isolated large animals that become agitated and excited are likely to injure handlers. Many serious cattle handling accidents have been caused by isolated frantic cattle (Grandin, 1987). If an isolated animal becomes agitated, other animals should be put in with it.

Cattle and sheep are motivated to maintain visual contact with each other (14, 95). Animals will readily follow the leader. Skillful handlers allow livestock to follow the leader and do not rush them. If animals bunch up, handlers should concentrate on moving the leaders instead of pushing a group of animals from the rear. Trained sheep can be used to lead sheep through a handling facility (5). Groups of animals that have body contact remain calmer (15). A tame pacifier cow will keep a wild cow calm during artificial insemination. The wild cow will stand quietly while maintaining tactile contact with the tame cow (31). A loading ramp for pigs or sheep that has a "see through" center partition (31) takes advantage of natural following behavior. As the animals walk up the twin single file chutes, they can see each other through the center partition. Solid outer walls block outside distractions.

Genetic Differences

Genetic factors affect an animal's reaction to handling. Brahman and Brahman cross cattle are more excitable and hard to handle than English breeds. Angus cattle are more excitable than Herefords, and Holsteins move more slowly than Angus or Herefords (89). When Brahman or Brahman cross cattle become excited they are more difficult to block at fences (89). Visually substantial fences built with planks or a wide belly rail should be used with these breeds (31). Brahman cattle will seldom run into a fence that appears to be a solid barrier.

Highly excited Brahman cattle may lie down and become immobile if they are repeatedly prodded with an electric prod. Continuous electric prodding of Brahman or Brahman cross cattle can result in death (31). If the animal is left alone for a few minutes, it will usually get up. English or European cattle such as Charolais will seldom become immobile.

1997 Update

"... Brahman cattle are more excitable than the British breeds but when they are handled gently they can become extremely docile. Brahmans are inquisitive sensitive cattle that respond well to quiet gentle handling and they respond poorly and may become agitated if they are treated roughly. Since Brahman have a more reactive nervous system they may become easily frightened when subjected to sudden novel experiences. For example, going through an auction ring. Brahmans will often remain calm if they have a familiar person who can handle them when they are in a novel strange situation. British cattle on the other hand are less likely to become fearful or agitated when subjected to sudden novelty**...."**

In pigs, Yorkshires move more slowly during loading than Pietrians (63). Observations at farms and slaughter plants by the author indicate that certain types of hybrid pigs are difficult to drive. They have extreme shelter seeking behavior (flocking together) and they refuse to move forward up a chute. They are also very excitable. This problem is most evident in some hybrid lines of pigs selected for high productivity. Pig breeders should select for temperament to avoid serious meat quality and animal welfare problems at the slaughter plant.

Different breeds of sheep also react differently to handling (82, 95). Rambouillet tend to flock tightly together and remain in the group. Cheviots are more independent than other breeds.

Handler Dominance

Handlers can often control animals more efficiently if they exert dominance over an animal. Exerting dominance is **not** beating an animal into submission. It is using the animal's natural behavior to exert dominance and the handler becomes the "Boss animal". Nomadic tribesmen in Africa control their cattle by entering the dominance hierarchy and becoming the dominant herd member (60).

The author has successfully achieved dominance over a group of pigs. Slapping the dominant pig when it bit the author had little effect on its behavior. The aggressive behavior was stopped by shoving the pig against the fence with a board pushed against its neck (31). The board against the neck simulated another pig pushing and biting. Pigs exert dominance over each other by biting and pushing against the neck (45). It is often advisable to handle the dominant pig first (P.Dziuk, 1983 personal communication). The odor of the dominant pig on the handler may make the other pigs more submissive. More research is needed to develop simple methods of exerting dominance which will enable handlers to control boars and other large animals with a minimum of force and greater safety.

Effect of Environment and Experience

The previous experiences of an animal will affect how it will react to handling (27). An animal's stress reaction to a handling procedure such as transportation or restraint, depends on three important factors. These are as follows: genetics, individual differences, and previous experiences (11, 52, 61, 63, 77, 87). Facility design can have strong influence on previous experiences. **Poor design will increase stress.**

Sheep raised in a pen in close contact with people had a less intense physiological response to handling than sheep raised on pasture (78). Hails (38) reported that calves lost less weight the second time they were transported. Hens which were not accustomed to being caught and handled had lowered egg production. Egg production, however, was not affected in hens accustomed to frequent handling (46). Piglets accustomed to repeated gentle handling by people approached a strange person readily at 24 months of age (42).

Environmental Stimulation

Providing additional environmental stimulation will reduce excitability. Pigs raised in a windowless building with hanging rubber hose toys and weekly petting were less excitable compared to pigs raised with no extra environmental stimulation (31, 32) Pigs raised outdoors with a variety of playthings and daily petting were more willing to approach a strange man and walk through a narrow chute compared to pigs raised indoors in small, barren pens with minimal contact with people (29, 32).

Loading pigs into a vehicle was more difficult when confinement reared pigs were handled. Pigs reared outdoors were easier to load (93).

Our experiments also illustrate the different effects of environmental stimulation under different conditions. In the first trial, environmental stimulation for pigs housed in a windowless building consisted of hanging rubber hoses and weekly petting. The stimulation made the animals easier to drive through a chute and less prodding was required (29, 31, 32). In the second trial, the animals were initially very tame and both the control and extra stimulation pens were washed twice weekly with a hose. There was a tendency for the controls to be easier to drive because the petted pigs approached people for petting. Frequent pen washing provided environmental stimulation and may have helped to calm the controls. Tame animals should be led with a feed bucket or lead rope.

Previous Experiences

Animals remember painful or frightening experiences. Research by Hutson (51) and Pascoe (71) indicated that cattle and sheep could remember an aversive experience for many months. Sheep which had been inverted in a sheep handling machine were more difficult to move through the corrals the following year. Many months later, cattle which had experienced electro-immobilization had elevated heart rates when they approached the place where the shock had occurred. Animals can readily discriminate and make a choice between the less aversive of two different handling treatments (36, 80). Livestock which have had previous experiences with gentle handling will be less stressed when they are handled in the future.

Calves accustomed to regular gentle handling had fewer injuries during marketing because they were accustomed to handling (96). Excitable cattle had lower weight gains (64). Dogs can be highly aversive to sheep (55). The use of dogs in a confined space where animals are unable to move away should be avoided. Electric prods should be used sparingly on cattle and never used on breeding pigs (31). Additional gentle methods for moving livestock are reviewed in Kilgour and Dalton (57). Cattle will be easier to handle in the future if they are not allowed to rush out of corrals back to pasture. Cattle should become accustomed to walking slowly past a handler when they exit the corrals (Bud Williams, personal communication).

Cattle handled roughly in poorly designed facilities had higher heart rates compared to cattle handled calmly in well designed facilities (83). Chickens handled gently had lower plasma corticosterone levels compared to chickens handled roughly (8).

2002 Update - Previous Experiences

Cattle differentiate between a person on a horse and a person on the ground. Cattle that are always worked on horseback may panic if they are moved by a person on the ground. To prevent this problem it is recommended to get the animals accustomed to being moved by both people on the ground and people on horseback. They should also be trained to have different people and vehicles around them. This photo shows a well designed wide curved alley that leads up to a round crowd pen. The cattle enter easily because they can see light through the building.

It is very important that an animal's first experience with a new person, corral, or vehicle is a good one. If an animal's first experience with something new is bad the animal may develop a permanent fear memory. Animals are very specific in how they perceive events around them. A horse may become afraid of black cowboy hats while white cowboy hats will be tolerated. The fear of black cowboy hats was caused by severe abuse by a man wearing a black hat.

Both pigs and cattle differentiate between people in alleys and people in their pens. To get animals accustomed to having people moving around them the people must enter the pens. Since animals do not have language, these memories will be in the form of pictures, sounds, or smells. Animals can instantly recognize the voice of a familiar trusted person. They may also become frightened when they hear the voice of a person who abused them. They also make associations such as people in blue coveralls are "safe" and people in white lab coats do painful procedures. Individual people that an animal associates with painful or frightening experiences may have difficulty training or working with an animal. The animal may be easier to train if a new person works with it.

Animals Feel Threatened

If an animal perceives a handling procedure or contact with a person as a threat, stress may increase. Sows that withdrew from a person's hand farrowed fewer piglets than sows which readily approached a person's hand (41). When extra human contact is provided to reduce excitability the handler must be careful not to intimidate the animals. He should squat down in the pen and allow the animals to approach (29). He must never chase them. In our experiments, weight gains were not adversely affected by petting pigs in the pens or a weekly walk in the aisles. However, if the pigs feel threatened or are hurt, weight gains will be reduced. Gonyou et al. (21) found that a looming, threatening person approaching the animals reduced gains. Animals can readily adapt to handling, such as daily weighing with no effect on weight gains (73). Pumprey (76) reported that calves accustomed to daily handling by people on horses had no difference in weight gain compared to unhandled controls during cool weather. During warm weather, heat stress which occurred due to physical exertion lowered weight gains. Apparently, the animals knew the routine and did not feel threatened.

If a person shocked pigs every few days a chronic stress state was created (21). Inconsistent handling will cause stress. If a handler occasionally mistreats an animal, the animal is liable to be stressed every time the person approaches. An occasional aversive treatment lowered weight gain and increased corticosteroid levels even though the handler was gentle with the pigs most of the time (43). The pigs had learned that the handler could not be trusted.

Novelty can be a strong stressor. Animals that have been raised in a variable environment are less likely to be stressed when confronted with novelty. In one study veal calves were raised in indoor stalls or in outdoor group pens (R. Dantzer, personal communication, 1983). When the calves reached market weight, both groups were exposed to a new indoor and outdoor environment. Calves raised indoors had higher serum glucocorticoid values when they were put in an outdoor arena. Calves raised outdoors were more highly stressed when they were put in an indoor arena. Both of the new locations were stressful to all calves, but their reactions were influenced to the greatest extent by variance from the type of environment in which they had been reared. Animals can be trained to accept irregularity in management (78). Pigs exposed to a variety of objects approached a novel object more quickly than animals raised in a barren environment (32). However, pigs which had grown accustomed to the same routine of blood pressure testing, responded to a change in routine with increased blood pressure (67).

In our previously described handling experiment, the pigs initially became highly agitated during the novel experience of pen washing (32). When they become accustomed to pen washing they walked up to be sprayed. The experience of pen washing was initially stressful but it soon became a pleasant experience that the animals actively sought.

2002 Update - Novelty and New Experiences

Novelty is paradoxical. New things are both attractive and frightening. They are attractive when the animal is allowed to voluntarily approach and frightening when suddenly forced upon the animal. For example, a flag placed in a field will attract most grazing animals and they will walk up to it. However that same flag may frighten a horse at a horse show and cattle being driven down an alley may balk and turn back to avoid walking past the flag. Animals that have a flighty excitable temperament are both most attracted to new things and afraid of them. New things must be introduced more slowly to flighty nervous animals.

It is good for animals to have new experiences and novelty in their lives. Horses exposed to flags and many new things are less likely to panic at a horse show. Feedlot cattle that are exposed to some activity such as seeing people and vehicles often have better weight gains because they are less likely to become fearful if they are suddenly confronted with something new. At one feedlot, cattle in a pen next to the manager's house always had high weight gains. They could see children playing in the yard and they got accustomed to seeing many different vehicles. There is an optimum level of exposure to stimulation and too much would be stressful and probably lower weight gains. Continuous very loud noise or constant disturbances that continued all night would probably be stressful and lower weight gains.

New Restraint Concept

The idea of training an animal to voluntarily accept restraint is a new concept to some people. Animals that are handled gently can be trained to voluntarily accept restraint in a comfortable device (29, 33, 69). Training valuable breeding animals or animals used in long-term research studies to voluntarily enter a restraining device has many advantages. Stress on both animals and people will be reduced. Large animals that are trained to walk into a restraint device can easily be handled by one person. Cooperative large animals are less likely to injure people or themselves. Feed rewards can be used to facilitate animal movement through a facility (51).

The author has trained sheep to voluntarily enter a squeeze tilt table for a grain reward (33). Some sheep were squeezed and tilted to a horizontal position nine times in one day. After being released from the squeeze tilt table, the animals rapidly ran into the crowd pen and lined up in the chute (33).

To train the animals to voluntarily accept restraint, the restraint device must be introduced gradually and gently with feed rewards (33). At first, the animal is allowed to walk through the restrainer several times. The next step is to allow the animal to stand in the restrainer without being squeezed. On the fourth to fifth pass through, the squeeze is applied gently. During each step the animal is given a food reward of palatable feed. A relatively tame animal can be trained to voluntarily enter a restrainer in less than an hour.

Training animals to voluntarily enter a restraint device is easier and less stressful if the animal is tame and has little or no flight zone. If a wild animal is being trained, it is important to catch it correctly on the first attempt. Fumbling and failing to restrain an animal on the first attempt will result in increased excitement (15). If an animal resists and struggles, it must not be released until it stops struggling, otherwise it will be rewarded for resisting (29). Animals that are released while resisting are more likely to resist in the future (29). The animal should be stroked and talked to gently until it calms down.

Animals will not voluntarily accept restraint if the restraint device causes pain. Selection of the right type of squeeze chute and headgate to fit the specific handling requirements is important (23). The use of new designs for restraint devices should be investigated. Double rail and V restrainers that are used in meat packing plants may provide less stressful restraint for veterinary and husbandry procedures (18, 34, 81). Pigs will readily relax and fall asleep when restrained upright in a padded V restrainer. Pressure applied to the flanks will induce relaxation (37). Sheep and calves held on a double rail restrainer had low stress levels (94). The author has observed that cattle restrained with nose tongs become more difficult to restrain in the future. Further observations by the author indicated that when a halter is used to hold the animal's head for blood testing, restraining the head becomes easier with successive tests. Cattle blood-tested with halter head restraint will learn to turn their head and expose their jugular. Cattle that have had experience with nose tongs will often fling their head about to avoid attachment of the tongs.

2002 Update - Teaching a Flighty Animal to Accept Restraint

Teaching antelope and other very excitable animals such as Arab horses or American bison to voluntarily accept restraint must be done very slowly and carefully. A basic principle is: the more flighty and nervous the animal is the more slowly new things must be introduced. If the flighty animal is frightened when the restraint device is first introduced it may develop a permanent fear memory and become almost impossible to train. An animal with calmer genetics will usually habituate and become less scared when it is forceably restrained, but a flighty animal may never habituate if it is forceably restrained. It may develop a permanent fear memory.

People working with animals need to always be aware of individual differences between animals. Even in animals of the same breed, some will be more fearful than others. The Suffolk sheep described previously were easy to train in one day because Suffolks are calm animals. For most cattle the best way to train them is to work with them for about 15 minutes each day. This gives them time to calm down between handling and restraint training sessions. Cattle can be trained in 3 or 4 days, bison may require 3 weeks and antelope may take 3 months. Quiet breeds of cattle will quickly habituate to being driven through a race and restrained in a squeeze chute. For flightly antelope it takes 10 days to habituate them to the sound of a sliding door opening. New sights and sounds have to be introduced very gradually to avoid panic. This is the difference between a domestic and a wild animal. The extreme flighty temperament has been bred out of cattle.

Handling Facility Layout

Handling facilities that utilize behavioral principles will make handling easier. Sheep research has shown that corrals are more efficient if the animals follow the same route for procedures such as dipping and sorting (3, 47). Orienting the exit end of a sorting chute, dip vat or squeeze chute towards the "home" pasture or pen will facilitate movement

Curved Chutes and Solid Fences

Curved single file chutes are especially recommended for moving cattle onto a truck or squeeze chute (22, 79). A curved chute is more efficient for two reasons. First, it prevents the animal from seeing what is at the other end of the chute until it is almost there. Second, it takes advantage of the natural tendency to circle around a handler moving along the inner radius. A curved chute provides the greatest benefit when animals have to wait in line for vaccinations or other procedures. A curved chute with an inside radius 3.5m (12 ft) to 5m (16 ft) will work well for handling cattle (22). The curve must be laid out as shown. If the chute is bent too sharply at the junction between the single file chute and the crowd pen, it will appear as a dead end. This will cause livestock to balk (31). If space is restricted, short 1.5m (5 ft) bends can be used (28). If bends with a radius smaller than 3.5m (12 ft) are used, there must be a 3m (10 ft) section of straight single file at the junction between the crowd pen and chute to prevent the chute from appearing to be a dead end. Handler walkways should run alongside the chute and crowd pen (31). The use of overhead walkways should be avoided. Livestock will often balk when they have to move from an outdoor pen into a building which contains the squeeze chute. Animals will enter a building more easily if they are lined up in a single file chute before they enter the building (22). Conversely, pigs reared indoors are often reluctant to move out into bright daylight. A pig loading ramp should be designed so that the pigs are lined up in single file, where they cannot turn around before they leave the building.

For all species, solid sides are recommended on both the chute and the crowd pen which leads to a squeeze chute or leading ramp (7, 22, 24, 79). For operator safety, man-gates must be constructed so that people can escape charging cattle. The crowd gate should also be solid to prevent animals from turning back (31). Wild animals tend to be calmer in facilities with solid sides. In holding pens, solid pen gates along the main drive alley facilitate animal movement.

2010 Update on Solid Sides

The use of solid sides is most important when animals with a large flight zone are handled in places that have lots of activity around the facility such as a truck loading ramp or a slaughter plant. If the animals can see moving vehicles, moving equipment, or people walking by outside the fence, a solid fence should be installed to block the view of these distractions. Solid sides are especially recommended when lots of different people will be using the facility such as a truck loading ramp. There are some experts in low stress handling methods that prefer a facility with open bar sides so that the animals can more easily respond to the movements of the handlers. This will only work with expert handlers who have extensive knowledge of the behavior principles of handling. They must be in a facility that is located either on a remote pasture or inside a building that has solid side walls. Some large feedlots and ranch managers have found that they have had success with a combination approach. They are using a curved facility that has solid sides on ALL outer fences of the single file chute (race) to block outside distractions. The crowd pen and crowd gate are completely solid. The one part of the facility that has an open barred fence is the inner fence of the curved single file chute (race). The catwalk on the single file chute is eliminated and a skilled handler walks on the ground to move cattle through the single file chute by carefully entering the flight zone to move animals. When no animals are being moved the handler backs COMPLETELY out of the flight zone of the animals standing in the chute. If this system is used, the area along side the single file chute (race) must be maintained as a people free zone except when it is time to move an animal. The open side will work very poorly if untrained people continually stand in the flight zone of animals standing in the single file chute. This may cause the animals to rear up or become agitated.

Crowd Pen Design

The crowd pen used to direct animals into a single file or double file chute must never be built on the ramp. A sloped crowd pen will cause livestock to pile up against the crowd gate (26). Round crowd pens shown are very efficient for all species. In cattle facilities, a circular crowd pen and a curved chute reduced time moving cattle by up to 50 percent (92). Practical experience has shown that the recommended radius for round crowd pens is 3.5m (12 ft) for cattle, 1.83m for pigs (6 ft) and 2.4m (8 ft) for sheep.

Cattle and sheep crowd pens should have one straight fence, and the other fence should be on a 30 degree angle (66). This layout should not be used with pigs. They will jam at the chute entrance. Jamming is very stressful for pigs (90). A single, offset step equal to the width of one pig should be used to prevent jamming at the entrance of a single file ramp (24, 31). Jamming can be further prevented by installing an entrance restricter at single file race entrances. The entrance of the single file chute should provide only 1/2 cm on each side of each pig. More detailed information on facility layout can be found in Grandin (22, 24, 25, 28, 30).

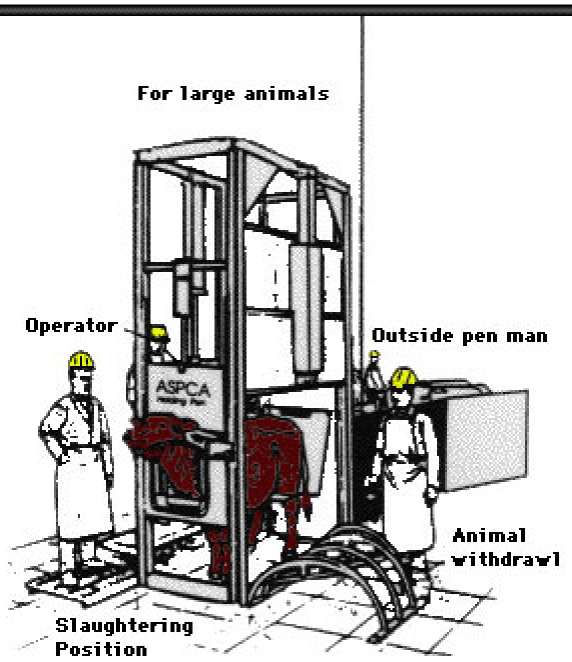
Ramp Steepness and Flooring

Excessively steep ramps may injure animals. The maximum recommended steepness for a stationary cattle or pig ramp is 20 degrees for market weight animals (26). If space permits a 15 degree slope is recommended for pigs (91). Stair steps are recommended on concrete ramps because they still provide good footing when dirty or worn (31).

Conclusions

The use of behavioral principles should improve efficiency of livestock handling and reduce stress on animals. Reducing stress also should help improve weight gain, reproductive performance and animal health. Livestock should be handled gently with a minimum of noise. To avoid agitation the handler should work on the edge of the flight zone. Animals which have been handled gently will be less stressed by handling in the future. Restraint devices should be designed so that they do not cause pain. In certain research situations animals can be easily trained to voluntarily enter a restraint device. This practice will help reduce stress. All areas where animals are crowded such as chutes and crowd pens, should have solid sides and diffuse lighting with a minimum of shadows.
A full copy of this paper and list of references is available at:
http://www.grandin.com/references/new.corral.html

ASPCA Pen



- This device consists of a narrow stall with an opening in the front for the animal's head. After the animal enters the box, it is nudged forward with a pusher gate and a belly lift comes up under the brisket. The head is restrained by a chin lift for the rabbi to perform shehita. Vertical travel of the belly lift should be restricted to 28 inches (71 cm) so that it does not lift the animal off the floor. The rear pusher gate should be equipped with either a separate pressure regulator or special pilot-operated check valves to allow the operator to control the amount of pressure exerted on the animal. The pen should be operated from the rear toward the front. Restraining the head is the last step. The operator should avoid sudden jerking of the controls. Many cattle will stand still if the box is slowly closed up around them, and less pressure will be required to hold them.
- An ASPCA pen can be easily installed in one weekend with minimum disruption of plant operations. It has a maximum capacity of 100 cattle per hour and it works best at 75 head per hour. A small version of this pen could be easily built for calf plants. Tips to improve animal movement into conveyor restrainers, stunning boxes, and squeeze chutes.

Tips to Improve Animal Movement into Conveyor Restrainers, Stunning Boxes and Squeeze Chutes

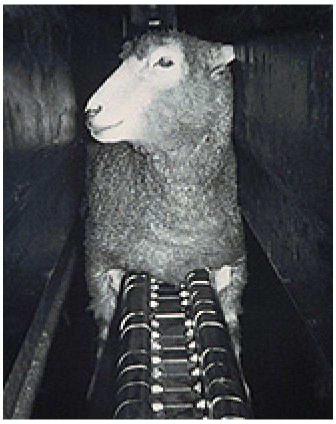
1. If the entrance to the restrainer, or stunning box is dark, use a spot light to illuminate it. The illumination must be **indirect** and it must **NOT** shine into an approaching animal's eyes.
2. Get in the race and look through it. If you can see people or moving objects, install shields so that incoming animals do not see people or moving objects.

3. Eliminate reflections on water or shiny metal that can cause balking. Often moving a lamp or adding a lamp is all that is needed. Look through the race at the animal's eye level.
4. Air blowing in an animals face will make it balk. Change ventilation to eliminate drafts blowing towards animals.
5. Install solid sides on races, squeeze chutes, and stunning boxes.
6. Pigs, sheep, and cattle will often refuse to enter a conveyor restrainer due to the visual cliff effect. They can see that the conveyor restrainer is elevated. Install a solid dark false floor under the conveyor about 6 inches (15cm) to 12 inches (30cm) below the animals feet. Old black conveyor belting works well. This makes the animal think that it has a solid floor to walk on.
7. Entrance ramps on conveyor restrainers should be non slip and have cleats or ridges for traction. Animals tend to back out and panic if they slip.
8. To induce animals to ride calmly in a conveyor restrainer install a solid piece of metal over the top of the restrainer. This metal top must be long enough to block the animal's vision until it's back feet are off the entrance ramp. If animals can see people before their feet are off the entrance ramp they are more likely to rear up. Experiment with pieces of cardboard before installing metal. Vision controls behaviour in livestock.
9. Eliminate air hissing and high pitched noise. Pad gates to stop banging and clanging.
10. Cattle may refuse to enter a stunning box if they can see movement under the stunning box door. Install a conveyor belt flap to block their vision.
11. Experiment, experiment with changing lighting, you will be amazed at the effect it has on animal movement.
12. Animals may refuse to enter a conveyor restrainer if the hold down bumps their back during entry.

Providing Less Stressful Pre-Slaughter Handling

Ron Kilgour from New Zealand was the first researcher to discuss that there was a need for greater emphasis on procedures that occur prior to stunning or slaughter (Kilgour, 1978).

Cattle and sheep will move quietly through single file races and ride quietly in a well designed conveyor restrainer system. Moving in single file is a natural behaviour for cattle. In the U.S., large stunning boxes which held more than one bovine have been replaced with conveyor restrainers.



- **Center track double rail restrainer. This system is available for both sheep and cattle. Livestock are riding the conveyor in a comfortable, upright position. This is a very humane method of restraint.**

- The V conveyor restrainer was introduced for cattle in the 1970s (Schmidt, 1972; Willems and Markley, 1972). It was replaced in the l990's with the center track double rail restrainer (Giger et al., 1977; Grandin, 1988b; 1991). Cattle and sheep will remain calm in conveyors because they are touching the animal in front and back of them.
- V conveyors work well for round, fat pigs, but less well for lean pigs. The author has observed that slender, lean pigs are not supported properly and heavily muscled pigs are pinched on the hams, whereas round, fat pigs are held in a comfortable position. Lean pigs are properly supported on a center track restrainer.
- In England, head restraint devices are required by legislation to hold a bovine's head for captive bolt stunning. The purpose of the legislation was to improve stunning accuracy. In some circumstances, head restraint can increase stress. Ewbank et al. (1992) found that cortisol levels were higher in a head restraint compared to a conventional single animal stunning box. It took an average of 32 seconds to induce the cattle to put their heads in the poorly designed yoke used in this study.
- Stress can be minimal in a well designed head restraint where the animal is stunned immediately after the head is caught (Tume and Shaw,1992; Frank Shaw, personal communication). The author has observed electrical stunning of

cattle in a head restraint in New Zealand. Each animal quietly entered the stunning box and was stunned within 2 seconds after the head was clamped. Information on the design of head restraint devices can be found in CSIRO (1989) and Grandin (1993; 1994).

- Stress caused by prolonged restraint will be a severe problem if live animals are subjected to intravenous injections shortly prior to slaughter. Payne and Young (1995) report that intravenous injections of lambs with antifreeze glycoproteins may improve the quality of frozen meat.

Design mistakes in races and forcing pens will cause stress.

One of the most serious design mistakes is laying the race out so that its entrance appears to be a dead end. Cattle will move more easily through a curved race compared to a straight race, but it must be laid out correctly
(Grandin, 1980; 1990; 1993).

- **Aerial view of a curved system for handling and loading cattle.**

Practical experience has shown that an animal standing in the forcing pen must be able to see a minimum of two to three body lengths up the single file race before it curves. Bending the single file race too sharply where it joins the forcing pen will cause animals to balk.

Cattle move more easily through a curved ramp.

Animal Handling Troubleshooting Guide:
Tips for Solving Common Animal Handling Problems

By Dr. Temple Grandin
Meat & Poultry, March 2000

To meet the needs of today's customers, there will be a greater and greater demand for quality meat free of defects such as dark cutters and pale, soft exudative pork. Dark cutting beef is shunned by consumers because it's drier, darker and has a higher pH level and a shorter shelf-life. P.S.E. pork dries out because the meat has poor water binding capacity.

Animal handling and welfare is becoming an increasingly important issue to consumers, and major meat buyers such as McDonald's Corp., Oak Brook, Ill., are auditing handling and stunning practices. Most problems with handling animals are easy to fix. Retraining employees and better supervision will fix most problems. Regular auditing will help maintain good handling practices.

People manage the things they measure. High levels of vocalization during handling (squealing, mooing and bellowing) are a sign of handling problems. In beef plants with good handling, 3 percent or fewer of the cattle will vocalize. The best pork plants will have a stunning room that is quiet 50 percent of the time.

P.S.E. and dark cutters are caused by a combination of in-plant and off-plant factors. This trouble-shooting guide will help you to sort out these factors. Dark cutting occurs when the animal runs out of glycogen, the energy source for muscle. It is like a car running out of gas the car will run fine until the tank is empty. Some of the factors that drain the animal's reserve are severe weather changes, excessive growth promotant implants, rough handling and spending the night at the plant. No one factor causes a dark cutter; it is usually a combination of factors.

P.S.E. is caused by a combination of genetic and in-plant factors such as excessive electric prod use and poor chilling. Plants that improve handling in the stunning chute have a 10 percent reduction in P.S.E. The last five minutes in the stunning chute are critical. A good pig can be ruined just prior to stunning.

Use this guide to track down and fix in-plant and off-plant problems, which can be contributing to dark cutters or P.S.E. This guide will also help you to receive excellent scores on the McDonald's audit or audits by other customers.

Problem: High levels of dark cutting	
Probable Causes	**Solutions**
Cattle from certain feedlots are the source of a high percentage of the dark cutters.	Work with the feedlot to reduce excessive use of growth promotant implants. TBA (a synthetic male hormone) and estrogen implants are associated with an increased susceptibility to dark cutters. These products should be used in moderation.
Some cattle from certain	Some crossbred cattle with European

feedlots are agitated and difficult to handle.	Continental genetics are excitable. These animals should be trained to tolerate handlers on foot before they arrive at the packing plant. Cattle moved through a feedlot exclusively by horses may be difficult to handle by a person on foot at the plant.
High percentages of bullers, cattle that ride and mount each other, will have more dark cutters.	Check implanted ears for crushed implants. At the feedlot provide more water troughs and possibly more bunk space. Cattle fighting over a crowded trough or feed bunk may have more bulling.
Cattle spending the night at the plant.	Reduce the numbers of cattle held overnight.
Rough handling and excessive electric prod use.	Retrain employees and refer to the balking section of this troubleshooting guide.
Sudden changes in temperature or extremely hot temperatures. This will have the greatest effect on nervous cattle or cattle that have been implanted to achieve the maximum possible weight gain.	Dark cutting is most likely to occur 24 hours to 48 hours after a severe weather change. Slaughter the cattle immediately, or hold them at the feedlot for 10 days to two weeks to allow glycogen levels to be replenished.
Steers were castrated at a late age.	Some producers do this to achieve high weight gain. Work with suppliers to castrate calves at a younger age.
Strange cattle are mixed together shortly before slaughter. Mounting, butting, and pushing use up the glycogen (energy) in the animal's muscles.	Avoid mixing cattle from different feedlot pens or pastures. When cattle are mixed they fight to establish a new dominance order. It may take more than seven days for the cattle to replenish their glycogen levels.

Problem: High levels of pale, soft exudative pork	
Probable Causes	**Solutions**
Excessive use of electric prods in the stunning area.	Retrain employees to improve animal movement. Get electric prods out of the employees' hands; they should sit on a rack most of the time. A plastic pipe, flag or paddle should be the primary driving tool.
Pigs from certain producers are excitable and difficult to drive.	Advise producers to have workers walk in the pens every day during finishing to train pigs to quietly get up and flow around the person. Changes in genetics can also reduce this problem.
Pigs from some producers have high levels of P.S.E. even when	The producer needs to change breeding stock to eliminate the stress gene or withdraw feed

they are handled quietly in the plant.	prior to shipping. Pigs full of feed have more P.S.E.
Large, heavy-weight pigs with big muscles have more P.S.E. than smaller pigs. This is most likely to occur during hot weather.	Improve chilling. Larger pigs chill more slowly and retain more body heat Possibly change genetics. All pigs should be showered prior to stunning and rested for at least two hours.

Problem: Animals balk and refuse to move through the system. Constant use of electric prods is require to keep up with the line.

Probable Causes	Solutions
Animals balk and refuse to enter the conveyor restrainer.	Install a lamp, such as a dock light used at the truckloading area, to light the entrance. It should illuminate the entrance, and it must NOT glare directly into an approaching animal's eyes. If this does not work, check the hold-down rack It should not touch the animal's back If balking still occurs, it may be due to the lack of a false floor under the restrainer. Install a false floor made of steel or conveyor belting to prevent animals from seeing the steep drop-off under the restrainer. Check to make sure the animals do not see people or moving objects through the restrainer.
On a sunny day, animals refuse to enter under a building or roof, but they move easily on cloudy days or at night.	Animals tend to move from a darker place to a brighter place. To admit more light, install white translucent skylights or side panels in the building to provide shadow-free light.
Sometimes animals move easily, and sometimes they are hard to drive for no apparent reason.	Look for changes in air drafts blowing down chutes and alleys. Animals will balk if they feel air blowing on their faces in the stunning chute. Air drafts may change when different fans are turned on in the plant. Changes in wind direction and seasons can also change air drafts.
Cattle refuse to enter the stunning box.	Attach a piece of conveyor belting to the bottom of the door to prevent the cattle from seeing the shackler's hands. Install muffling devices on air exhausts to reduce noise, or install a shield to prevent the cattle from seeing people or moving carcasses as they enter the box. Cattle will also balk if they see the feet of a previously stunned animal under the door.
Animals refuse to leave the crowd pen and enter the single-	Retrain employees to move smaller bunches of cattle and pigs and fill the crowd pen half

file chute.	full. Cattle and pigs need room to turn. Sheep may be handled in large bunches. Look through the chute at the animals' eye level to look for distractions such as a moving piece of chain, water dripping in a reflecting puddle, shiny metal that jiggles or seeing people ahead. Repositioning lights on the ceiling will often help eliminate reflections. Avoid grates at the chute entrance.
Cattle or pigs balk in a main drive or at the scale.	Look for moving objects that may not be obvious such as fan blades slowly moving in the wind or a piece of loose plastic or insulation on an overhead pipe.

How Stressful Is Slaughter?

Numerous studies have been conducted to determine the relative stressfulness of different husbandry and slaughter procedures. Measurements of cortisol (stress hormone) is the most common method of evaluating handling stresses. One must remember that cortisol is a time-dependent measure. It takes approximately 15-20 minutes for it to reach its peak value after an animal is stressed. Evaluations of handling and slaughter stress will be more accurate if behavioural reactions, heart rate and other blood chemistries are also measured. Adrenaline and noradrenaline have limited value in measuring slaughtering stress because both captive bolt and electrical stunning trigger massive releases (Warringtom,1974; Pearson et al.,1977; van der Wal,1978). If the stunning method is applied properly the animal will be unconscious when the hormone release occurs and there will be no discomfort.

Absolute comparisons of cortisol levels between studies must be done with great caution. Cortisol levels can vary greatly between individual animals (Ray et al.,1972).

Cattle that show signs of behavioural excitement usually have higher levels than calm animals. A review of many reports indicates that cortisol levels is cattle fall into three basic categories:

1. Resting baseline levels.*
2. Levels provoked by being held in a race or restraint in a head gate(bail) for blood testing.
3. Excessive levels which are double or triple the farm restraint levels.

*Baseline levels vary from a low of
(2 ng ml)-1 (Alam and Dobson,1986)
to
(9 ng ml)-1 (Mitchell et al.,1988).

Restraining excessively raised semi-wild cattle for blood testing under farm conditions elicits cortisol readings of:

- (25-33 ng ml)-1 in steers (Zavy et al.,1992)
- (63 ng ml)-1 in steers and cows (Mitchell et al.,1988)
- (27 ng ml)-1 in steers (Ray et al.,1972)
- (24-46 ng ml)-1 in weaner calves (Crookshank et al.,1979)

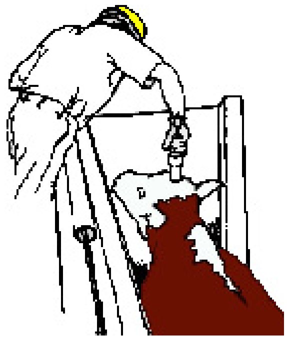
(In some studies cortisol levels were expressed in (nmol 1)-1. These values were converted into (ng ml)-1 by multiplication by 0.36.

Average cortisol levels for commercial cattle slaughter with captive bolt stunning.

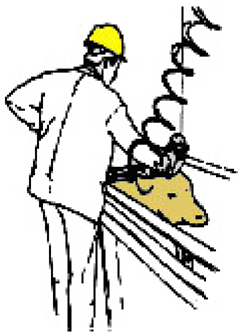
Recommended Captive Bolt Stunning Techniques
Safety Tips for Workers

1. Cartridge-fired stunners must ALWAYS be uncocked before they are set down.
2. NEVER, NEVER throw a cartridge-fired stunner to another person.
3. Inspect latches on stunning boxes to make sure they latch securely. Before the next animal is admitted to the box, check the latch.
4. All guards must be kept in place over exposed pinch points which could be easily touched by employees during normal operation of the restrainer system equipment.
5. If a worker has to get inside a restrainer conveyor system to unjam it, lock it out first to prevent somebody else from turning it on.
6. Cartridge-fired stunners must always be kept unloaded when they are carried away from the stunning area.
7. Good maintenance is essential on pneumatic stunners to prevent excessive recoil which can strain and injure the operators hands, arms or back.

- To produce instantaneous unconsciousness, the bolt must penetrate the brain with a high concussive impact. For cattle, the stunner is placed on the middle of the forehead on an "X" formed between the eyes and the base of the horns. Some plants which save brains, place the stunner on the hollow behind the animal's poll on the back of the head. This position is less effective, therefore the frontal position on the forehead is recommended.



- A good stunner operator learns not to chase the animal's head. Take the time and aim for one good shot. The stunner must be placed squarely on the animal's head. All equipment manufacturers' recommendations and instructions must be followed. Pneumatic stunners must have an adequate air supply. Low air pressure is one cause of poor stunning.



- Poor maintenance of captive bolt stunners is a major cause of bad stunning. Pneumatic captive bolt stunners require cleaning and seal replacement every night in large plants. For example, a cattle plant which is double shifted and has a chain speed of 250 head per hour will require two to three pneumatic stunners to be completely serviced every night. It is important to keep stunner cartridges dry and the correct cartridge strength must be used.

- Eye reflexes should be checked often to insure that stunning is making the cattle unconscious. When the eyelid or cornea is touched there should be no response. An animal that blinks is not properly stunned. Breathing should have stopped and there should be no indication of a righting reflex when the animal is hanging on the rail. Reflexes may cause a stunned animal's legs to move, but the head should hang straight down and be limp.

When slaughtering is done carefully cortisol levels in cattle can be substantially lower than farm handling conditions. Tume and Shaw (1992) reported that steers and heifers slaughtered in a small research abattoir had and average cortisol levels of only 15 (ng ml)-1, and cattle slaughtered in a commercial slaughter plant had levels similar to farm handling.

Beta-endorphin levels, which is another indicator of stress, were not significantly different between the two groups.

For commercial cattle slaughter with a captive bolt stunning the following average values have been recorded:

- (45 ng ml)-1 (Dunn,1990)
- (25-42 ng ml)-1 (Mitchell et al.,1988)
- (44.28 ng ml)-1 (Tume and Shaw,1992)
- (24 ng ml)-1 (Ewbank et al.,1992)

When things go wrong the stress levels increase greatly. Cockram and Corley (1991) reported a median value of 63(ng ml)-1. One animal had a high of 162(ng ml)-1. The slaughter plant observed by Cockram and Corley (1991) had a poorly designed forcing pen and slick floors. About 38% of the cattle slipped after exiting the holding pens and 28% slipped just before entering the race. Cortisol levels also increased when delays increased waiting time in the single file race. This was the only study where vocalizations shortly before stunning were not correlated with cortisol levels. This can probably be partly explained by earlier stress caused by the slick floors. Ewbank et al.,(1992) reported the lowest average value. This may be explained by excellent handling before the stunning box.

Handling problems and cortisol levels.

Restraint of Livestock

Dr. Temple Grandin, Ph.D.

During twenty years of work on livestock handling and design of restraining devices for animals, I have observed that many people attempt to restrain animals with sheer force instead of using behavioural principles. Improvements in the design of restraining devices enhances animal welfare and will reduce stress and injuries. A series of surveys conducted by the author showed that changing the design of a squeeze chute would reduce injuries to cattle (Grandin 1975), but there is still a great need to improve squeeze chutes that are used on larger feedlots and ranches. Under the best conditions, cattle can become bruised or injured in a conventional squeeze chute. A survey of seven major feedlots by Brown et al (1981) indicated that in five of the feedlots 1.6% to 7.8% of the animals were bruised. Even though bruises would heal by marketing time, pain and trauma may reduce weight gain. Cattle can become asphyxiated by excessive pressure on the carotid arteries. In a standard hydraulic stanchion squeeze chute used in most commercial feedyards an inexperienced operator can cause 2% of the cattle to collapse from pressure on the carotid arteries (Grandin 1980). A collapsed animal will die if the operator fails to release it immediately. Excessive hydraulic pressure can cause severe injuries. The animal's diaphragm can be ruptured (Fulton, R. 1973 personal communication). Excessive pressure can break the pelvis (Miles, D. 1992 personal communication). The author has also observed that excessive squeeze pressure can cause a significant reduction in weight gain. Good management can prevent many of these problems but there is still a great need for improved restraint devices for use on ranches and feedlots. I did not realize how poor existing chutes in feedlots were until I developed restraint devices for calf and beef slaughter plants.

Over the years I have designed several different types of cattle restraint devices for use in meat packing plants. During the course of developing these devices I have learned that the use of behavioural principles will keep both cattle and pigs calm. Many of these ideas could be incorporated into new designs for cattle restraining devices for the ranch farm or feedlot.

Tips for Reducing Stress During Handling

1. **Move small groups of animals.**
2. **DO NOT overcrowd crowd pen - fill it only 1/2 full.**
3. **Handlers should understand the basic concepts of flight zone and point of balance.**
4. **Ranches and facilities must have non-slip flooring.**
5. **Keep animals calm. Calm and quiet animals move more easily.**

Ewbank et al.,(1992) found a high correlation between cortisol levels and handling problems in the stunning box. Use of a poorly designed head restraint device which greatly increased behavioural agitation and the time required to restrain the animal resulted in cortisol levels jumping from 24 to 51 (ng ml)-1. In the worst case the level increased to 96 (ng ml)-1.

Cattle slaughtered in a badly designed restraining pen that turned them upside down had average values of 93(ng ml)-1 (Dunn,1990).

Stunning References

Grandin, T. 1994

Euthanasia and Slaughter of Livestock
Journal of American Veterinary Medical Association
volume 204 : 1354 - 1360

Livestock Handling Systems, Cattle Corrals, Stockyards, and Races

This section of Grandin.Com contains drawings of cattle corral designs with curved races. Curved cattle chutes are more efficient for handling cattle because they take advantage of the natural behavior of cattle. Cattle move through curved races more easily because they have a natural tendency to go back to where they came from. In the computer aided drawing section there are layout drawings of cattle yard designs for both large and small ranches and feedlots. There are also drawings of a cattle loading ramp for trucks, diagonal stockyard pens for cattle, and detail drawings of a single file race and cattle dip vat. If you are planning to build new corrals or other cattle handling facilites you can download blueprints of cattle pen layouts that will reduce stress on cattle and improve handling efficiency.

Handling Facility Layout Rules:

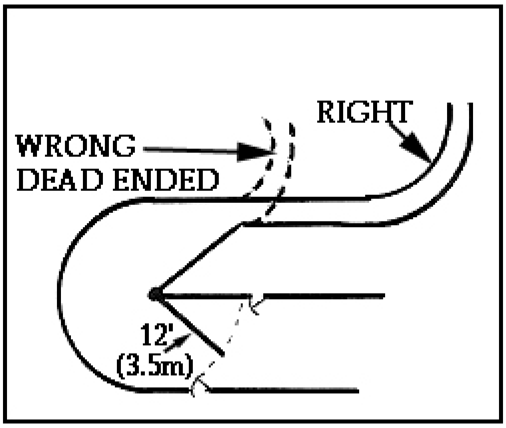
1. The crowd pen must always be level.
2. If the system includes a ramp, it should be located within the single file chute.
3. An animal standing in the crowd pen must be able to see 2 to 3 body lengths up the single file chute before it curves. This will facilitate entry into the chute.

Sample Designs of Cattle Races and Corrals

Revised July 2011

Why does a curved chute and round crowd pen work better than a straight one?

1. As the animals go around the curve, they think they are going back to where they came from.
2. The animals can not see people and other moving objects at the end of the chute.
3. It takes advantage of the natural circling behaviour of cattle and sheep.

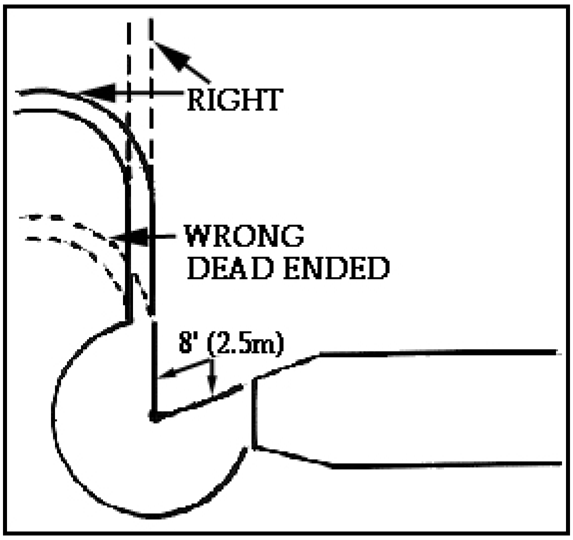


Right and wrong layout for Cattle.

This diagram shows both the right and wrong layout for a curved race system. If the single file race is bent too sharply where it joins the crowd pen the cattle may refuse to enter because it looks like a dead end. Cattle standing in the round crowd pen must be able to see a minimum of three body lengths up the single file chute before the curve begins.

Right and wrong layout for Pigs

This diagram shows both the right and wrong layout for pigs. If the single file race is bent too sharply where it joins the crowd pen, the pigs may refuse to enter. The pigs must be able to see a minimum of three body lengths up the race before it bends.



Design Recommendations

1. The round crowd pen will work most efficiently if it is a full half circle, 180 degrees. A full half circle takes advantage of the natural tendency of cattle to go back to where they came from. For cattle, the crowd pen should have a 12 ft (3.5 m) radius. A shorter radius can be used for pigs and sheep.
2. A single file chute (race) will be very efficient if it has a single 180 degree or 90 degree curve. Multiple curves do not improve efficiency. The serpentine design with 2 180 degree curves should only be used in places where space is restricted. If there is sufficient space, a single 180 degree or 90 degree curve is recommended. It is a mistake to design many multiple curves into the single file race. Refer to drawings in the this website for more information.
3. Never build a crowd pen on a ramp. If a ramp is required, it should be in the single file chute (race). Cattle and pigs will pile up if a crowd pen is built on a ramp.
4. Install solid shields so that approaching animals do NOT see the people up ahead.

Recommended lengths of single file races for cattle

Facility Type	Line Speed	Minimum length	Maximum length
Cattle Ranch and Properties	N/A	40 ft (12.2 m)	75 ft (23 m)

Cattle Slaughter Plants	Under 100/hour	40 ft (12.2 m)	75 ft (23 m)
Cattle Slaughter Plants	100 to 400/hour	80 ft (25 m)	200 ft (60 m)

Recommended lengths of single file races for pigs and sheep

If pigs are handled in groups in a gas stunning system, no race is needed.

Loose shackle systems where pigs can be batched on the bleed rail can operate efficiently with shorter races than systems that have to operate with a continuous flow.

Continuous flow systems with shackles attached to a chain conveyor for pigs or sheep:

0 to 100 animals per hour - 10 ft (3 m) to 25 ft (7.6 m)
100 or more animals per hour - 25 ft (7.6 m) to 50 ft (15 m)

Computer Aided Drawings of Cattle Corral Designs:
http://www.grandin.com/design/cad/cad.html

Non Slip Flooring for Livestock Handling

by Temple Grandin
Colorado State University

Quiet handling of cattle and pigs is impossible if animals slip or fall during handling. Animals tend to panic if they slip even a little bit. If cattle are constantly agitated while standing in a race, stun box or restraining chute, this is often due to slipping. On ramps and in restraining chutes the cleats must be spaced to fit the stride width of the animal. This prevents the hoof from slipping between the cleats. Cleats must be spaced so that an animal's hoof can fit comfortably between them without slipping. Stairsteps work really well on concrete ramps. For cattle the steps should be 10 cm (3 in) high and 30 cm (12 in) to 45 cm (18 in) long. Each step should have grooves that are 2.5 cm (1 in) deep. The angle of a non-adjustable loading ramp should be 20 degrees or less. If at all possible, ramps should be avoided in pig handling facilities. Pigs are easier to handle on a level surface. Cattle and sheep will go up and down ramps more easily than pigs. Never build the crowd pen which leads up to a single file race (chute) on a ramp. The animals will tend to pile up on the back gate. If a system has to contain a ramp, it will work best if the crowd pen is level and the single file chute is a ramp.

Non Slip Flooring

The flooring described in this article is designed for use in stockyards, veterinary facilities, truck loading pens, ranch corrals, feelot cattle handling systems and slaughter plants. It is designed to provide non slip flooring during animal handling. Use high quality concrete when making floors for livestock. Poor concrete will wear out. It is also important to cure concrete properly to get a hard surface. Do not pour too large an area at a time. It will set before it can be grooved.

Figure 1. An old slick concrete floor has been re-grooved with a concrete grooving machine. Grooving machines can be rented from a concrete supply company. This floor is suitable for handling pigs and dairy cows. Another good surface is to print the pattern of expanded metal mesh into the wet concrete. Make a stamp out of raised expanded metal mesh with an opening width of 2.5 cm (1 in). Rough broom finishes are not recommended because they wear out too quickly.

Figure 2. Diamond pattern floor that works well for pigs. The grooves are in a diamond pattern. The diamonds are 10 cm (4 in) by 13 cm (5 in). The grooves are 1 cm (0.5 in) wide by 1 cm (0.5 in) deep.

Figure 3. Deep square pattern for handling facilities for beef cattle. The squares are 20 cm (8 in) by 20 cm (8 in). The V shaped grooves are a minimum of 2.5 cm (1 in) deep and 2.5 cm (1 in) wide. The grooves can be made by pressing angle iron into the wet concrete or making a stamp. Pour a practice slab first to learn how to do it. The pattern can not be properly made if the concrete starts to set. Do not use this pattern in dairies. It will be too rough for cattle to walk on every day. It is intended for use in handling facilities such as truck loading ramps, feedlot handling facilities, stockyards, slaughter plants, and other places where cattle occasionally walk. These grooves can also be made in a diamond pattern that will make washing easier. Orient the points of the diamonds towards the drain.

Figure 4. This photo shows a non-slip metal floor grating for use in high traffic areas for beef cattle. It is recommended for cattle scales, stunning boxes, crowd pens and the area in front of a squeeze chute. To prevent damage to the hooves, the bars must be welded so that the grid lies flat. Do not cross the bars on top of each other. Use heavy steel rods. The minimum diameter of the rods is 2.5 cm (1 in). The size of the squares is 30 cm (12 in) by 30 cm (12 in). People often ask why such heavy rods should be used. Thinner rods tend to bend and pull away from the floor. A grating built from heavy rods will lie flat on the floor.

Other methods that can be used to reduce slipping are applying sand on the floor. In the U.S., mats made from woven tire treads can be purchased for use in high traffic areas. Feedlots will often install these mats in front of the squeeze chute. One advantage of these mats is they reduce the chance of hoof damage. The disadvantage of the mats is difficulty with cleaning.

Directions for laying out Curved Cattle Handling Facilities on ranches and feedlots:
http://www.grandin.com/design/curved.handling.facilities.html

Design of Chutes, Ramps, and Races for Cattle, Pigs, and Sheep at Slaughter Plants

by Dr. Temple Grandin

Revised July 2011

I have received drawings of livestock handling facilities from many processing plants around the world. Many companies ask me to check their designs to see if I can point out any design problems before they are constructed. Some have been really great and could be built as drawn. However, others contained serious design mistakes. These oversights would cause animals to refuse to enter the chute, fall down, pile up or jam.

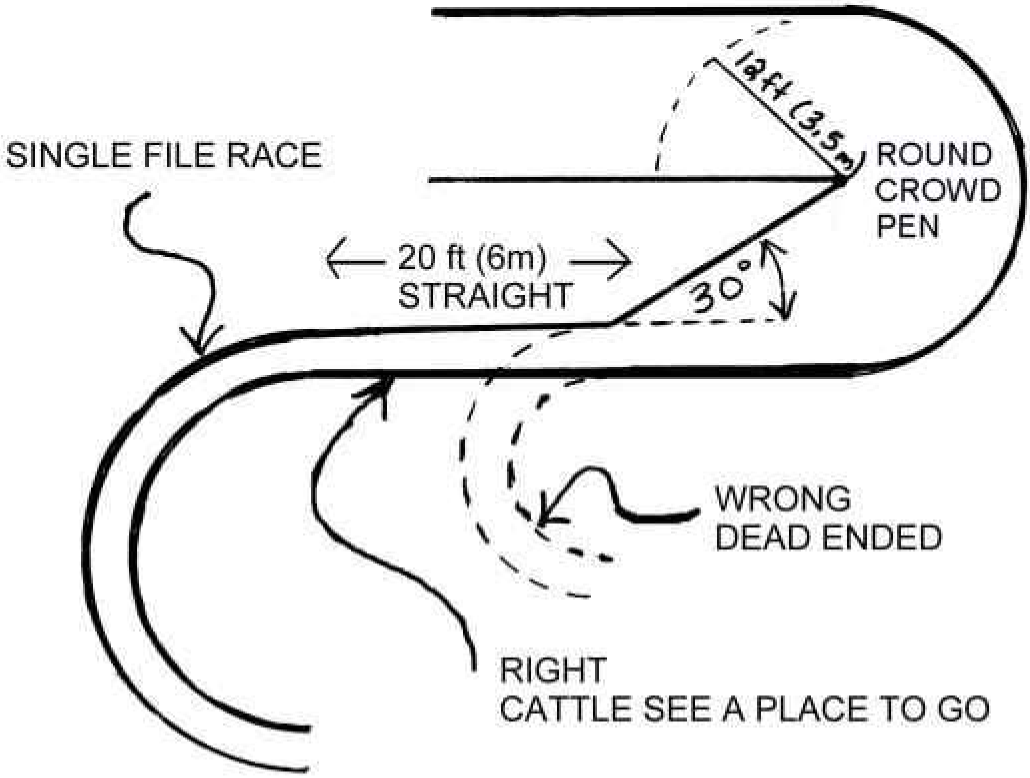
One of the most critical parts of the handling system is the junction between the crowd pen and the single file chute. The correct design will enable animals to move smoothly from a group into a single file, while the wrong design will cause the animals to either refuse to enter or the animals to jam up the entryway.

Modern, curved-chute systems with round crowd pens will work better than straight chutes, but they must be laid out correctly. Here are four tips on how to avoid some common mistakes:

1. Never dead end the entrance of the single-file chute. Animals have to be able to see a place to go. They will not enter if the entrance looks like a wall. The junction between a crowd pen and the single-file chute is one of the most critical points of the system. An animal standing at the single-file chute entrance must be able to see at least three body lengths up the single-file chute before it turns. That will be about 20 feet (6m) for cattle and 12 feet (4m) for pigs and sheep. Animals will move easily through tight bends after they have entered the first section near the entrance.
2. Correct crowd pen angle at the single-file chute entrance. For cattle and sheep, one side must be on a 30 degree angle and the other side should be straight. This recommendation applies to both circular and crowd pens and straight ones. For pigs, the junction between the single file and the crowd pen should be abrupt. A very gradual transition or a crowd pen that narrows gradually causes jamming. I received two sets of drawings this year that contained this very serious mistake.
3. The crowd pen and staging area must be level. Crowd pens, staging areas and holding pens built on ramps will cause animals to fall down and pile up. Groups of animals held stationary on a ramp will move back and pile on the back gate. A slight drainage slope will not cause a problem. If the system has a ramp, it should be in the single-file chute part of the system. Newer facilities for pigs should contain no ramps and be level. Cattle and sheep will stand quietly in single file on a ramp.
4. Design single-file chutes to the correct length. A common mistake is to make the single-file chute (race) too short. If the chute is too short handlers have to hurry and push animals too hard to keep up. The chute should be long enough to hold enough animals so that the handlers have plenty of time to refill the crowd pen without running out. The chute also needs to be long enough to take advantage of

natural following behavior. It is possible to make a chute too long. For large cattle plants processing 100 or more cattle per hour, the minimum length is 80 feet (25m).

5. Curved single file races work efficiently because they prevent cattle from seeing people up ahead of them. They also take advantage of the animal's natural behavior to return to where they came from. Multiple curves in the single file races are NOT recommended. The best design is a single file race with a single 180 degree half circle or 90 degree quarter circle. The serpentine design with two tight curves should only be used in places where space is restricted. When sufficient space is available a radius of 10 ft (3 m) to 12 ft (3.5 m) is recommended for races used at slaughter plants.
6. When a round crowd pen is used it should be a full half circle or 180 degrees. This will take advantage of the behavioral tendency of cattle to go back to where they came from. For cattle, a 12 ft (3.5 m) radius is recommended. Do NOT use a larger radius for the crowd pen.



An animal standing at the single-file chute entrance must be able to see at least three body lengths up the single file chute before it turns.

Handling Facility Design and Production Systems:
http://www.grandin.com/design/handling.facility.design.and.production.systems.html

Temple Grandin Ph.D., F.A.S. (Member)
American Registry of Professional Animal Scientists
June 1, 1999

(Updated October 2004)

Improvements in Handling and Stunning of Beef Cattle in Slaughter for 1999

This report summarizes improvements in handling and stunning of beef cattle. It.compares data collected in 1996 for the USDA by Grandin Livestock Handling Systems to data collected during 1999. The data collected during 1999 was obtained during animal welfare audits conducted by Temple Grandin and the McDonald's HACCP team and data from other plants visited by Temple Grandin. As stated on the McDonald's webpage, McDonald's Corporation continues to implement animal welfare programs. The summaries in this report compare data on compliance to the guidelines of the American Meat Institute. All plants are in the United States. Today, many other restaurant companies, such as Burger King and Wendy's, are also auditing plants. Supermarkets are also becoming involved in audit programs. Today most of the audits are being done by third party independent auditors. Since 1999, many more large meat buyers are auditing slaughter plants.

The data clearly show that the audit program conducted by McDonalds has resulted in a greater percentage of slaughter plants which are now in compliance with the guidelines. The percentage of plants which passed the stunning audit has doubled in 1999 when compared to 1996. The percentage of plants that received an acceptable score for vocalization (moos and bellows stress measurement) has almost doubled. These improvements have been maintained by continuous audits for the last five years. Some of the plants have better animal welfare than they had in 1999.

CATTLE STUNNING

Percentage of plants that were in compliance with the American Meat Institute guidelines which specify that 95% of the cattle must be rendered instantly insensible with one shot from a captive bolt gun. All cattle must be completely insensible and unconscious on the bleed rail for a plant to pass.

Percentage of Beef Plants which Passed the Stunning Audit.

> 1996 - USDA Survey.........30% Data collected at 10 beef plants
> 1999 - Audits.....................74% Data collected at 19 beef plants - first six months of 1999
> 1999 - Audits.....................90% Data collected at 41 plants - Entire year of 1999
> For 2000, 2001, 2002, and 2003 data, see the survey section of www.grandin.com.

Today, these improvements have been maintained.

Averages of the Percentage of Cattle Stunned Correctly on the First Attempt

> 1996 - USDA Survey.........89% Data collected at 10 beef plants

1999 - Audits.....................94.37% Data collected at 19 beef plants - first six months of 1999
1999 - Audits.....................96.61% Data collected at 41 plants - Entire year of 1999
For more recent data, see the survey section of www.grandin.com.

Today, these improvements have been maintained.

The 1999 average was lowered by two plants which got very poor scores of under 80%. When these two plants are removed the remaining 15 plants averaged 96.6%. The major cause of poor stunning was a lack of stun gun maintenance. This is similar to the findings in 1996. In two plants very high lines speeds of 390 per hour may have been a factor.In these plants one operator was used to stun the cattle. Two plants running 390 per hour that used two operators passed the audit.

VOCALIZATION SCORES

Counting the number of cattle that vocalize (moo or bellow) during handling and stunning is a sensitive indicator of distress. When plants improve their handling practices the percentage of animals that vocalize will decrease. Each animal is scored on a yes/no basis as either a vocalizer or a non-vocalizer. They are scored as they move through the stunning chute area. Compared to the USDA Survey in 1996 there has been a great improvement and the percentage of cattle that vocalized during handling and stunning has decreased. The American Meat Institute guidelines specify that a plant passes and receives an acceptable rating when 3% or less of the cattle vocalize during stunning and handling.

Percentage of Plants which Passed the Vocalization Audit

1996 - USDA Survey..............38% 7 plants data recorded
1999 - Audits..........................78% 18 plants data recorded - first six months of 1999
1999 - Audits..........................72% 42 plants - Entire year of 1999
For 2000, 2001, 2002, and 2003 data, see the survey section of www.grandin.com.

Averages - Percentage of Cattle that Vocalized during Stunning and Handling

1996 - USDA Survey..............12% 7 plants data recorded
1999 - Audits..........................3.4% 18 plants data recorded - first six months of 1999
1999 - Audit............................2.77% 42 plants - Entire year of 1999

The major cause of elevated vocalization percentages was excessive prodding of cattle with electric prods at the entrance of the restrainer. In one plant the problems were due to untrained people and in the other plant cattle balked at a dark restrainer entrance. Adding a light at the restrainer entrance reduced their vocalization score to zero. Another cause of elevated vocalization percentages was poor maintenance of restrainer conveyors. Worn out equipment had broken sharp edges which stuck into the cattle. There were four plants which failed the audit on vocalization. The average vocalization percentage for the 14 plants that passed the vocalization audit is a good score of 1.3%.

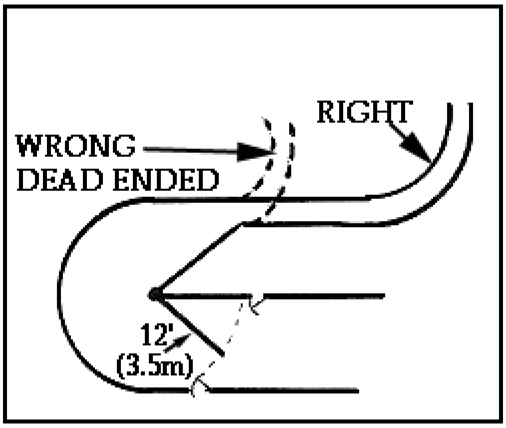
The slight decrease in the percentage of beef plants passing the vocalization audit was partly due to the fact that data collected during the second half of 1999 had a greater percentage of smaller cow plants. The first half of 1999 had a greater percentage of very large fed beef plants. Forty beef plants out of 41 (97%) rendered 100% of the cattle insensible prior to hoisting to the bleed rail. In 1996 nine beef plants out of 10 (90%) achieved 100% insensibility prior to hoisting. All cattle were rendered insensible prior to slaughter procedures. One problem area in certain regions of the country is a few dairies allow some of their cows to deteriorate into emmaciated downers. This problem must be corrected at the dairies.

These summaries clearly show that the industry has improved. Audits conducted by McDonalds Corporation have motivated the beef industry to improve handling and stunning of cattle. The improvements in these summaries have mostly occurred when the McDonald audits were started. The audits conducted by McDonalds in conjunction with their supplier food safety program have resulted in substantial improvements in animal welfare in slaughter plants.

Sample Designs of Cattle Races and Corrals
Revised July 2011

Why does a curved chute and round crowd pen work better than a straight one?

1. As the animals go around the curve, they think they are going back to where they came from.
2. The animals can not see people and other moving objects at the end of the chute.
3. It takes advantage of the natural circling behaviour of cattle and sheep.

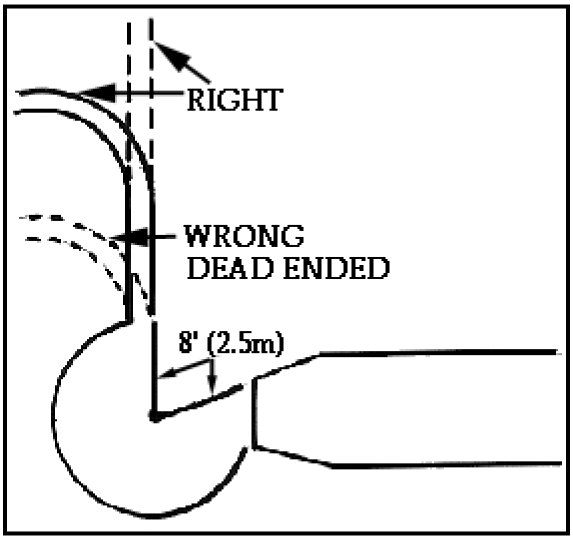


Right and wrong layout for Cattle.

This diagram shows both the right and wrong layout for a curved race system. If the single file race is bent too sharply where it joins the crowd pen the cattle may refuse to enter because it looks like a dead end. Cattle standing in the round crowd pen must be able to see a minimum of three body lengths up the single file chute before the curve begins.

Right and wrong layout for Pigs

This diagram shows both the right and wrong layout for pigs. If the single file race is bent too sharply where it joins the crowd pen, the pigs may refuse to enter. The pigs must be able to see a minimum of three body lengths up the race before it bends.



Design Recommendations

1. The round crowd pen will work most efficiently if it is a full half circle, 180 degrees. A full half circle takes advantage of the natural tendency of cattle to go back to where they came from. For cattle, the crowd pen should have a 12 ft (3.5 m) radius. A shorter radius can be used for pigs and sheep.
2. A single file chute (race) will be very efficient if it has a single 180 degree or 90 degree curve. Multiple curves do not improve efficiency. The serpentine design with 2 180 degree curves should only be used in places where space is restricted. If there is sufficient space, a single 180 degree or 90 degree curve is recommended. It is a mistake to design many multiple curves into the single file race. Refer to drawings in the this website for more information.

3. Never build a crowd pen on a ramp. If a ramp is required, it should be in the single file chute (race). Cattle and pigs will pile up if a crowd pen is built on a ramp.
4. Install solid shields so that approaching animals do NOT see the people up ahead.

Recommended lengths of single file races for cattle

Facility Type	Line Speed	Minimum length	Maximum length
Cattle Ranch and Properties	N/A	40 ft (12.2 m)	75 ft (23 m)
Cattle Slaughter Plants	Under 100/hour	40 ft (12.2 m)	75 ft (23 m)
Cattle Slaughter Plants	100 to 400/hour	80 ft (25 m)	200 ft (60 m)

Recommended lengths of single file races for pigs and sheep

If pigs are handled in groups in a gas stunning system, no race is needed.

Loose shackle systems where pigs can be batched on the bleed rail can operate efficiently with shorter races than systems that have to operate with a continuous flow.

Continuous flow systems with shackles attached to a chain conveyor for pigs or sheep:

0 to 100 animals per hour - 10 ft (3 m) to 25 ft (7.6 m)
100 or more animals per hour - 25 ft (7.6 m) to 50 ft (15 m)

More information and step by step instructions for building curved livestock handling facilities is in the book, Humane Livestock Handling, by Temple Grandin and Mark Deesing, published by Storey Publishing, North Adams, MA, USA.

Why does a curved chute and round crowd pen work better than a straight one?

1. As the animals go around the curve, they think they are going back to where they came from.
2. The animals can not see people and other moving objects at the end of the chute.
3. It takes advantage of the natural circling behaviour of cattle and sheep.

Cattle should be cut close to the jawbone to improve welfare during Kosher and Halal slaughter without stunning

by Temple Grandin
Colorado State University

Two major welfare problems can occur during slaughter without stunning. They are a prolonged period where the bovine remains sensible and aspiration of blood into the trachea (windpipe) and respiratory tract. Blood entering the respiratory tract is a welfare concern because the sensation caused by blood entering the respiratory system is likely to be very distressful. Observations and research done by Neville Gregory and other researchers indicates that cutting cattle close to the jawbone will eliminate the transmission of "potentially unpleasant sensory signals associated with blood contaminating the upper and lower respiratory tract" (Gregory et al, 2011). When the cut is made close to the jawbone in the C1 (Cervical 1) position, the sensory nerve to the respiratory tract is severed. Most Halal and Kosher cuts are made further away from the jaw in the C2 to C4 position (Gregory et al, 2011). In this position, the sensory nerve remains in tact and distressful sensations could be transmitted to the brain before the animal loses sensibility.

Cutting in the C1 position close to the jaw will also help prevent prolonged periods of sensibility caused by sealing off of the artery ends. Gregory et al (2011) have also reported that approximately 3 to 5% of the cattle have delayed onset of insensibility. This is similar to observations I have made in plants that have expert Kosher slaughter. Most cattle that have delayed onset of insensibility will have occluded arteries caused by false aneurysms. Cutting close to the jawbone in the C1 position greatly reduces the formation of false aneurysms. When cattle were cut in the C1 position, only 1% of the arteries were occluded. When they were cut in the C3 position, which is further away from the jaw, one-third of the cattle had false aneurysms. Switching the position of the cut to the C1 position has the potential to greatly improve animal welfare. Some Halal slaughter is already being performed by cutting close to the jawbone. In Halal, cutting in the C1 position is strongly recommended. For Kosher slaughter, the knife is not permitted to touch the jawbone. Research is needed to determine if Kosher cuts that are ritually correct will reliably sever the nerve to prevent distressful sensations from aspirated blood from being perceived by the cattle. Gregory et al (2011) concluded "changing to a cut a C1 could partly reduce the potential for suffering during slaughter without stunning."

References

Gregory, N.G., von Wenzlawowicz, M., von Hollenben, K., Fielding, H.R., Gibson, T.J., Mirabito, L., and Kolesar, R. (2010). Complications during halal slaughter or shechita in cattle. Humane Slaughter Association Centenary International Symposium, Portsmouth, UK.

Questions about death of the animal when different stunning methods are used before Halal or Kosher Slaughter

by Temple Grandin
Department of Animal Science
Colorado State University

Many religious authorities have questions about the effects of various stunning methods on the death of the animal. Since the 1980s, head only electrical stunning has been used in New Zealand prior to Halal slaughter. When the electrical current is applied across the head only, it causes a temporary loss of consciousness. If the animal is not bled promptly, it will wake up and fully recover. Unconsciousness is induced by causing an epilectic seizure. To prevent the animal from returning to sensibility it must be bled within 15 to 23 seconds (Gregory, 2007; Lambooij, 1982). Head only stunning is completely reversible. In the 1980s, a test was done that showed that cattle stunned with a head only stunner could graze on a pasture after they recovered. When head only electrical stunning is performed, the heart continous to beat (Weaver and Wotton, 2008; Gilbert and Devine, 1982).

There is a second type of electrical stunning that will stop the heart and kill the animal. When it is done correctly, the animal will not recover. It is called cardiac arrest stunning because it stops the heart (Vogel et al, 2010; Gilbert and Devine, 1982). When this method is used, electrodes are applied to BOTH the head and on the body near the heart. Electrode position is the main variable that differentiates head only reversible electric stunning from cardiac arrest stunning. When head only reversible electric stunning is used the electrodes are placed only on the head.

Some religious authorities use heartrate to determine whether or not the animal is dead. When either penetrating or non-penetrating captive bolt is used, the heart will continue to beat for up to 8 to 10 minutes if bleeding is delayed (Vinnic et al, 1983). The heart will continue to beat even when the brain has been destroyed. It will continue to beat until the heart runs out of oxygen. The heart eventually runs out of oxygen because captive bolt stunning stops breathing. However, if cessation of a heartbeat is used as a definition of death, then an animal shot with a captive bolt will be alive for 8 to 10 minutes. This provides sufficient time for death to be induced by a throat cut on the neck.

A full copy of this paper and list of references can be found at:

http://www.grandin.com/ritual/questions.diff.stun.methods.html

Welfare During Slaughter without stunning (Kosher or Halal) differences between Sheep and Cattle

by Temple Grandin
Department of Animal Science
Colorado State University

Revised August 2011

Slaughter without stunning is controversial from an animal welfare standpoint. When this subject is being discussed it is essential to consider species differences between cattle and sheep. Welfare issues are greater for cattle because they take longer to become unconscious compared to sheep. When both carotid arteries are severed, sheep will lose sensibility within 2 to 14 seconds (Newhook and Blackmore 1982, Gregory and Wotton 1984, Nangeroni and Kennett 1963, Schulz et al 1978, Blackmore 1984). Most sheep will be insensible within 10 seconds. Calves and cattle take a longer period of time to become insensible and they are more likely to have a prolonged period of insensibility. The time to loss of insensibility when good cutting technique is used will range from 17 sec to 85 sec (Blackmore 1984, Blackmore et al 1983l, Gregory and Wotton, 1984, Grandin 2010, Daly et al 1988, Gregory et al 2010). Some cattle may have prolonged periods of sensibility lasting up to 385 seconds (Blackmore, 1984). When good technique is used the average time to collapse is 17 seconds (Grandin 2910). Both scientific research and practical experience indicate that cattle have more problelms with prolonged periods of sensibility compared to sheep. Another problem in cattle is occlusion of the carotids which can occur after the act (Gregory 2010). This problem is less likely to occur in sheep and goats. Occlusions caused by false aneuryms do not occur in sheep and goats (N. Gregory, Personal Communication in 2011).

The main reason for the differences between cattle and sheep is due to differences in the anatomy of the blood vessels that supply the brain. When slaughter without stunning is done, both carotid arteries are cut. In sheep the carotid arteriees that are located in the front of the throat provide the brain with it's entire supply of blood. In cattle the vertebral arteries which are not severed by the cut also supply the brain with blood. Therefore, when the carotids are severed in cattle the brain still has a blood supply. The differences in the blood supply to the brain of sheep and catle have been researched in detail (Baldwin and Bell 1963 a,b,c,d). It is also likley that the yak is similar to cattle (Ding et al 2007).

Overall Welfare

Some sheep die more quickly and are less likely to have extended periods of insensibility and should not be lumped together with cattle when welfare without stunning is being discussed. Sheep also do not require expensive, complicated restraint equipment. A lamb can be easily straddled by a person while standing in an upright position and cut. It is likely that a lamb slaughtered on the farm with a very sharp knife may have better welfare than a lamb that has to be subjected to the stress of being transported. A very sharp knife is essential. To test the knife it should be able to slice a standard A4 printer paper that is held dangling by one corner. The knife must be dry for this test. To help prevent pain the wound must be held opend during the act and the knife must be long enough so that it's tip remains outside the neck during the cut. The best cutting method is a Kosher or Halal cut that severs both carotid areteris. In

situations where the loss of posture cannot be observed, a fixed fully dilated pupil can be used to determine complete loss of sensibility. When sheep are cut correctly, a fixed fully dilated pupil will occur in 20 seconds (Miriam Parker, Personal Communication in 2011). In sheep the wound should be held open during bleed out to facilitate bleed out. Cutting cattle close to the jawbone in the C1 position will help prevent false aneuryms and improve bleed out compared to the C2 to C4 position (Gregory et al, 2011).
A full copy of this paper and list of references is available at:
http://www.grandin.com/ritual/welfare.diffs.sheep.cattle.html

The rules of Shechita for performing a proper cut during kosher slaughter

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Rabbi Chanoch Kesselman from the Union of Orthodox Hebrew Congregations in London has provided an accurate english translation for the rules of shechita. Following these rules will improve welfare during slaughter and reduce the animal's reaction.

There are five rules that Jewish law requires for a correct cut. I have observed that if the rules are disobeyed the animal will struggle. If these rules are obeyed the animal has little reaction. The five rules are (Code of Jewish Law Y.D. 23):

- 'Shehiyah' (Delay) - A pause of hesitation during the incision of even a moment makes the animal's flesh unkosher. The knife must move in an uninterrupted sweep.
- 'Derasah' (Pressing) - The knife must be drawn across the throat by forward/backward movements, not by hacking or pressing. Any undue pressure renders the animal unkosher.
- 'Haladah' (Digging) - The knife must be drawn over the throat so that it is visible while shechita is being peformed. It must not be stabbed into the neck or buried by fur, hide, or feathers in the case of a bird.
- 'Hagramah' (Slipping) - The limits within which the knife may be applied are from the large ring in the windpipe to the top of the upper lobe of the lung when it is inflated, and corresponding to the length of the pharynx. Slaughtering above or below these limits renders the meat unkosher.
- 'Ikkur' (Tearing) - If either the esophagus or the trachea is torn during the shechita incision the carcass is rendered unkosher and cannot be eaten by Jews. Tearing can occur if there is a nick in the chalaf (special knife used only for shechita).

The shochet also has to check the blade before and after each animal is slaughtered to make sure it is perfectly smooth and has no nicks. A nick will cause pain. If the blade is not perfect it is forbidden to use it. It must be re-honed or replaced.

The transection must be examined by the shochet immediately after the incision to ascertain that is was done according to the requirements of shechita.

Discussion of research that shows that Kosher or Halal Slaughter without stunning causes pain

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Updated February 2010

A study done in New Zealand in 2009 shows that slaughter without stunning causes pain. A new EEG (brainwave) method was used, which can determine when an animal is feeling pain. In these experiments, lightly anesthetized calves were cut with a very sharp knife that was 24.5 cm long. The weight of the calves was 109 to 170 kg. One reason why the calves were lightly anesthetized was to prevent animal movements (movement artifact) from changing and distorting the EEG patterns. The experiments showed that the calves would have been experiencing pain during the cut (Gibson et al, 2009 ab).

The knife used in this experiment was much shorter than the special long knives that are used in Kosher slaughter. The use of a shorter knife may possibly have had an effect on the painfulness of the cut. The author has observed that shorter knives, where the tip of the knife gouges into the wound during the cut, will cause struggling. An animal may also struggle when the wound closes back over the knife during the cut. Since the calves were anesthetized, it was impossible to observe behavioral reaction during the cut. From reading the methods sections in the papers, it was not possible to determine if the wound was held open during the cut, which may help reduce pain. The knife used in this experiment was similar to many of the knives the author has observed being used for halal slaughter. The special long knife used in kosher slaughter is important. When the knife is used correctly on adult cattle, there was little or no behavioral reaction (Grandin, 1992, 1994). Barnett et al (2007) reported similar reactions in chickens. Only four chickens out of 100 had a behavioral reaction. Grandin (1994) reported that the behavioral reaction of cattle was greater when a hand was waved in their faces compared to well done Kosher slaughter. All of the cattle were extensively raised animals with a large flight zone. They were all held in an upright position in a restraint box. The results of this study clearly show that the use of a knife with a 24.5 cm long blade definitely causes pain. Another factor that may have had an effect on pain was the use of a grinding wheel to sharpen the knife instead of a whet stone. There is a need to repeat this experiment with a Kosher knife and a skilled shochet who obeys all the Kosher rules for correct cutting.

Aspiration of Blood

Research also shows that cattle aspirate (inhale) blood into the lungs during Kosher and halal slaughter. This can vary from 36% to 69% (Gregory et al, 2008). The cattle were restrained in an upright position. The author has also observed aspiration of blood during Kosher and halal slaughter. It is the author's opinion that aspiration of blood is more likely to be a serious welfare problem for cattle, because bovines take longer to lose sensibility (consciousness) compared to sheep (Baldwin, 1971 and Blackmore, 1984). This provides more time for cattle to aspirate blood compared to sheep. Sheep lose sensibility more quickly due to differences in their blood vessel anatomy compared to cattle (Baldwin, 1971; Baldwin and Bell, 1963). See other articles on www.grandin.com on slaughter methods. The Gregory et all (2008) data was collected in commercial slaughter plants. Furhter research is needed to determine why some cattle aspirated blood and others did not. Possibly, improving procedures to facilitate rapid loss of sensibility may reduce aspiration of blood. This needs further research.

All of this research needs to be looked at in the perspective of the entire process. Abusive handling practices prior to slaughter and highly stressful methods of restraint may cause more suffering than the actual slaughter itself. The author has been in dreadful places where large, 600 kg cattle were hung up by one leg and they were all thrashing and bellowing. The OIE slaughter standards state that these stressful methods of restraint should not be used. Plants that use stressful methods of restraint such as shackling and hoisting or shackling and dragging need to stop using these abusive methods.

A full copy of this paper and list of references is available at:
http://www.grandin.com/ritual/slaughter.without.stunning.causes.pain.html

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Kosher Box Operation, Design, and Cutting Technique will Affect the Time Required for Cattle to Lose Sensibility (Updated December 2010)

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To insure an acceptable level of animal welfare, cattle should become insensible and collapse quickly after kosher slaughter. Data collected in five kosher plants in several different countries indicated that improvements in procedures will greatly shorten the interval between the cut and loss of sensibility. All five plants had an upright kosher restraint box that held the animal in a standing position. The time in seconds was recorded from the end of the cut until the eyes rolled back and the animal started to collapse.

Plant 1. Time Until Eye Rollback and Collapse After Kosher Slaughter

	Group 1	Group 2	Group 3
Average time in seconds	15	35	22
Shortest time	13	14	11
Longest time	18	61	38
Number of cattle	9	17	23
Percentage that collapsed within 30 seconds	100%	35%	91%

Plant 1 had a good upright box that was long enough so that long cattle would not be pushed up too hard against the front of the box. Pushing the animal's chest up against the front of the box will restrict blood flow. It was standard practice in this plant to totally release the head holder belly lift and rear pusher gate immediately after the animal was cut. This will promote bleeding.

Plant 1, Group 1: Excellent box operator and cutting technique
Plant 1, Group 2: Cutting done by a different rabbi than Group 1
Plant 1, Group 3: Released pressure from the head holder, belly lift and rear pusher more quickly than Group 2

Plant 2. Time Until Eye Rollback and Collapse After Kosher Slaughter		
	Group 1	**Group 2**
Average time in seconds	17	33
Shortest time	10	15
Longest time	38	120
Number of cattle	17	19
Percentage that collapsed within 30 seconds	94%	68%

Plant 2 had a good box that fit the cattle. Group 1 had shorter collapse times because pressure on the animal's body from the head holder, rear pusher gate and belly lift was released more quickly.

Plant 3. Time Until Eye Rollback and Collapse After Kosher Slaughter		
	Group 1	**Group 2**
Average time in seconds	15	16
Shortest time	8	10
Longest time	35	25
Number of cattle	13	21
Percentage that collapsed within 30 seconds	92%	100%

Plant 3 was doing everything right. They had an excellent upright box and both the box operator and the schohets had worked on perfecting the details of box operation and cutting. The schohets made deep cuts with a swift stroke with very little sawing motion. The total time that the animal was held tightly fully restrained in the box was under 10 seconds. Immediately after the cut, the head holder and rear pusher were released, and the animal was removed from the box. Plant 3 is one of the few plants that perform no second cut after the kosher cut. This plant has a very low level of blood splash.

Plant 4. Time Until Eye Rollback and Collapse After Kosher Slaughter	
	Group 1
Average time in seconds	29
Shortest time	13
Longest time	89
Number of cattle	25
Percentage that collapsed within 30 seconds	72%

Plant 4 had an excellent schohet, but there were problems with the design of their box. It was too short for long cattle which caused vocalization (bellow) in 30% of the cattle. They did not perform the total release procedure that has been successfully used in other plants because the box was too short to release the rear pusher gate. The head holder was released immediately after the cut.

Plant 5. Time Until Eye Rollback and Collapse After Kosher Slaughter		
	Group 1	**Group 2**
Average time in seconds	34	31
Shortest time	14	14
Longest time	120	95
Number of cattle	7	21
Percentage that collapsed within 30 seconds	77%	55%

In plant 5, cattle were held in the box too long while a second cut was being done in the box. Their box also held the animal too tightly and applied excessive pressure.

Recommendations to shorten the interval between cutting and loss of sensibility. These methods will also reduce bloodsplash damage in the meat (Grandin 2010).

1. Deep cuts
2. Rapid swift knife stroke with a minimum of sawing motions.
3. Minimize the time that the animal is fully restrained by the head holder, belly lift, and rear pusher. Under 10 seconds is ideal.
4. Restrict travel of the belly lift so that it does not lift the animal off the floor.
5. Immediately after the cut, COMPLETELY release the head holder, belly lift, and rear pusher gate.
6. Keep cattle calm and reduce use of the electric prod. Calm cattle bleed out faster.
7. Install non-slip flooring in the box and lead up chute. Cattle panic when they slip.
8. The percentage of cattle vocalizing (bellow or moo) should be 5% or less. Vocalizing cattle are stressed.
9. Avoid excessive pressure applied by the rear pusher gate that compresses the animal's chest against the front of the box.
10. If the neck opening is too tight, it may restrict bleed out.

Gregory et al (2010) have reported very similar results when good techniques were used. In this study, 88% of the cattle collapsed within 30 seconds and a few cattle had prolonged periods of sensibility. This is similar to our observation. Cattle take longer to lose sensibility compared to sheep and goats. Sheep will lose consciousness and become insensible within 2 to 14 seconds (Gregory and Wotton 1984, Blackmore 1984).

When a rotating box is used, scoring of onset of insensibility can be determined by observing the animal's response to waving a hand within 15 cm (6 in) of it's eye. Any response such as natural blinking, flinching, vocalization, or kicking is a sign that the animal is still sensible. Another indicator of sensibility is eye tracking when a hand is moved slowly past the eye (H. Anil personal communication, 2010).

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Maintaining acceptable animal welfare during Kosher or Halal slaughter

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Performance and operation requirements for upright restraining equipment for Kosher or Halal slaughter to provide acceptable animal welfare.

1. The restraint equipment must hold the animal in a comfortable upright position before and during religious slaughter.
2. Operation of the equipment must be able to comply with the following minimum performance standards which are determined by observing 50 to 100 animals:
    - **Falling Score** - 0 to 1% of the animals fall while entering the restraint equipment and while they are held in the equipment before slaughter. A fall is recorded if the animal's body touches the floor. Applies to all animal species.
    - **Electric Prod (Goad) Score** - For a minimum acceptable score, 75% or more of the cattle must enter the restraint equipment easily with no electric prod. For an excellent score, 95% or more of the cattle must be moved with no electric prod. Electric prods must never be used with sheep.
    - **Vocalization (Mooing and Bellowing) Score (Cattle Only)** - When cattle are distressed during handling and restraint, they will vocalize. Some of the stressful events that can cause vocalization are slipping on the floor, excessive pressure from the restraining equipment, sharp edges, electric prod use, or abuse by people such as hitting or tail twisting. For an acceptable score, 95% of the cattle must be silent. Vocalization scoring is on a per animal basis. Each animal is either a vocalizer or silent. Cattle vocalization is scored in the restrainer equipment and during entry into the equipment.
3. If the animal's feet are lifted off the floor, the animal's body must be fully supported. Applies to all animal species.

4. Devices that clamp the feet or hoisting or dragging the sensible animal by the head, feet, or legs must never be used. Applies to all animal species.
5. On restraint devices that operate with either hydraulics or pneumatics, the controls must be designed so that the operator can incrementally control the amount of pressure applied to the animal by the head holder and other parts of the apparatus. Midstroke position control of cylinders is strongly recommended.
6. Using the concept of optimum pressure, the device must apply sufficient pressure to provide the animal with the sensation of being held, but excessive pressure that would cause pain must be avoided.
7. Moving parts of the restraint device should move with steady smooth motion. Sudden jerky motion causes animals to become agitated.
8. Races (chutes) and restraint devices must have non-slip flooring.
9. After the animal is completely restrained in the head holder, religious slaughter must be performed within 10 seconds. Animals fight restraint if held too long.
10. Head holding devices should be designed to avoid excessive bending of the neck.
11. The designs on this website contain many ideas for building a restrainer which will provide acceptable animal welfare. Innovative people are encouraged to invent restrainer devices that will conform to the this performance standard.
12. Engineer restrainers to reduce noise such as metal clanging and banging and air hissing.
13. A solid barrier must be built around the head holder to prevent the animal from seeing people and moving equipment while it is entering the equipment.
14. The restrainer must be illuminated in such a manner to encourage animal entry. See other parts of www.grandin.com.

Troubleshooting animal welfare problems during Kosher or Halal slaughter

1. **Problem** - Animals refuse to enter the restrainer.

   Solution - Install barriers so that people or moving equipment are not visible to the approaching animals. change the lighting. Animals are afraid of dark places. See troubleshooting guide in the American Meat Institute Guidelines. Eliminate air drafts that blow into the faces of approaching animals.

2. **Problem** - Animals are agitated and struggle.

   Solutions -

   1. Install non-slip flooring. Animals panic when they slip.
   2. Perform slaughter within 10 seconds after restraint.
   3. Train people to handle animals quietly. Excited animals may struggle.
   4. Animals may struggle in pain if the knife is too short because it digs into the incision. Use a knife that is twice the width of the neck.
   5. Do not allow the wound to close over the knife during the cut.
   6. Excessive bending of the neck will cause agitation. Reduce bending of the neck.
   7. Excessive pressure by the restraint device can cause struggling. Pressure should be reduced.

8. Adjust the restrainer so that the animal is held in a balanced upright position. If the animal feels off balance, it may struggle.
9. Eliminate sudden jerky motion of moving parts. Install flow controls or speed reducers on hydraulic or pneumatic equipment.

3. **Problem** - Cattle vocalization score of more than 5%.

   Solutions -

   1. Reduce excessive pressure applied to the animal's body.
   2. Reduce excessive prod (goad) use.
   3. Remove sharp edges that stick into the animals.
   4. Head restrainer openings and head yokes should have rounded surfaces.
   5. Install non-slip flooring. Cattle that slip may vocalize.
   6. Perform slaughter within 10 seconds after restraint.

4. **Problem** - Animals have prolonged sensibility and do not collapse within 10 seconds.

   Solutions -

   1. Use a very sharp knife that is twice the width of the neck.
   2. A swift cut is best. Slow cutting is more likely to prolong sensibility.
   3. Calm animals will collapse more quickly than excited or agitated animals.
   4. Replace the slaughterman. Observations in slaughter plants indicate that some slaughtermen are more efficient than others. A skilled slaughterman can induce over 90% of the cattle to collapse within 10 seconds.
   5. Reduce pressure on the animal's body immediately after the cut.
   6. Animals that do not collapse within 20 seconds should be shot with a captive bolt, before removal from the restraint device.

Recommended Ritual Slaughter Practices To Improve Animal Welfare And Employee Safety

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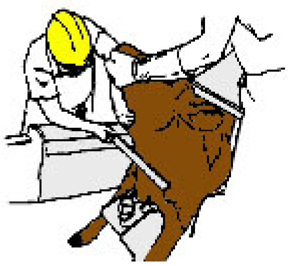
Safety Tips for Workers

Shackling and hoisting large cattle and calves can be very dangerous. It has caused many serious accidents such as loss of an eye, permanent knee damage and head injuries from kicking and falling shackles. In one plant, replacement of the shackle hoist with a restrainer resulted in a 500 percent reduction in accidents. Shackling and hoisting of live sheep is also hazardous. There have been several incidents of teeth knocked out.

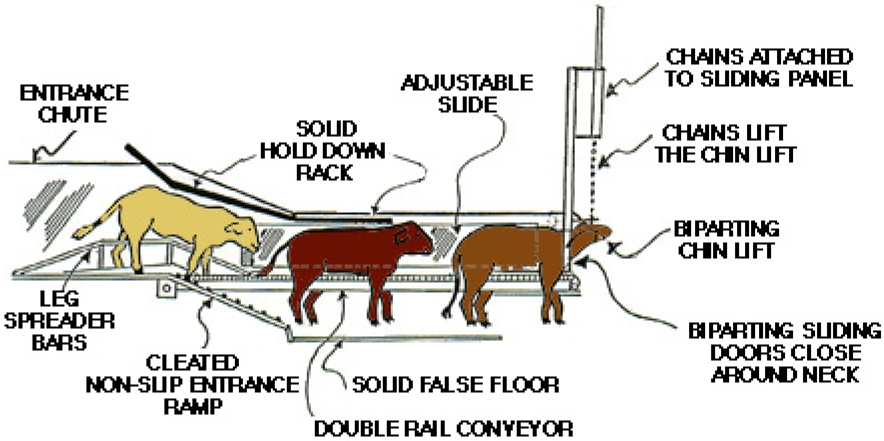
- **Center track restrainer being used for ritual slaughter.**
  The animal is being restrained in a very humane manner, comfortably upright. A person can hold the head of calves and sheep. For adult cattle, a mechanical head holding device is used.



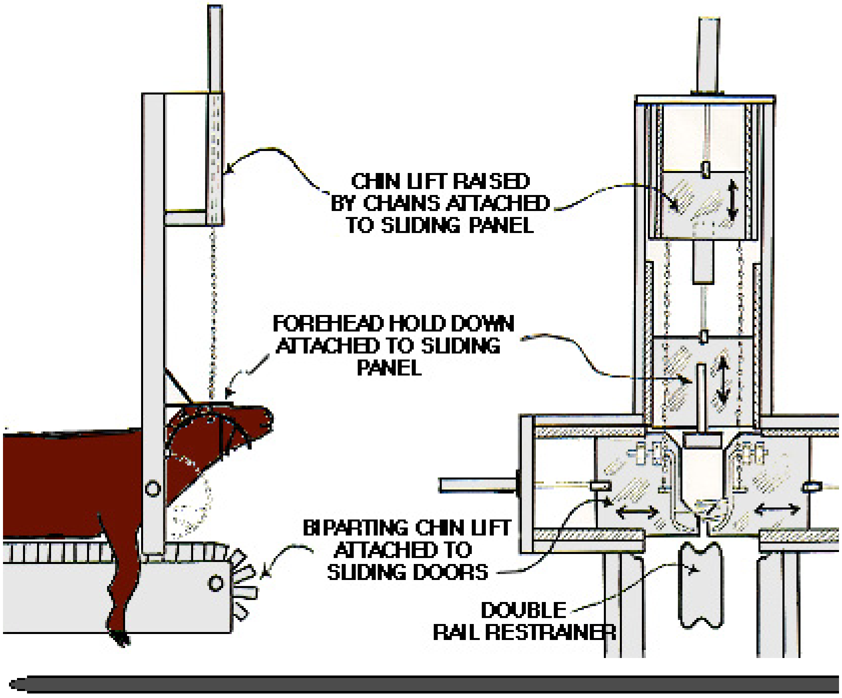
- There **are** humane options to shackling and hoisting animals.
  - Conveyor systems with headholder chin lifts provide a calmer animal, and a safer environment for workers.
  - The ASPCA pen is another humane option available for humane ritual slaughter.

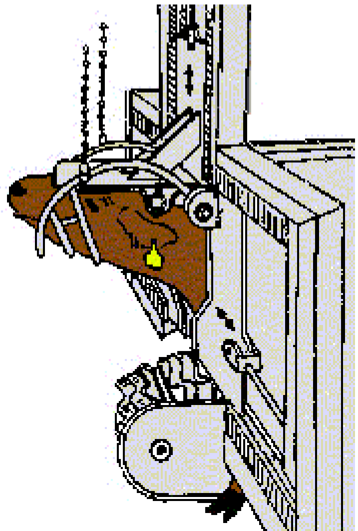
CONVEYOR SYSTEMS

To induce the cattle to stay still and ride quietly, the solid hold down rack MUST be long enough so that the animal entering the restrainer can NOT see out until it's feet are completely off the enterance ramp.

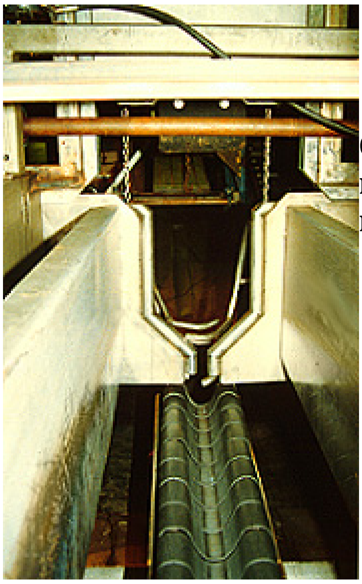


Detail showing double rail restrainer and chin lift.



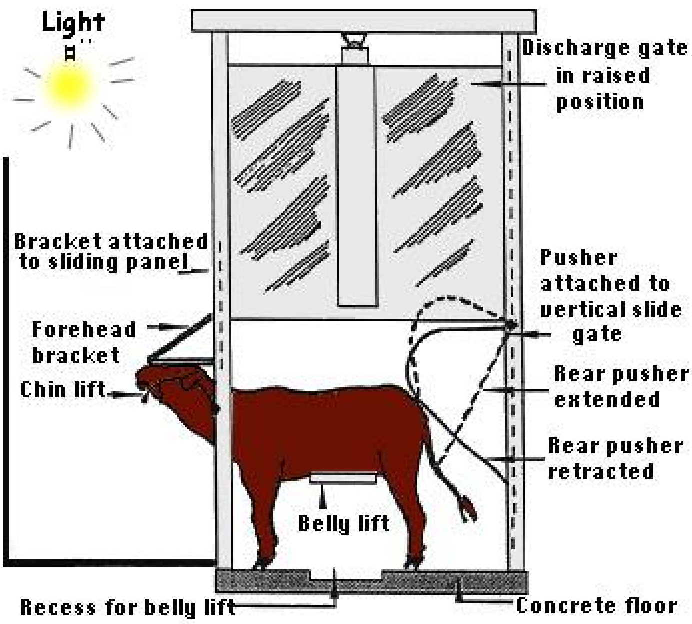


- **Headholder for the double rail restrainer.**
  Another humane option for ritual slaughter. This device holds the animals head comfortably and allows a Rabbi to perform the Kosher cut with the animal quietly restrained.



Cow's eye view of the head holding device for ritual slaughter on the center track double rail restrainer.

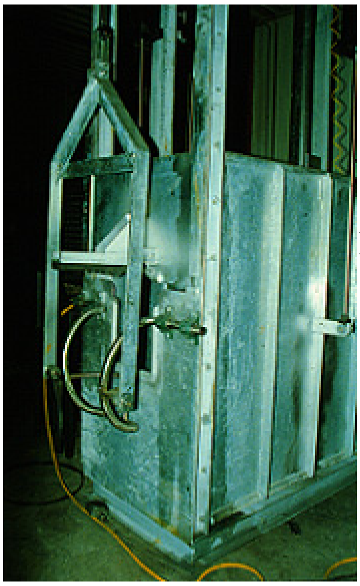
ASPCA PEN



- **Upright kosher restraint box**
  Side view illustrating the proper cattle position for restraint.

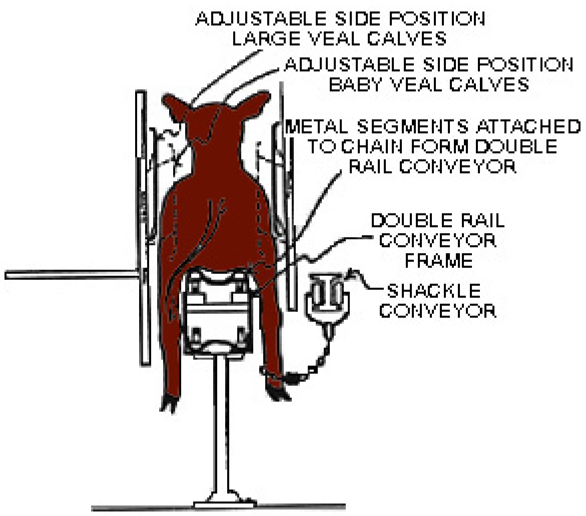
This drawing illustrates (on the left side, in front of the animal) the solid barrier that is necessary to

block the animal's vision.
The sides of the ASPCA box must also be completely solid



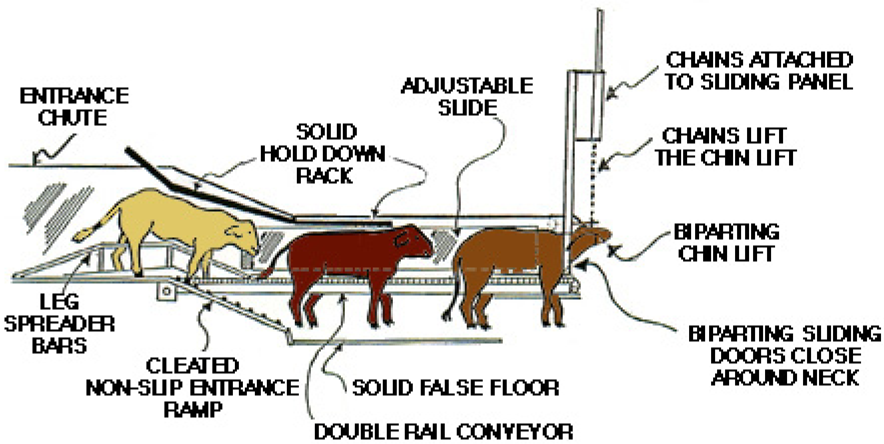
Restraining box with headholder for ritual slaughter holds the animal in an upright position.

Conveyor Restrainer Systems

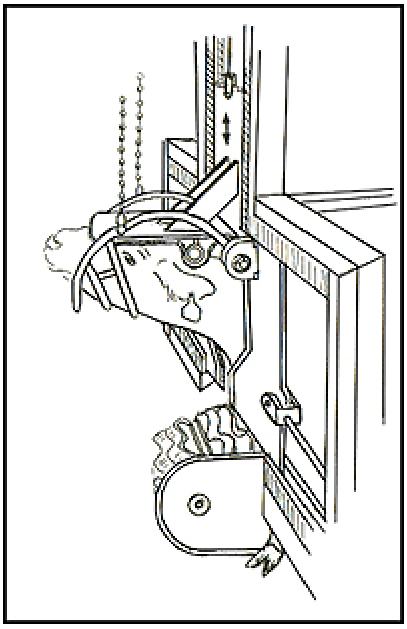


There are several alternatives for the humane restraint of livestock during ritual slaughter. From an animal welfare standpoint, the most important issue in ritual slaughter is the method of restraint. Animals should be restrained in the most comfortable **upright position** possible. Having animals upright prior to slaughter is not only more humane, but also provides a safer environment for handlers.

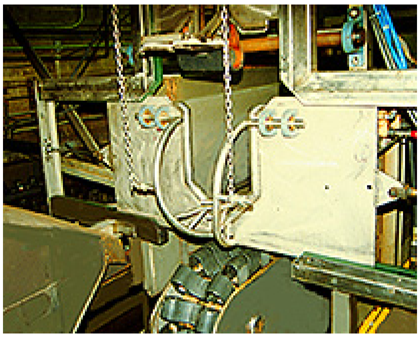
To induce the cattle to stay still and ride quietly, the solid hold down rack MUST be long enough so that the animal entering the restrainer can NOT see out until it's feet are completely off the enterance ramp.

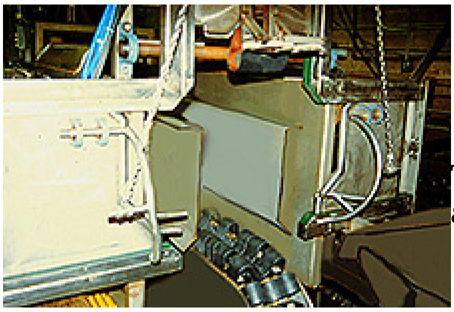


- **Either V restrainer or center track restrainer systems can be used for holding cattle, sheep or calves in an upright position during shehita. The restrainer is stopped for each animal and a head holder holds the head for the rabbi.**
  Research in Holland indicates that the center track design provides the advantage of reducing bloodspots in the meat.

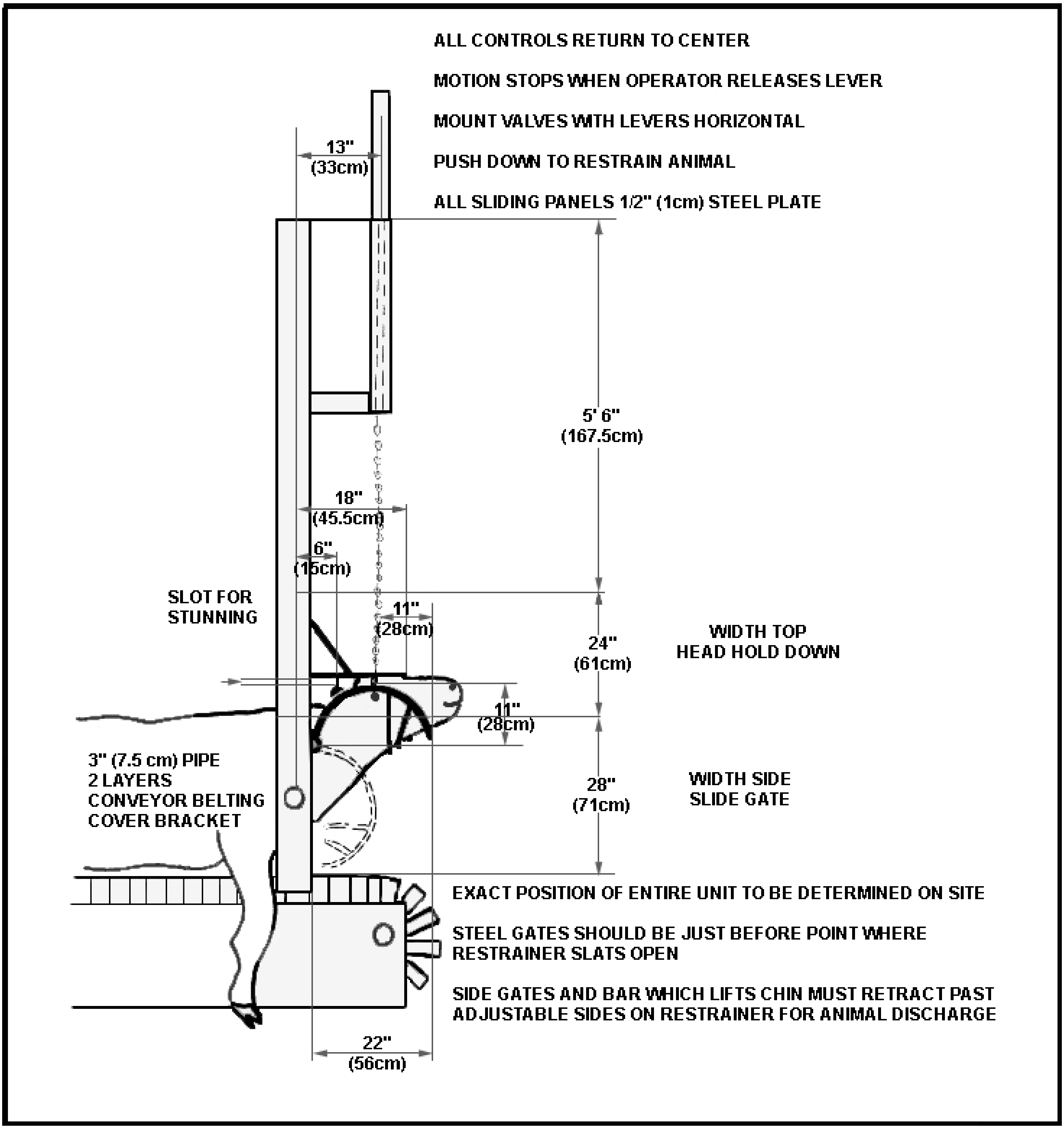


The headholder in a closed position ready to receive the next animal.

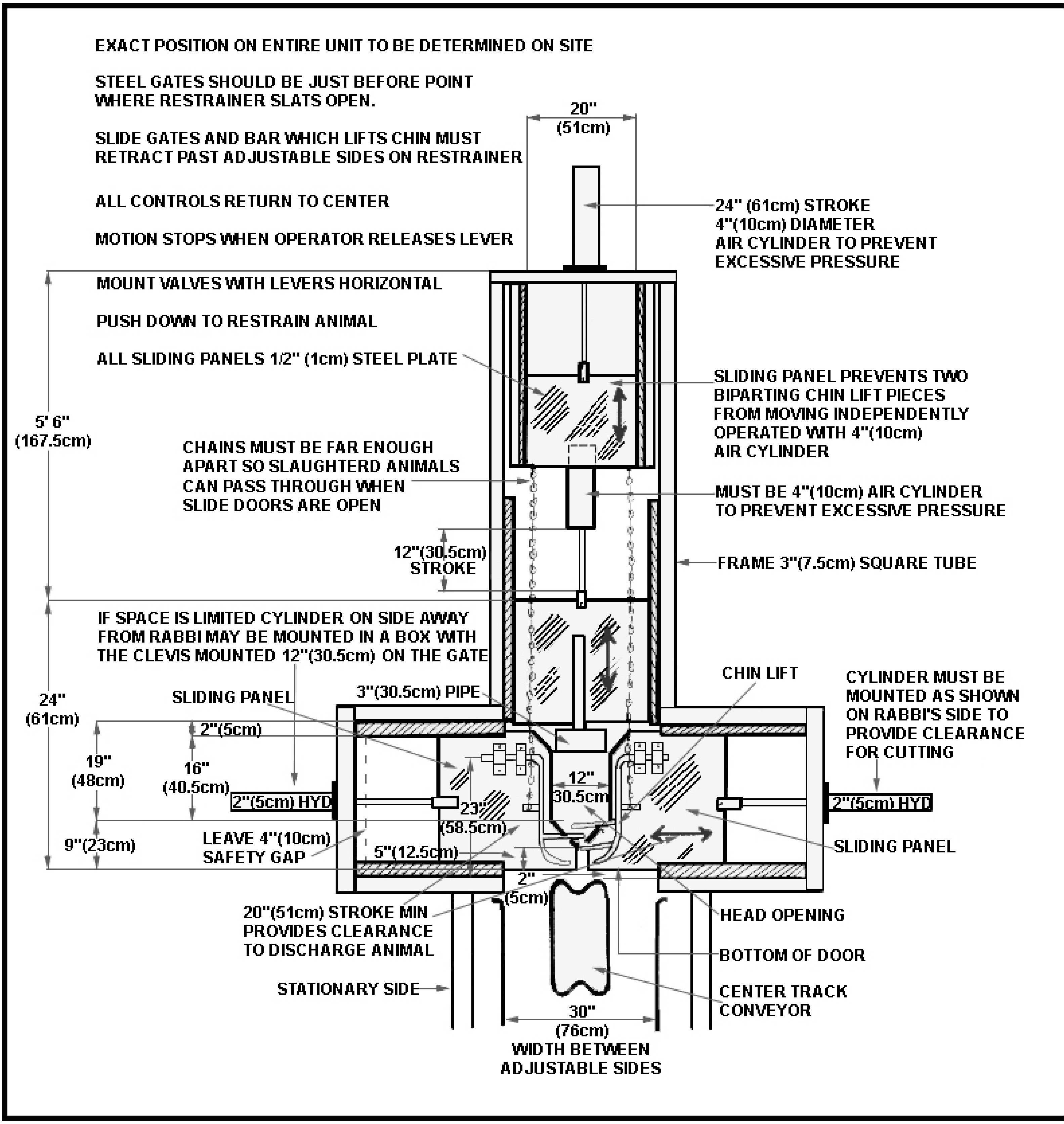




The headholder in an open position, ready for an animal to exit.



This headholding device is in the public domain and can NOT be patented. Diagrams are published in T. Grandin 1993. Livestock Handling and Transport, CABI Publishing, p. 306. This was done to make this device readily available and to improve animal welfare.



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Religious slaughter and animal welfare: a discussion for meat scientists.

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Both the Muslim and Jewish faiths have specific requirements for the slaughter of religiously acceptable animals. The major difference from the general practices in most countries is that the animals are not stunned prior to slaughter. It is important that meat scientists understand the implications of these differences. They need to critically consider the scientific information available about the effects of different slaughter practices on animals before reaching any judgements about the appropriateness of a particular form of slaughter. It is also important that they understand the importance of these practices to the people who follow these religious codes. We hope to discuss some information that may be useful in evaluating religious slaughter.

The Jewish dietary code is described in the original five books of the Holy Scriptures. The Muslim code is found in the Quran. Both codes represented major advancements in the respect for animals and their proper handling in ancient times. For example, the Jewish code specifically forbid the use of limbs torn from live animals and the slaughter of both a mother animal and her children on the same day.

One way to view the rather comprehensive legal system of the Jewish faith is spelled out in the paragraphs below. We feel this explanation may help others understand the degree of significance of these religious practices to those of the Jewish faith (Grunfeld, 1972).

"And ye shall be men of holy calling unto Me, and ye shall not eat any meat that is torn in the field" (Exodus XXII:30)

Holiness or selfsanctification is a moral term; it is identical with...moral freedom or moral autonomy. Its aim is the complete selfmastery of man.

"To the superficial observer it seems that men who do not obey the law are freer than law-abiding men, because they can follow their own inclinations. In reality, however, such men are subject to the most cruel bondage; they are slaves of their own instincts, impulses and desires. The first step towards emancipation from the tyranny of animal inclinations in man is, therefore, a voluntary submission to the moral law. The constraint of law is the beginning of human freedom....Thus the fundamental idea of Jewish ethics, holiness, is inseparably connected with the idea of Law; and the dietary laws occupy a central position in that system of moral discipline which is the basis of all Jewish laws.

"The three strongest natural instincts in man are the impulses of food, sex, and acquisition. Judaism does not aim at the destruction of these impulses, but at their control and indeed their sanctification. It is the law which spiritualises these instincts and transfigures them into legitimate joys of life."

We hope that the above quote suggests the importance of the kosher dietary laws to people of the Jewish faith. Similar religious philosophies underpin the Muslim requirements. Thus, the ability to carry out ritual slaughter is extremely important to people of these two faiths. The banning of such slaughter would certainly be viewed as a hostile act.

The actual reference to slaughter in the Jewish Holy scriptures is quite cryptic:

"...thou shall kill of thy herd and of thy flocks, which the Lord hath given thee, as I have commanded thee..."(Deuteronomy XII:21)

Clearly it was assumed that people were familiar with the rules for kosher slaughter. These were a pan of the "oral code". Eventually these rules were written down in the series of volumes referred to as the Talmud as well as in other religious texts. The Talmud contains an entire section on slaughter and the subsequent inspection of animals to ensure that they are religiously "clean". The text includes detailed anatomical information in order to teach the religious Jew exactly what was to be done during slaughter and the subsequent post-mortem inspection.

The Muslim rules with respect to animals and slaughter are contained in the Quran. Blood, pork, animals dying due to beating, strangulation, falls, goring or other damage from animals and animals dedicated to other religions are all forbidden. Any Muslim may slaughter an animal while invoking the name of Allah. In cases where Muslims cannot kill their own animals, they may eat meat killed by a "person of the book", i.e., a Christian or a Jew. Again stunning prior to slaughter is generally not the practice . However, a non-penetrating concussion stunning prior to slaughter has received approval from some Muslim authorities. Work in the 80's in New Zealand led to the development of a very sophisticated electrical stunning apparatus that met a Muslim standard where an animal must be able to regain consciousness in less than a minute and must be able to eat within five minutes. Head-only electric stunning prior to Muslim slaughter is used in almost all sheep slaughter plants in New Zealand and Australia. Electric stunning of cattle is used in many New Zealand Muslim cattle slaughter plants and the practice is spreading to Australia. Meat from electrically stunned cattle and sheep is exported to middle eastern countries with stringent religious requirements. "Halal" slaughter in New Zealand and Australia may be carried out by regular plant workers while Muslim religious leaders are present and reciting the appropriate prayers. However, the larger Halal slaughter plants in Australia, New Zealand, and Ireland do employ Muslim slaughtermen. Muslim slaughter without stunning is forbidden in New Zealand. With Muslim slaughter in countries not using stunning, we are also concerned about the training given to the slaughtermen. More work is needed on training programs to teach proper sharpening of knives and to improve the actual slaughter techniques.

The Jewish religious codes require that allowed animals be slaughtered by a specially trained Jewish male, while the Muslims prefer that allowed animals be slaughtered by a person of that faith. In the case of the Jewish dietary laws, a specially trained person of known religiosity carries out the slaughter. This person, the "shochet", is specifically trained for this purpose. He is trained to use a special knife, called the "chalef", to rapidly cut in a single stroke the jugular vein and the carotid artery without burrowing, tearing or ripping the animal. The knife is checked regularly for any imperfections which would invalidate the slaughter. This process when done properly leads to a rapid death of the animal. A sharp cut is also known to be less painful .

Need for objective evaluation

Given the importance of religious slaughter to people of these two major faiths, it is important that scientists must be absolutely objective when evaluating these practices from an animal welfare standpoint.

Evaluation of religious slaughter is an area where many people have lost scientific objectivity. This has resulted in biased and selective reviewing of the literature. Politics have interfered with good science. There are three basic issues. They are stressfulness of restraint methods, pain perception during the incision and latency of onset of complete insensibility.

Restraint

A key intellectual consideration is separation of the variable of restraint stress from the animal's reaction to the slaughter procedure. Stressful or painful methods of restraint mask the animal's reactions to the throat cut. In North America some kosher slaughter plants use very stressful methods of restraint such as shackling and hoisting fully conscious cattle by one rear leg.

Observations of the first author indicate that cattle restrained in this manner often struggle and bellow and the rear leg is bruised. Bruises or injures caused by the restraint methods (or from any other cause) would be objectionable to observant Jews. In Europe, the use of casting pens which invert cattle onto their backs completely mask reactions to the throat cut. Cattle resist inversion and twist their necks in an attempt to right their heads. Earlier versions of the Weinberg casting pen are more stressful than an upright restraint device (Dunn 1992). An improved casting pen, called the Facomia pen, is probably less stressful than order Weinberg's pens but a well designed upright restraint system would be more comfortable for cattle. Another problem with all types of casting pens is that both cattle and calves will aspirate blood after the incision. This does not occur when the animal is held in an upright position.

Unfortunately some poorly designed upright American Society for the Prevention of Cruelty to Animals (ASPCA) restraint boxes apply excessive pressure to the thoracic and neck areas of cattle. In the interest of animal welfare the use of any stressful method of restraint should be eliminated. A properly designed and operated upright restraint system will cause minimum stress. Poorly designed systems can cause great stress. Many stress problems are also caused by rough handling and excessive use of electric prods. The very best mechanical systems will cause distress if operated by abusive, uncaring people.

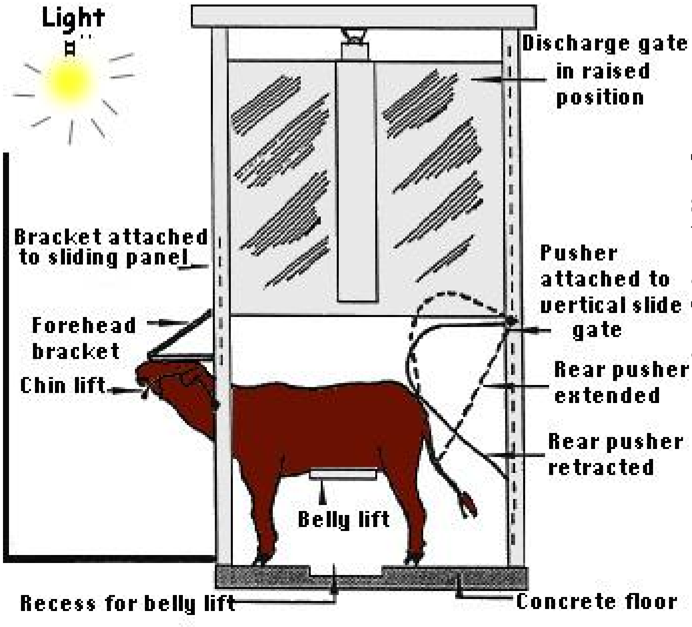
In Europe there has been much concern about the stressfulness of restraint devices used for both conventional slaughter (where the bovine is stunned) and ritual slaughter. Ewbank et al., (1992) found that cattle restrained in a poorly designed head holder, i.e., where over 30 seconds was required to drive the animal into the holder, had higher cortisol levels than cattle stunned with their heads free. Cattle will voluntarily place their heads in a well designed head restraint device that is properly operated by a trained operator (Grandin 1992). Tume and Shaw (1992) reported very low cortisol levels of only 15 ng/ml in cattle during stunning and slaughter. Their measurements were made in cattle held in a head restraint (personal communication, Shaw 1993). Cortisol levels during on-farm restraint of extensively reared cattle range from 25 to 63 ng/ml (Mitchell et al., 1988; Zavy et al., 1992).

Head stanchions used for electrical stunning of cattle in New Zealand work quite well. The first author observed these systems in two plants. Most cattle entered the stunning box voluntarily and quietly placed their heads in the stanchion. The animal was immediately stunned after its head was clamped. Immediate electrical stunning is essential in order to prevent the animal from fighting the stanchion. When this system was operated correctly the cattle were quiet and calm. The electric stun stanchion did not restrain the body. For ritual slaughter or captive bolt stunning devices to restrain the body are strongly recommended. Animals remain calmer in head restraint devices when the body is also restrained. Stunning or slaughter must occur within 10 seconds after the head is restrained.

Reactions to the throat cut

The variable of reactions to the incision must be separated from the variable of the time required for the animal to become completely insensible. Recordings of EEG or evoked potentials measure the time required for the animal to lose consciousness. They are not measures of pain. Careful observations of the animal's behavioural reactions to the cut are one of the best ways to determine if cutting the throat without prior stunning is painful. The time required for the animals to become unconscious will be discussed later.

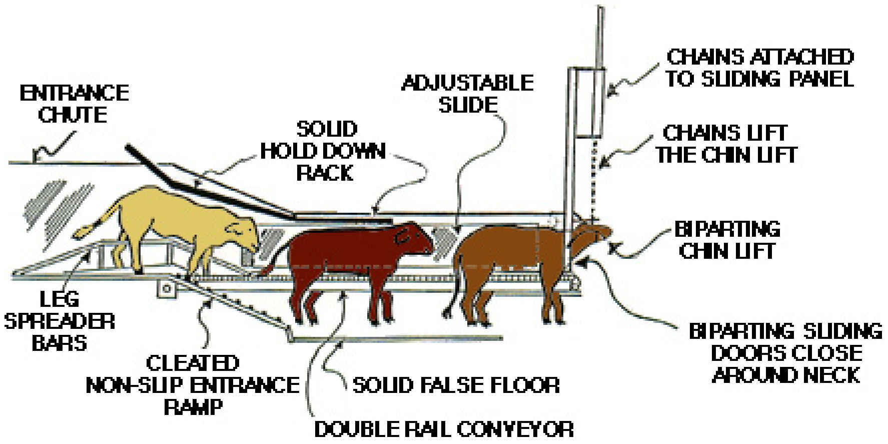
Observations of over 3000 cattle and formula-fed veal calves were made by the first author in three different U.S. kosher slaughter plants. The plants had state of the art upright restraint systems. The systems are described in detail in Grandin (1988,1991,1992,1993a). The cattle were held in either a modified ASPCA pen:



This drawing illustrates (on the left side, in front of the animal) the solid barrier that is necessary to block the animal's vision.
The sides of the ASPCA box must also be completely solid

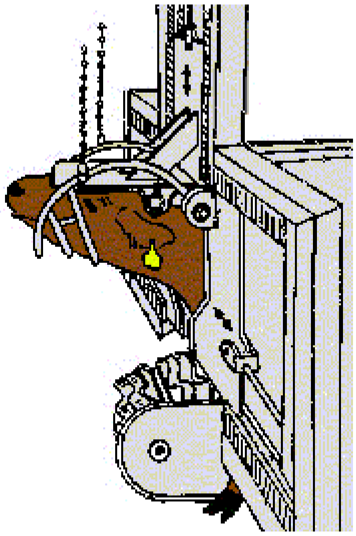
or a double rail (centre track) conveyor restrainer:

To induce the cattle to stay still and ride quietly, the solid hold down rack MUST be long enough so that the animal entering the restrainer can NOT see out until it's feet are completely off the enterance ramp.



This equipment was operated by the first author or a person under her direct supervision. Very little pressure was applied to the animals by the rear pusher gate in the ASPCA pen. Head holders were equipped with pressure limiting devices. The animals were handled gently and calmly. It is impossible to observe reactions to the incision in an agitated or excited animal. Blood on the equipment did not appear to upset the cattle. They voluntarily entered the box when the rear gate was opened. Some cattle licked the blood.

In all three restraint systems, the animals had little or no reaction to the throat cut. There was a slight flinch when the blade first touched the throat. This flinch was much less vigorous than an animal's reaction to an eartag punch. There was no further reaction as the cut proceeded. Both carotids were severed in all animals. Some animals in the modified ASPCA pen were held so loosely by the head holder and rear pusher gate that they could have easily pulled away from the knife.



These animals made no attempt to pull away. In all three slaughter plants, there was almost no visible reaction of the animal's body or legs dunng the throat cut. Body and leg movements can be easily observed in the double rail restrainer because it lacks a pusher gate and very little pressure is applied to the body. Body reactions during the throat cut were much fewer than the body reactions and squirming that occurred during testing of various chin lifts and forehead hold-down brackets. Testing of a new chin lift required deep, prolonged invasion of the animal's flight zone by a person. Penetration of the flight zone of an extensively raised animal by people will cause the animal to attempt to move away (Grandin, 1993a). The throat cut caused a much smaller reaction than penetration of the flight zone. It appears that the animal is not aware that its throat has been cut. Bager et al., (1992) reported a similar observation with calves. Further observations of 20 Holstein, Angus and Charolais bulls indicated that they did not react to the cut. The bulls were held in a comfortable head restraint with all body restraints released. They stood still during the cut and did not resist head restraint. After the cut the chin lift was lowered, the animal either immediately collapsed or it looked around like a normal alert animal. Within 5 to 60 seconds, the animals went into a hypoxic spasm and sensibility appeared to be lost. Calm animals had almost no spasms and excited cattle had very vigorous spasms. Calm cattle collapsed more quickly and appeared to have a more rapid onset of insensibility. Munk et al.,(1976) reported similar observations with respect to the onset of spasms. The spasms were similar to the hypoxic spasms which occur when cattle become unconscious in a V-shaped stanchion due to pressure on the lower neck. Observations in feedyards by the first author during handling for routine husbandry procedures indicated that pressure on the carotid arteries and surrounding areas of the neck can kill cattle within 30 seconds.

The details spelled out in Jewish law concerning the design of the knife and the cutting method appear to be important in preventing the animal from reacting to the cut. The knife must be razor sharp and free of nicks. It is shaped like a straight razor and it must be twice the width of the animal's neck. The cut must be made without hesitation or delay. It is also prohibited for the incision to close back over the knife during the cut. This is called "halagramah" (digging) (Epstein, 1948). The prohibition against digging appears to be important in reducing the animal's reaction to the cut. Ritual slaughtermen must be trained in knife sharpening. Shochets have been observed using a dull knife. They carefully obeyed the religious requirements of having a smooth, nick-free knife, but they had failed to keep it sharp. Observations of Halal cattle slaughter without stunning done by a Muslim slaughterman with a large, curved skinning knife resulted in multiple hacking cuts. Sometimes there was a vigorous reaction from the animal.

Further observations of kosher slaughter conducted in a poorly designed holder, i.e., one which allowed the incision to close back over the knife during the cut, resulted in vigorous reactions from the cattle during the cut. The animals kicked violently, twisted sideways, and shook the restraining device. Cattle which entered the poorly designed head holder in an already excited, agitated state had a more vigorous reaction to the throat cut than calm animals. These observations indicated that head holding devices must be designed so that the incision is held open during and immediately after the cut. Occasionally, a very wild, agitated animal went into a spasm which resembled an epileptic seizure immediately after the cut. This almost never occurred in calm cattle.

Time to loss of consciousness

Scientific researchers agree that sheep lose consciousness within 2 to l5 seconds after both carotid arteries are cut (Nangeroni and Kennett, 1963; Gregory and Wotton, 1984; Blackmore, 1984). However, studies with cattle and calves indicate that most animals lose consciousness rapidly, however, some animals may have a period of prolonged sensibility (Blackwore, 1984; Daly et al, 1988) that lasts for over a minute. Other studies with bovines also indicate that the time required for them to become unconscious is more variable than for sheep and goats (Munk et al., 1976; Gregory and Wotten, 1984). The differences between cattle and sheep can be explained by differences in the anatomy of their blood vessels.

Observations by the first author of both calf and cattle slaughter indicate that problems with prolonged consciousness can be corrected. When a shochet uses a rapid cutting stroke, 95% of the calves collapse almost immediately (Grandin 1987). When a slower, less decisive stroke was used, there was an increased incidence of prolonged sensibility. Approximately 30% of the calves cut with a slow knife stroke had a righting reflex and retained the ability to walk for up to 30 seconds.

Gregory (1988) provided a possible explanation for the delayed onset of unconsciousness. A slow knife stroke may be more likely to stretch the arteries and induce occlusion. Rapid loss of consciousness will occur more readily if the cut is made as close to the jaw bone as religious law will permit, and the head holder is loosened immediately after the cut. The chin lift should remain up. Excessive pressure applied to the chest by the rear pusher gate will slow bleed out. Gentle operation of the restrainer is essential. Observations indicate that calm cattle lose consciousness more rapidly and they are less likely to have contracted occluded blood vessels. Calm cattle will usually collapse within 10 to 15 seconds.

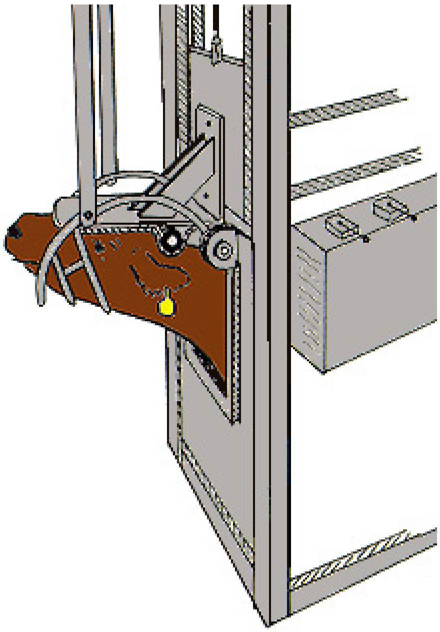
Upright restraint equipment design

Good upright restraint equipment is available for low stress, comfortable restraint of sheep, calves and cattle (Giger et al., 1977; Westervelt et al., 1976; Grandin, 1988,1991,1992,1993). To maintain a high standard of animal welfare, the equipment must be operated by a trained operator who is closely supervised by plant management. Handlers in the lairage and race areas must handle animals gently and induce each animal to calmly enter the restrainer. Unfortunately, some very poorly designed restraint systems have recently been installed in Europe. The designers had little regard for animal comfort. Below is a list of specific recommendations:

- All restraint devices should use the concept of optimal pressure.

  The device must hold the animal firmly enough to provide a "feeling of restraint" but excessive pressure that would cause discomfort should be avoided. Many people operating pens make the mistake of squeezing an animal harder if it struggles. Struggling is often a sign of excessive pressure.

- To prevent excessive bending of the neck, the bovine's forehead should be parallel to the floor. This positions the throat properly for ritual slaughter and stretches the neck skin minimizing discomfort. There is an optimal tightness for the neck skin. If it is too loose, cutting is more difficult. If it is too tight, the Jewish rule which prohibits tearing may be violated as the incision would have a tendency to tear before being cut by the knife. This also would be likely to cause pain. Some head restraints cause great distress to the cattle due to excessive bending of the neck in an attempt to obtain extreme throat skin tightness. This is not necessary for compliance with religious law. One must remember that 4000 years ago hydraulic devices which could achieve such extremes of throat tightness were not available. All head holders must be equipped with pressure limiting devices. Pressure limiting valves will automatically prevent a careless operator from applying excessive pressure. A 15 cm wide forehead bracket covered with rubber belting will distribute pressure uniformly and the animal will be less likely to resist head restraint. The forehead bracket should also be equipped with an 8 cm diameter pipe that fits behind the poll. This device makes it possible to hold the head securely with very little pressure.

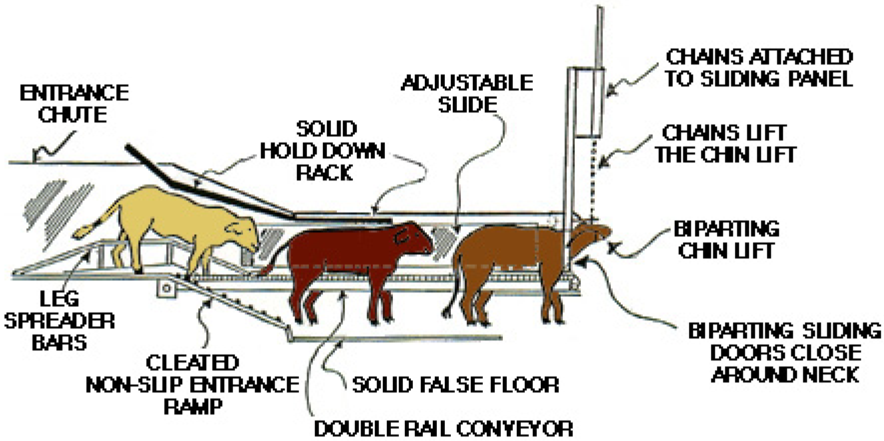


- The rear pusher gate of the ASPCA pen must be equipped with a pressure limiting device. The animal must not be pushed too far forward in the head holder. The pressure must be regulated so that the animal stands on the floor with its back level. Arching of the back is a sign of excessive pressure. A calm relaxed animal will stand quietly in the pen and will not attempt to move its head. If the animal struggles, this is due to excessive pressure or being thrown off balance by the pusher gate.
- The animal must not be lifted off the floor by the belly lift of an ASPCA pen. The list is for restraint not lifting. Lift travel should be restricted to 71 cm from the floor to the top of the lift. Other restrainers such as the double rail system are designed to give full support under the belly. The conveyor slats must be shaped to fit the contours of the animal's sternum.
- All parts of the equipment should always move with a slow steady motion. Jerky motions or sudden bumping of the animal with the apparatus excites and agitates them. Jerky motion can be eliminated by installing flow control valves. These valves automatically provide a smooth steady motion even if the operator jerks the controls. All restraint devices should use the concept of **optimal (NOT maximum)** pressure. Sufficient pressure must be applied to give the animal a feeling of being held, but excessive pressure that causes struggling must be avoided. Animals will often stop struggling when excessive pressure is slowly reduced.
- All equipment must be engineered to reduce noise. Air hissing and clanging metal noises cause visible agitation in cattle. Air exhausts must be muffled or piped outside. Plastic guides in the sliding doortracks will further reduce noise.

- A solid barrier should be installed around the animal's head to prevent it from seeing people and other distractions in it's flight zone. This is especially important for extensively reared cattle, particularly when they are not completely tame. On conveyor systems the barrier is often not required because the animals feel more secure because they are touching each other.
- Restraint equipment must be illuminated to encourage animals to enter. Lighting mistakes or air blowing back at the animals will cause cattle to balk (Grandin 1993b). Distractions that cause balking must be eliminated.

For plants which slaughter small numbers of sheep and goats a simple upright restrainer can be constructed from pipe (Giger et al., 1977). For veal calf plants a small ASPCA pen can be used. For large high speed plants a double rail restrainer can be equipped with a head holding device.

To induce the cattle to stay still and ride quietly, the solid hold down rack <u>MUST</u> be long enough so that the animal entering the restrainer can <u>NOT</u> see out until it's feet are completely off the enterance ramp.



Some rabbinical authorities prefer inverted restraint and cutting downward because they are concerned that an upward cut may violate the Jewish rule which forbids excessive pressure on the knife. There is concern that the animal may tend to push downward on the knife during an upward cut. Observations indicate that just the opposite happens. When large 800 to 950 kg bulls are held in a pneumatically powered head restraint which they can easily move, the animals pull their heads upwards away from the knife during a miscut. This would reduce pressure on the blade. When the cut is done correctly, the bulls stood still and did not move the head restraint. Equal amounts of pressure were applied by the forehead bracket and the chin lift.

Upright restraint may provide the additional advantage of improved bleed out because the animal remains calmer and more relaxed. Observations indicate that a relaxed, calm animal has improved bleedout and a rapid onset of unconsciousness. Excited animals are more likely to have a slower bleedout. The use of a comfortable upright restraint device would be advantageous from a religious standpoint because rapid bleedout and maximum loss of blood obeys the biblical principle of:

"Only be sure that thou eat not the blood: for the blood is life"
(Deuteronomy 12:23)

Rapid bleedout and a reduction in convulsions provide the added advantage of reducing petechial haemorrhages and improving safety. Convulsing animals are more likely to injure plant employees. A calm, quiet animal held in a comfortable restraint device will meet a higher animal welfare standard and will have a lower incidence of petechial haemorrhages.

Welfare aspects of slaughter

Many welfare concerns are centered on restraint. In Europe and the U.S. highly stressful restraint devices are still being used. Many of these systems apply excessive pressure or hold the animal in a position that causes distress. The recent l992 decision by the Swedish Board of Agriculture to uphold its ban on slaughter without stunning was largely driven by their concerns about forceful immobilisation and clamping of cattle (Andersson et al., 1992). Proper design and operation of restraint devices can alleviate most of these concerns with cattle and sheep.

Restraint devices will perform poorly from an animal welfare standpoint if the animals balk and refuse to enter due to distractions such as shadows, air hissing or poor illumination. These easily correctable problems will ruin the performance of the best restraint system. Abusive workers will cause suffering in a well designed system. For more information about properly operating pens, see Grandin, 1993.

Restraint devices are used for holding animals both for ritual slaughter and for conventional slaughter where animals are stunned. The use of a head restraint will improve the accuracy of captive bolt stunning. In large beef slaughter plants without head restraint captive bolt stunning has a failure rate of 3 to 5, i.e., a second shot is required.

Captive bolt and electric stunning will induce instantaneous insensibility when they are properly applied. However, improper application can result in significant stress. All stunning methods trigger a massive secretion of epinephrine (Van der Wal 1978; Warrington 1974). This outpouring of epinephrine is greater than the secretion which would be triggered by an environmental stressor or a restraint method. Since the animal is expected to be unconscious, it does not feel the stress. One can definitely conclude that improperly applied stunning methods would be much more stressful than kosher slaughter with the long straight razor sharp knife. Kilgour (1978), one of the pioneers in animal welfare research, came to a similar conclusion on stunning and slaughter .

Halal (Muslim) slaughter performed with a knife that is too short causes definite distress and struggling in cattle. We recommend to those Muslim religious authorities who require slaughter without stunning that they require that the knife must be razor sharp with a straight blade that is at least twice the width of the neck. Unless the animals are stunned, the use of curved skinning knives is not acceptable. Due to the fact that Muslim slaughtermen do not usually receive as extensive special training in slaughter techniques as Jewish Shochtim, preslaughter stunning is strongly recommended. As stated earlier, reversible head-only electrical stunning is accepted by most Muslim religious authorities. Preslaughter stunning allows plants to run at higher line speeds and maintain high standards of animal welfare.

In some ritual slaughter plants animal welfare is compromised when animals are pulled out of the restraint box before they have lost sensibility. Observations clearly indicated that disturbance of the incision or allowing the cut edges to touch caused the animal to react strongly. Dragging the cut incision of a sensible animal against the bottom of the head opening device is likely to cause pain. Animals must remain in the restraint device with the head holder and body restraint loosened until they collapse. The belly lift should remain up during bleedout to prevent bumping of the incision against the head opening when the animal collapses.

Since animals cannot communicate, it is impossible to completely rule out the possibility that a correctly made incision may cause some unpleasant sensation. However, one can definitely conclude that poor cutting methods and stressful restraint methods are not acceptable. Poor cutting technique often causes vigorous struggling. When the cut is done correctly, behavioural reactions to the cut are much less than reactions to air hissing, metal clanging noises, inversion or excessive pressure applied to the body. Discomfort during a properly done shechitah cut is probably minimal because cattle will stand still and do not resist a comfortable head restraint device. Observations in many plants indicate that slaughter without stunning requires greater management attention to the details of the procedures than stunning in order to maintain good welfare. Ritual slaughter is a procedure which can be greatly improved by the use of a total quality management (TQM) approach to continual incremental improvements in the process. In plants with existing upright restraint equipment significant improvements in animal welfare and reductions in petechial haemorrhages can be made by making the following changes:

- training of employees in gentle calm cattle handling
- modifying the restrainer per the specifications in this article
- eliminating distractions which make animals balk
- and careful attention to the exact cutting method

There needs to be continual monitoring and improvements in technique to achieve rapid onset of insensibility. A high incidence of prolonged sensibility is caused by poor cutting technique, rough handling, excessive pressure applied by the restraint device, or agitated excited animals.

The meat industry and other animal industries need to constantly strive to improve their methods and to use the best available technology. The industry must be the leader in bringing about legitimate animal welfare goals. The veterinarian, the animal scientist, and the meat scientist can often be an important and positive contributor to this process. With your knowledge of animal biology and behaviour, you should be speaking up in a positive way for the best possible processes to slaughter animals while respecting the religious needs of others. The responsibility of all those involved in animal agriculture is to assure that animals are properly handled at all times.

A full copy of this paper and list of references is available at:
http://www.grandin.com/ritual/kosher.slaugh.html

Vocalization Scoring of Restraint for Kosher Slaughter of Cattle for an Animal Welfare Audit

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The American Meat Institute standard for vocalization in restraint devices where a head holder is used is 5% of the cattle. Vocalization is a sensitive indication of animal distress, when it occurs in direct response to an aversive event such as electric prods, slipping, excessive pressure from a restraint device, missed stuns, pinching or falling.

There has been concern that kosher plants may have difficulty complying with the standard. Data that has been collected from 1996 through 2005 indicates that kosher plants can reach the vocalization standard. There has been much progress. I remember my early experiences observing shackling and hoisting of live cattle in a plant that kosher slaughtered 150 cattle per hour. The animals were forced into a box with a slanted floor that caused 100% of them to fall down. Loud bellowing was continuous and never stopped. In 1991, before formal collection of vocalization data, I was hired to tear out the cruel shackling hoist system and replace it with restraining boxes where the cattle stood upright. I designed the hydraulic and pneumatic controls on the boxes so that all parts of the restrainer moved smoothly and the operator could precisely control the amount of pressure applied to the animal. I spent hours operating the box and 70% of the cattle had no reaction at all to the head holder. No vocalization data was collected because this was before I developed vocalization scoring. However, I estimate that the vocalization score was under 5% in this Glatt kosher plant.

Data on vocalization during kosher slaughter 1996 through 2005 in U.S., Canada, and Europe

Plants are not in chronological order to conceal identity. All plants restrained the cattle in an upright position unless noted. There are no veal calves in this data. Data is based on the percentage of cattle that vocalized. It is yes/no scoring. An animal is scored as either silent or as a vocalizer. The data includes BOTH vocalizations while entering the box and vocalizations while the animal was restrained in the head holder. All plants were doing religious slaughter at the time of the audit.

Percentage of Cattle Vocalizing During Upright Restraint for Kosher Slaughter

Plant #	Audit #	Score	Notes
1	1st	5.6%	Mostly due to electric prods
	2nd	1%	
	3rd	2%	
2	1st	1%	Brand new head holder
	2nd	9%	Malfunctioning controls which were partially broken
3	1st	6%	Mostly due to electric prods

	2nd	3%	
4	1st	32%	Box too short for the animals, exerted excessive pressure
	2nd	5%	Built new pusher gate, no electric prods
5	1st	5%	0% in head holder, vocalization due to electric prods
	2nd	4%	
	3rd	3%	
6	1st	4%	Over 300 cattle scored
7	1st	7%	Mostly due to electric prods
	2nd	5%	
8	1st	7%	Sharp corners on head holders
9	1st	5%	
10 (Europe Halal Rotating Box)	1st	10% (estimate)	Occurred when the head holder was applied. Rotation did NOT cause vocalization. Problems with the head holder are correctable and this box is capable of reaching the 5% standard

In all cases where the vocalization score exceeded the 5% limit there was an easy way to correct the problem such as sharp edges, malfunctioning controls, excessive pressure, or electric prods. In plant 2 the vocalization score greatly increased because the controls were partially broken and the head holder became very difficult to operate. In the plant with the very high 32% vocalization score (plant 4), a new pusher gate reduced the vocalization score to 5%.

Careful operation of a kosher restraint box will greatly reduce damaging blood spotting in the meat. In 1991 I developed a kosher box which exerted less pressure and blood splashing was greatly reduced. When a skilled employee ran the box the percentage of blood splashed cattle ranged from 3.5% to 5%. The cattle were kept calm, and the pusher gate was released immediately after the cut. More recent observations indicate that the best way to reduce blood splash and facilitate bleed-out is to completely release both the head holder and the rear pusher gate immediately after the cut.

Box operation steps to reduce blood splash:

1. Calm cattle
2. No electric prods
3. Be very gentle with the butt pusher gate
4. Minimize time with head held tight in the head holder
5. After the cut IMMEDIATELY release both the butt pusher and the head holder. Remove all pressure from the animal's body and head.

Recommendations to facilitate onset of rapid insensibility after Kosher or Halal religious slaughter (Updated August 2011)

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Fixing many little details of upright restraint box design, operation, and cutting technique makes it possible for 95% of the cattle to rapidly collapse and quickly lose sensibility. You manage the things that you measure. The following variables should be measured weekly in plants conducting religious slaughter to maintain an adequate level of animal welfare.

1. Percentage of cattle or calves vocalizing
2. Percentage of animals slipping on the floor while held in the restraint box
3. Percentage of animals falling
4. Percentage moved with no electric prod
5. Percentage that collapse within 15 seconds
6. Percentage insensible on the bleed rail

Each variable is scored on a per animal yes/no basis. Continuous measurement makes it possible to have continuous improvement of the procedures. Two beef plants that use an upright restraint box that the cattle stand in, are achieving a rapid collapse rate of 95% to 96%. Previous observations I have made of veal calves showed that with the best shochet 95% of the calves collapsed within 10 seconds. They used a swift fast cutting stroke.

The following recommendations will enable other plants to achieve this superior performance. These recommendations are based on the changes that worked in these plants.

1. Keep cattle calm and remove distractions so that cattle will voluntarily enter the restraint box. See other parts of www.grandin.com for recommendations.
2. Eliminate electric prods or use them on 5% or less of the cattle.
3. Maintain a vocalization score of 5% or less of the cattle vocalizing during entry into the restraint box and in the restraint box.
4. Non-slip flooring is essential. Even slight slipping will cause the cattle to become agitated.
5. Be very careful with the butt pusher gate and apply only enough pressure to move the animal forward.
6. Minimize the time the animal is held tightly by the head holder. Perform shehita within 10 seconds after the head is restrained.
7. The neck opening in the front of the box must not constrict the blood vessels in the neck. Pushing the animal up against the front of the box too hard with the butt pusher may constrict blood vessels.
8. The belly lift must NOT lift the animal up. The principle is to apply as little pressure as possible to the animal's body. Calm animals standing on a non-slip floor require very little pressure to hold them.
9. A rapid fast cutting stroke is usually more effective than a very slow knife stroke to induce rapid collapses. The faster stroke may help prevent the blood vessels from re-

scaling. To facilitate bleed out, the animal should be cut close to the jawbone to help prevent sealing off of the blood vessels.

10. Rapid release of the head holder and butt pusher after the cut is essential. All pressure should be removed from the animal's head and body immediately after the cut to allow the animal to relax. The butt pusher should be **completely** retracted and the chin lift and sliding neck plates should be **completely** opened. The animal should stand in the box with all the restraints removed until it collapses. This rapid release of pressure makes a big difference.
11. Eliminate air hissing noise with mufflers and reduce metal clanging and banging.
12. All parts of the box should move with smooth steady motion and be equipped with pressure limiting devices to prevent excessive pressure from being applied.
13. Avoid the use of solenoid activated valves. Smoother motion is achievable with simple hand operated valves that have good throttling ability. The best valves work like a car accelerator, the more the operator pushes it the faster the equipment moves.
14. Keep score on collapse rate. The rabbis and the plant employees will be able to continuously improve if they keep score on the six previously listed variables.

It is amazing how fixing several little things can make such a huge difference. At a third plant I consulted with they had failed an audit due to a high 10% vocalization score. I visited the plant for two days and the vocalization score during kosher slaughter dropped to 1.5% after we fixed the items listed below:

1. Steel rods were welded to the floor of the kosher box to prevent slipping. Careful observations were made to make sure that the rods prevented the animal from making repeated rapid small slips that caused agitation.
2. Welded a fence in the leadup chute to prevent rattling and clanking that caused cattle to become agitated.
3. Redesigned the forehead bracket to reduce bending of the neck and installed a pad on it.
4. Modified the butt pusher gate to prevent the animal's tail from getting caught against a sharp edge.
5. To prevent jerky motion of the butt pusher gate, solenoid operated values were replaced with a standard hydraulic valve so that the box operator could control the pusher gate with greater precision. The new valves worked like a car accelerator pedal.

Percentage of cattle vocalizing in kosher plants with either an upright or rotating restraint box during 2006

	Percentage at First Audit	**Percentage at Second Audit**
Plant 1	2%	n/a
Plant 2	3.8%	n/a
Plant 3	5.7% - Excessive butt pusher pressure	3.2%
Plant 4	10%	1.5% - After the equipment modifications listed above

All 4 plants confirmed to the AMI guidelines of a maximum of 5% of the cattle vocalizing after the 2nd audit.

Signs of loss of sensibility after religious slaughter:

1. Loss of posture, falls, and can no longer stand.
2. The eyes roll back into the head when loss of sensibility first starts.
3. No natural blinking like a live animal in the stockyards.
4. No eye tracking of movement.
5. No rhythmic breathing.
6. No righting reflex (lifting of the head) when hung on the rail.
7. Before skinning or any other dressing procedure is started ALL signs of return to sensibility must be absent. The eye must relax back into a glossy blank stare and there must be no corneal reflex in response to touching the eye and the animal must have a fixed fully dilated pupil.
8. Ignore kicking and leg movements. These are reflexes. Look at the head.

The Relationship Between Good Handling / Stunning and Meat Quality in Beef, Pork, and Lamb

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INTRODUCTION

Meat consumers are increasingly demanding that animals be reared, handled, transported and slaughtered using humane practices (Appleby and Hughes, 1997). Manteca (1998) says concern for animal welfare is a major consideration in meat production and is based upon the belief that animals can suffer. Cortesi (1994) characterized need for humane treatment of animals in slaughterhouses as follows: (a) Man has the moral obligation to respect all animals and also to safeguard animals, which are destined for slaughter, from unnecessary suffering. (b) Each country should establish regulations to secure humane conditions of slaughter for each animal species. (c) Unloading, lairaging, moving, stunning and bleeding of animals are important for animal welfare; training and sensitivity of personnel are also essential. (d) Ethological principles should be applied to the handling of animals and the design of slaughterhouse facilities. (e) Efforts should be made to improve existing slaughter methods and/or develop new systems that ensure animal welfare, meat quality and work safety, while reducing costs and human labor, if possible. (f) Animal welfare will probably be maximized if economical, ethical and qualitative considerations coincide. Schafer et al. (1997) reported that there is growing public concern regarding the welfare of animals during transportation and handling which necessitates reduction in such stresses.

Most of those in the production, marketing, transportation and packing sectors of the U.S. meat-animal industry practice good husbandry, have a caring attitude about animals and their welfare, and handle animals appropriately, while a tiny fraction of people do not (Smith and Grandin, (1999a). It is to those few who either do not know, or do not care, that inappropriate/improper handling can cause problems and that proper handling can improve products and profitability, that this paper is directed. Warriss (1992) said “Getting animals from farm to abattoir forms the first link in the chain of meat production and one which is both important and, to some degree, contentious; important because it can influence carcass and lean meat quality, and contentious because the processes of handling and transport provide many opportunities for the animal's welfare to be compromised." If animal handling is exemplary, little or nothing will be gained by attempting to improve it; but, if, in any sector, there is room for improvement in animal handling, attempts to rectify situations that compromise products/profitability will be well worth the effort. Seventeen years ago, Grandin (1981 b) found that quiet, gentle handling of feedlot cattle cut bruises in half at the packing plant.

THE EXTENT OF PRODUCTION/MANAGEMENT PROBLEMS WITH BEEF AND PORK

Lambert (1991) identified $11.999 billion of losses, and determined that such losses -- costs of beef industry inefficiencies -- amounted to nearly $458 per head for each slaughter steer/heifer produced in the U.S. Of the $11.999 billion of losses, $5.037 billion was due to factors that are associated with production/management mistakes or errors (Lambert, 1991). The 1991 National Beef Quality Audit (Smith et at., 1992) concluded that -- To Increase The Consistency And Competitiveness Of Fed Beef -- those in the industry need to (a) Attack Waste, (b) Enhance Taste, (c) Improve Management, and (d) Control Weight. Potential revenue gains, if all steers/heifers had no defects due to Improper Management (no hide defects, no carcass/ liver/tongue condemnations, no injection-site lesions, no bruises, no dark-cutters and no grubs/ blood-splash/calluses/yellow-fat) would be $27.26 for each slaughter steer/heifer produced in the U.S. (Smith et al., 1992). Grandin (1981 b) found that producers who sold cattle as carcasses ("In the beef") had cattle with half as many bruises as did producers who sold cattle on the basis of liveweight; feedlot operators who sell cattle on a liveweight basis have less economic incentive to reduce the incidence of bruises. The 1994 National Non-Fed Beef Quality Audit (Smith et al., 1994) determined that industry should: (1) Manage Non-Fed Cattle To Minimize Defects And Quality Deficiencies. (2) Monitor The Health And Condition Of Non-Fed Cattle. (3) Market Non-Fed Cattle In A Timely Manner. Potential revenue gains, if all non-fed cattle had no defects due to Improper Management (no hide damage, no cattle/carcass/offal condemnations, no bruises, no need to specially handle disabled cattle, no injection-site lesions, no dark-cutters and no yellow fat), would be $38.43 for each cull cow/bull produced in the U.S. (Smith et al., 1994).

The 2000 National Beef Quality Audit (Smith et al., 2001) established "Goals, By 2005" for improving the quality and value of fed beef. These goals are: (1) Eliminate USDA Standards. (2) Eliminate Yield Grades 4 and 5 carcasses. (3) Eliminate injection-site lesions from all whole-muscle cuts. (4) Eliminate side branding. (5) Reduce horns to less than 5% in fed cattle. (6) Develop and implement a standardized, electronic, individual animal identification system. (7) Develop an information system that allows producers to benchmark their own herd. (8) Assure seedstock animals are accompanied by meaningful genetic data (EPDs, etc.). (9) Assure that 100% of cattlemen complete BQA training. (10) Eliminate major and critical bruises. (11) Improve the transportation (handling and equipment) of cattle. (12) Continually improve the eating quality of beef. Potential revenue gains, if all steers/heifers had no defects due to Improper Management (no hide defects, no cattle/carcass/offal condemnations, no injection-site lesions, no bruises, no dark-cutters and no grubs/blood- splash/calluses/yellow fat), would be $18.23 (compared to $40.14 in 1995) for each slaughter steer/heifer produced in the U.S (Smith et al., 2001). The 1995 International Beef Quality Audit (Morgan et al., 1995) identified the following principle reasons that foreign importers of beef purchase product from the U.S.: (1) Ability Of The U.S. To Supply Individual Beef Cuts And Offal Items. (2) Tenderness And Flavor Of U.S. Beef Is Exemplary. (3) High Perception Of Value Of U.S Beef. (4) High Overall Product Quality. (5 tie) Image Of The U.S And Its Beef Quality Grading System. (5 tie) Confidence In The Safety Of U.S Beef. Smith (1995) identified, as the primary inconsistencies in the quality of U.S. beef, (a) Insufficient Palatability, (b) Inadequate Marbling, (c) Problems With Color, Water-Loss And Shelflife Of Beef Muscle, and (d) Production/Management Errors Causing Blemishes, Bruises, Defects, Diseases And Condemnations. Smith and Morgan (1995) said that the research needed most to resolve the inconsistencies in beef quality must involve genetic studies and further investigations of the supplemental feeding of Vitamin E to feedlot cattle. National Cattlemen's Beef Association (1998) in its long range plan, identifies as a desired Outcome of the Food Safety, Quality and Consistency Leverage Point, "Reduce carcass defects 50% by the year 2001 ". Using the 1995 National Beef Quality Audit (Smith et al., 1995) as the baseline, the U.S. beef industry reduced defects and recaptured 15.43% ($20.96) of the value lost in 1995 due to production related defects (Smith et al., 2001)

The 1993 National Pork Chain Quality Audit (Morgan et al., 1993) identified, among the greatest pork-quality concerns of packers, three items related to production/management: (2) Elevated Incidence Of Color/Texture Problems Associated With Pale, Soft And/Or Watery Pork, (4) Too High Incidence Of Injection-Site Blemishes And Broken Hypodermic Needles In Carcasses And Cuts, and (6) Excessive Amounts Of Trimming Required On Carcasses. Slaughter-floor audits revealed (Morgan et al., 1993) that 0.2% of all market hogs sent to slaughter were condemned (with 36% of the 0.2% due to dead-on-arrivals or dead-in-pens) and that at least superficial bruising (but usually worse) occurred on 1.9%, 0.4% and 0.9% of hams, loins and shoulders, respectively, of market hogs. Fabrication audits revealed that 9.1 % of all hams and loins had lean that was pale, soft and watery while 2.5% of all hams and loins had lean that was dark, firm and dry (Morgan et al., 1993).

The 1994 International Pork Quality Audit (Morgan et al., 1994) revealed that the top five reasons that foreign importers of pork purchase product from the U.S. were: (1) Confidence In Product Safety. (2) Competitive Prices. (3) Excellent Palatability (Especially, Excellent Tenderness). (4) High Perception/Image Of The United States Of America. (5) Availability Of Individual Pork Cuts. The top five areas in which U.S. pork, for export, needs to be improved (Morgan et al., 1994) were: (1) Variation In Lean Quality Characteristics. (2) Lack Of Customer Service. (3 tie) Abscesses/Bruises/Foreign Materials Occur In Pork, Too Often. (3 tie) Excessive Seam Fat. (5) Cut-Sizes That Are Too Large. Smith (1995) identified, as the primary inconsistencies in the quality of U.S. pork, (a) Insufficient Palatability, (b) Inadequate Color/Firmness/Water-Holding-Capacity Of Muscle, and (c) Production/Management Errors Causing Blemishes, Abscesses, Bruises And Presence Of Foreign Materials In Pork. Smith and Morgan (1995) said the research needed most to resolve the inconsistencies in pork quality must involve genetic studies.

CAN PROGRESS BE MADE IN SOLVING PRODUCTION/MANAGEMENT PROBLEMS-
There is evidence that progress can be made in solving production/management problems with beef. The 1993 Strategic Alliance Field Study (Eilers et al., 1993) demonstrated that $8.66 for each slaughter steer/heifer involved in that study could be saved (in comparison to the losses identified in the 1991 National Beef Quality Audit) by improving management. Eilers et al. (1993) determined that it pays for those in the various sectors within the beef industry to communicate with each other and to focus their efforts on the quality of the final product rather than upon the economics of intermediary steps/stages. In the Strategic Alliance Field Study (Eilers et al., 1993) the Alliance cattle had less economic loss from carcass/liver/tongue condemnations (saving $1.78 per animal), from injection-site lesions (saving $1.74 per animal), from bruises (saving $0.15 per animal), from dark-cutters (saving $4.73 per animal) and from grubs/blood-splash/calluses/yellow-fat (saving $0.26 per animal), for a total savings (compared to costs from the 1991 National Beef Quality Audit) of $8.66 per steer/heifer. Moreover, results of the 1995 National Beef Quality Audit determined that 30% of purveyors, 40% of retailers and 33% of packers surveyed said there were fewer injection-site lesions in beef than there had been in 1991 (Smith et al., 1995). Boleman et al. (1998) contrasted results of the 1991 National Beef Quality Audit (analyzed scientifically by Lorenzen et al., 1993) with those of the 1995 National Beef Quality Audit (analyzed scientifically by Boleman et al., 1998) and concluded that: (a) Management problems can be solved at a faster rate than can genetic problems, but that

more cultural barriers exist for instituting different management practices. For example, it is difficult to persuade producers to change the locations and sizes of hot-iron brands. (b) The beef industry has progressed in some areas (e.g., excess fat has decreased) but has failed to make progress in other areas (e.g., marbling has decreased and the incidence of brands and bruises has increased) since the time of the 1991 National Beef Quality Audit. (c) The beef industry should strive to make progress in all areas of concern if product improvements and total cost reductions are to be achieved.

ARE THERE REWARDS FOR USING APPROPRIATE ANIMAL HANDLING-

Warriss (1992) says "During the time between leaving the farm and slaughter, animals are subjected to removal from their home environment, loading and unloading from vehicles, transport, and holding in unfamiliar surroundings. They may be exposed to stressors such as noise, strange odors, deprivation of food and water, vibration and changes of velocity, extremes of temperature, breakdown of social groupings, close confinement and often overcrowding. These stressors often elicit behavioral and physiological responses, some of which can, if extreme, contribute to a reduction in carcass and meat quality. Herein lies the link between welfare and quality."

Vansickle (1990) reported results of a 1989 survey of 12 beef, calf and sheep packing plants in seven states by Temple Grandin as follows: (a) Compared to results of surveys conducted in 1972-1974 and in 1986-1988, handling has gotten better because people understand that rough, abusive handling costs money in bruises, sickness and lowered meat quality. (b) Packing plants have good handling when top management personnel insist on it. (c) Successful handling hinges on employee behavior and that has improved in the large packing plants because management personnel are emphasizing and enforcing good handling. (d) Handling ratings for employees in the 12 plants were "excellent" in 5 plants and "acceptable" in 7 plants while no plants had "not acceptable" or "cruelty" ratings. (e) Handling ratings for equipment in the 12 plants were "excellent" in 6 plants, "acceptable" in 4 plants and "not acceptable" in 2 plants while no plant received a "cruelty" rating. (f) The primary reasons the 2 plants were considered "not acceptable" for the equipment rating were broken chutes, slick floors, or of such poor design that quiet, humane handling was impossible.

Appropriate handling of cattle and swine, as contrasted with improper or inappropriate handling, can result in improved productivity of live animals; in higher quality of slaughter livestock, carcasses and cuts; and in greater profitability in the production and packing sectors (Smith and Grandin, 1999b). Improved productivity accompanying more appropriate handling could occur in the form of higher daily gains, improved feed efficiency and greater margins of profit in the livestock production sector. Grandin (1998a) has demonstrated that reducing handling stress improves both productivity and welfare of farm animals. Voisinet et al. (1997b), for example, has determined that feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments; from those results, it can be extrapolated that keeping cattle calm -- through careful handling -- would likewise improve rate of gain in the feedlot as contrasted with handling cattle in ways that cause them to be frightened or to act aggressively. Feedlot managers have found that reducing electric prod usage in feedlots and increasing quiet handling helps cattle to go back on feed more quickly and reduces death loss due to respiratory sickness (Grandin, 1998d). A recent article by Messenger (1998) describes the importance of handling sows with care because gentle handling can improve a sow's attitude and productivity; from such findings, it can be extrapolated that keeping market hogs calm would likewise improve productivity during the finishing phase as contrasted with handling hogs in ways that cause them to react negatively to such treatment. Messenger (1998) quotes Julie Morrow-Tesch (an animal behaviorist with USDA) as saying "The difference between the best and worst pork operations is the people" and quotes Temple Grandin as saying "Breeding stock reach maximum performance if they are relaxed with their handlers."

Improvements in quality of livestock, carcasses and cuts accompanying more appropriate handling could occur in the form of fewer bruises, improved tenderness, lower incidence of darkcutting beef, and lessened occurrence of pale, soft and exudative as well as dark, firm and dry pork. A conclusion of the 1991 National Beef Quality Audit was that four sectors of the beef industry-producers, feeders, truckers and packers-can work together to eliminate bruises: (a) Producers and feeders can remove horns. (b) Truckers can take care in loading and unloading cattle. (c) Packers can use careful handling practices up to the moment of slaughter (Smith et al., 1992). Excessively long stun-to-stick intervals can cause blood-splash in both cattle and swine. Callused muscles in beef carcasses can result from severe physical trauma and, perhaps, from improper use of pour-on medications (Smith et al., 1992) so care should be exercised to minimize such occurrences in meat animals. Voisinet et al. (1997a) demonstrated that Bos indicus-cross feedlot cattle with excitable temperaments have tougher meat and a higher incidence of borderline dark cutters. Quiet, calm handling of slaughter hogs can reduce the incidence of carcasses with pale, soft and exudative muscle by 10% to 12% based on field studies conducted at two packing plants (Grandin, 1998d).

Appropriate handling of cattle and swine can improve profitability of operations in the production sector (through enhanced performance and higher valuations in merit-pricing systems) and in the packing/processing sector (through higher quality carcasses, fewer condemnations and lessened trim losses). Cattle and swine feeders can realize greater profits if animals, because they are calm and undisturbed, gain more rapidly and efficiently. And, for those cattle and swine feeders who sell animals based on carcass merit-pricing systems, generating carcasses with fewer discounts (due to condemnations; bruise losses; dark-cutting beef; pale, soft and exudative pork; dark, firm and dry pork) and of higher quality. For those in the packing/processing sector, benefits of proper handling of cattle and swine are accumulative-such that prevention of quality/condemnation/trim losses at the production sector, during marketing (e.g., at auction yards and at buying stations), during transport, and during holding, assembling, driving and stunning at the packing plant are additive, and accrue majorally in the packing/processing sector.

Wood et al. (1998) reported that extreme paleness or darkness is sometimes found in pork and beef, due to a combination of environmental and genetic factors; animals which experience stress over a lengthy period (>10 hours), usually because of mixing with unfamiliar animals or poor handling, deplete muscle glycogen stores and can develop high pH meat which is dark, firm and dry (DFD) and has poor keeping quality. Alternatively, in pigs, if the stress is experienced immediately before slaughter, muscle pH falls rapidly as anaerobic metabolism occurs and pale, soft and exudative (PSE) muscle results. Both of these conditions (DFD and PSE) can be avoided on many farms by the application of good management (Wood et al., 1998).

Proper handling of meat animals can improve productivity, quality and profitability; so, it's just good business to do it right. Appropriate handling weakens arguments by animal rightists/welfarists that those in the production and packing sectors do not have a caring attitude about the animals in their charge. Grandin (1998e) concluded that slaughtering, today, is handled more humanely than it was 20 years ago; in 1978, the Humane Slaughter

Act of 1958 was expanded to cover all U.S. plants and now (in 1998), USDA is stepping up enforcement of the Act.

Grandin and Smith (2000) said the most important factor determining whether a packing plant has good or bad animal welfare practices is the attitude of management personnel; the best facilities and the latest technology make handling cattle easier but they don't make the manager better. Until the owner or manager is convinced that proper handling practices pay off economically, it is unlikely that employees will follow procedures day-in and day-out. The manager that is most effective in maintaining high humane standards is involved enough in day-to-day operations to know and care, but not so involved that he or she becomes numb and desensitized (Grandin and Smith, 2000).

FACTORS ASSOCIATED WITH SHEEP MEAT QUALITY

Sanudo et al. (1998) conducted an extensive review of the scientific literature and concluded that the factors affecting sheep meat quality were animal (intrinsic factors), cut or muscle, handling in life (handling, environment, diet), multicausal factors, preslaughter conditions, slaughtering conditions, postslaughter conditions and marketing and consumption. Included by Sanudo et al. (1998) as factors under preslaughter conditions were type and condition of transport, fasting and conditions of the pens in the abattoir; Included as factors under slaughtering conditions were stunning method, type of slaughter, conditions (bleeding, offal removal, etc.) for preparing the carcass and hygiene.

PROBLEMS ASSOCIATED WITH IMPROPER HANDLING OF SWINE

Russo et al. (1998) studying pork quality in pigs in Italy reported that: (a) The handling of pigs before slaughter has been recognized as an important factor influencing meat and carcass quality. (b) Poor handling during the different steps in the preslaughter period -- i.e., loading transport, unloading and lairage -- may lead to impaired meat quality and carcass damage with serious economic implications for the processor. (c) In mixed pigs transported for less than 2 hours, prolonging lairage to 3 or 4 hours could be positive for the quality of meat because it reduces the incidence of PSE pork without seriously increasing carcass damage. (d) When transport exceeds 2 hours, the practice of prolonging lairage for 3 or 4 hours should be avoided as its beneficial effect on meat quality could be counterbalanced by an excessive incidence of skin blemish. (e) If pigs are unmixed, the reduction of resting time from overnight, to 3 hours, can slightly reduce the carcass damage but increase the risk of more hams being rejected for pale meat.

Schultz-Kaster (1998) identified the four most important problems associated with improper handling of market hogs as: (1) Dead pigs. (2) Bruising and blood-splashing. (3) Broken bones. (4) Pale/soft/exudative pork and pork muscle with low water-holding capacity. Dead pigs are those DOA (dead on arrival) and those DIP (dead in pens); it is not known how or why such deaths occur but swine of genotypes that are susceptible to stress (e.g., those pigs susceptible to Porcine Stress Syndrome) when subjected to excessively high ambient temperatures and to rough handling are undoubtedly the source of many fatalities. Bruising of swine is caused by animals contacting sharp-edged objects on their own-but exacerbated by rough handling or excitement-or by people striking or kicking animals in efforts to direct or hasten pig movement. Blood-splashing (rupture of capillaries in muscle; occurrence of blood spots in the meat) can be caused by excessively long stun-to-stick intervals or by improper stunning (especially electrical stunning) but can be exacerbated by the hogs being of genotypes that are susceptible to stress and if that is combined with inappropriate animal handling. Broken bones (largely the backbone, femur and rib) largely result from improper handling but such occurrence is exacerbated by lack of sufficient calcium and phosphorus in the finishing diet of pigs (Schultz Kaster, 1998).

Anderson et al. (1998) reported that present problems with excessive drip loss and light color in pork are a consequence of relatively low ultimate pH in the meat; low ultimate pH depends on the initial glycogen level in the muscle at the time of slaughter and the level of stress induced on the animals during transportation and preslaughter procedures. By decreasing the digestible starch content, in a strategic feeding procedure, these researchers were able to reduce muscle glycogen in pigs at the time of slaughter and thereby to produce darker colored meat (superior to that in control pigs) and a tendency toward higher muscle pH (Anderson et al., 1998). Stalder et al. (1998) compared effects of rest (for 16 hours after shipment and prior to slaughter) vs. no rest (slaughter immediately following shipment) and of mixing (with unfamiliar pigs during transport and lairage) vs. not mixing (transported and held with animals with which they were familiar) on muscle quality of carcasses from pigs that were Porcine Stress Syndrome (PSS) normal (genotype NN), PSS susceptible (genotype nn) or PSS heterozygous (genotype Nn). Resting of PSS heterozygous pigs, increased carcass pH values, decreased Minolta-Y and Hunter-L values of loin muscles and lowered muscle glycogen levels; even though 16 hours of rest before slaughter improved the color and water-holding capacity of muscles from PSS heterozygous pigs, effects were small and were much less than those that were due to the PSS gene. Mixing had no effects on muscle pH or color characteristics of loin muscles but did result in higher chewiness scores of cooked loin chops from PSS heterozygous pigs (Stalder et al., 1998).

Tarrant (1998) has concluded that: (a) Greatly improved systems that are compatible with industry needs are required for preslaughter animal handling; such systems should include suitable equipment and the training and supervision of animal handlers at the farm and abattoir. (b) PSE cannot be eliminated by use of the PCR-based halothane gene test, as the halothane gene probably accounts for only 25 to 35% of the PSE meat observed in commercial abattoirs. (c) The most important factors affecting PSE and DFD incidences occur after the animal has left the farm.

The five major causes of pale, soft and exudative condition and low water-holding capacity in pork muscle have been identified by Schultz Kaster (1998), Grandin (1995) and Schwartz (1998) as (1) Genotype of pigs (especially those which carry the Halothane or RN genes and thus are more susceptible to stress). (2) Chilling carcasses too slowly. (3) Improper handling and stunning (especially when using carbon-dioxide immobilization). (4) Inadequate resting time prior to slaughter. Market hogs must be given adequate resting time (I hour must be the absolute minimum) after hauling and prior to slaughter. (5) Excessive "rail-out" time on the slaughtering/dressing floor. Both Schultz Kaster (1998) and Schwartz (1998) agree that, for pigs of genotypes that are susceptible to stress, handling must be exemplary or the incidence of pale, soft and exudative pork will be unacceptably high. Barton Gade (1998) studied quality of meat from Danish pigs and concluded that chilling at -16'C was preferred over chilling at -12'C because there was less PSE meat and eating quality was not compromised. Overnight lairage had a number of advantages compared to slaughter on the day of arrival including slightly higher muscle pH values and less PSE pork.

Inasmuch as there is no way for packing-plant employees to know which market hogs are or are not highly susceptible to stress, extreme care must be taken to handle all pigs carefully as though each was a "ticking time bomb." Careful (proper, appropriate) handling of market hogs requires consideration of adequate resting time; of careful (quiet and calm) assembling and driving; of proper stunning; of expedited slaughtering/dressing, and; of rapid chilling, if incidence of pork muscle with pale/soft/exudative condition and low water-holding-capacity is to be minimized. Messenger (1998) quotes Temple Grandin as saying "It's up to management to train employees right; there are a lot of training videos available but just showing the video is not enough. You have to teach workers and illustrate that you're serious about good handling."

Danish researchers (Barton Gade and Christensen, 1999) compared carcass and meat quality characteristics of pigs placed, before harvesting, in pens of two sizes. There was less skin damage, fewer carcasses with DFD muscle and slightly less blood-splash in carcass muscles when 15 rather than 45 pigs were held in a pen. Incidence of P.S.E. muscle was equivocal with higher percentages of PSE in biceps femoris in pigs held in smaller pens and higher percentages of PSE in longissimus dorsi in pigs held in larger pens. Further Danish research conducted by van der Wal et al (2000) compared the effects of gender (boars vs. gilts) and preslaughter stress on meat quality. Conclusions from this study indicate that boars were two times more likely to exhibit aggressive behavior and more "commotion" than gilts and meat quality (drip-loss and color) was negatively effected when pigs were negatively forced through the handling system compared to pigs moved calmly through the handling system and stunned immediately.

At the most recent International Congress Of Meat Science And Technology (Barcelona, Spain; August 30-September 5, 1998) there were 20 scientific presentation on Animal Handling And Welfare; nine studies involved "Preslaughter Effects On Welfare And Meat Quality; Interactions Between Preslaughter And Processing Effects," four investigations considered "Free Range (Outdoors) Versus Intensive (Indoors) Rearing Effects On Meat Quality" and seven papers compared "Electricity Versus Carbon Dioxide Atmosphere As Stunning Methods." Animal rights and animal welfare are of much greater concern among residents of countries in the European Union than among people who live in other parts of the world; so, scientists in EU countries are focusing heavily on properties of meat for which effects of improving handling, rearing, and/or well-being are documentable. Conclusions from those 20 scientific presentations, in the composite, were described by Wood (1998) as follows: (1) Differences, both quantitative and qualitative, in the qualities/properties of meat from animals reared under free-range vs. intensive circumstances are "only in the minds of people and have not, as yet, been documented." (2) Effects of differences in preslaughter handling on welfare of animals are temporal; on meat quality are well-documented and easy to demonstrate scientifically, and; on meat-processing attributes are real and verifiable (e.g., differences in yields of PSE, DFD and normal pork cuts, when they are pumped or marinated, are very large). (3) Animal welfarists prefer electrical stunning (because it is sudden) rather than captive-bolt stunning (because it falls too often) or carbon-dioxide immobilization (because animals struggle excessively) while research has demonstrated disadvantages in pork quality from electrically stunning pigs (because it increases the rate of muscle pH decline-sometimes excessively).

Meisinger (1999) identified nine Quality Control Points that are integral parts of "A System For Assuring Pork Quality"; those are: (1) Quality Control Point 2 - Genetic Inputs, (2) Quality Control Point 2 - Nutritional Inputs, (3) Quality Control Point 3 - On-Farm Hog Handling, (4) Quality Control Point 4 - Transporting_Hogs, (5) Quality Control Point 5 - PreSlaughter Handling, (6) Quality Control Point 6 - Stun & Early Postmortem, (7) Quality

Control Point 7 - Evisceration, (8) Quality Control Point 8 - Carcass Chilling, and (9) Quality Control Point 9 - Fabrication. Meisinger (1999) further stated that the producer and the packer each contribute about half to potential quality deterioration in fresh pork; whatever is done to pigs, carcasses or pork products can either sustain the inherent genetic quality or degrade it. There is nothing except enhancement (injection of phosphate in water) or further processing that can improve pork quality.

National Pork Producers Council (1999) has developed a "Producer Pork Quality Checklist" which includes the following items related to handling traits and pork quality characteristics: (a) I require that all my breeding stock purchases be certified stress-gene free; I also certify that I do not or will not knowingly market hogs with the halothane (stress or RYR 1) gene. (b) I have considered the advantages and economics of adding vitamins E and D, carnitine, macin and magnesium for their meat quality benefits and have made a decision on that basis. (c) Even though restricting amino acids in late finishing results in dramatic increases in intramuscular fat, I do not practice it due to other negative quality consequences. (d) I do my best to make sure that all my market hogs are without feed for a period of 12 to 18 hours before stick at the plant. (e) I have eliminated (or at least significantly curtailed) the use of electric prods in my operation and I have made my pigs accustomed to human activity during the finishing period. (f) My facilities provide the least resistance and stress for pigs during handling and loading. (g) My trucker has watched the NPPC videotape on "Handling for Transporters." (h) I only hire haulers who have flat-floor trailers or, I am transitioning all my own trailers to flat-floor trailers to enhance pork quality and to reduce the DOAs. (i) I haul no more than 183 head in my 48' by 102' standard flat-floor trailer. j) I give special consideration to market hogs during weather extremes. (k) I ensure my packer is concerned about factors affecting pork quality, has taken the necessary steps to improve the quality of the end-product, and has read the "System For Assuring Pork Quality" booklet or the "Critical Points Affecting Pork Quality In Packing Plants" fact sheet.

EFFECTS OF STUNNING PROCEDURE/PROTOCOL ON PORK QUALITY

Schoberlein et al. (1979) compared use of electrical insensitization (75 volts, 15 seconds) alone or following intensive electrical stimulation and irritation of various parts of the animal's body and found that minor deviation from proper practice of electrical insensitization caused no significant deterioration in cutlet muscle and ham muscle quality but that intensive irritation immediately before insensitization caused higher percentages of PSE (16.7%) and DFD (16.7%).

Preslaughter stunning of pigs is accomplished most commonly by use of electricity or carbon dioxide; electrical stunning is followed by an acute fall of the muscle pH due to the powerful activation of glycolysis in the muscles (Henckel et al., 1998). The improvement in quality-reduction in both blood splashing and PSE meat incidences-more than outweigh the added financial costs of using C02 anesthetization which is the reason why Denmark uses C02 stunning for pig slaughter (Barton Gade, 1992).

Henckel et al. (1998) compared stunning of pigs with electricity (10 seconds; 250 volts; 1.3 amps; tong with one prong placed behind one ear and the other at the opposite eye) VS. C02 (3 minutes in bottom position; dip-lift installation; CO-, concentration of 90%) and reported that for pigs with similar genetic background (free from the Halothane gene) and with the same environmental exposure prior to stunning, electrical stunning resulted in twice the drip loss in the longissimus dorsi with the same ultimate pH and subjective meat color.

Facco Silveira et al. (1998) compared stunning of pigs with electricity (5 seconds; 220 volts; 1.2 amps applied manually) VS. C02 (60 to 75 seconds; 70% CO, plus 30% air; inhalation) and concluded that C02 stunning was most attractive because of higher 24-hour muscle pH, slightly more desirable muscle color (a* and b* values) and more desirable water-holding capacity of the meat. The latter scientists further concluded that: (a) Any stress placed on pigs immediately before slaughter should be avoided. (b) Unstunned, unrestrained pigs produced longissimus dorsi muscles with lower pH values (at 1 hour and 24 hours postmortem), higher luminosity (L*) values, more extensive blood-splashing and lower water-holding-capacity than pigs stunned with either electricity or carbon dioxide. (c) Considering the functional properties investigated, C02 stunning is favored over electrical stunning; the problem is mainly to avoid frightening the pigs when driving them and thus reduce excitement before they reach the anesthetization plant whether it is operating with electricity or carbon dioxide. These results were confirmed by Channon et al. (2000) who found that genotype (halothane-Nn vs. normal NN), preslaughter handling (minimal vs. stressed) and stunning method (C02 vs. electrical) had an interactive effect on the pH, tenderness and drip-loss of pork. It was concluded that pig processors should optimize their handling systems and techniques, especially if pigs carrying the halothane-n gene are being processed, minimize exposure to unfamiliar, preslaughter stressors and implement a C02 stunning system in order to improve the quality of their pork products.

Faucitano et al. (1998) compared stunning of pigs with electricity (MIDAS system; 2.4 seconds; 220 volts; 800 Hz; via two electrodes between the eye and ear P us 1.7 to 2.0 seconds; 100 volts; 50 Hz; via one electrode to the chest) VS. C02 (COMPACT system; six-chair conveyor; 83% C02; inhalation) and concluded that the higher degree of muscle activity during the epileptic attack of electrically stunned pigs compared to C02 stunned pigs led to a higher incidence of PSE (8.8% vs. 3.8%, 2 hours postmortem; 18.8% vs. 13.31/0, 7 hours postmortem; head-to-chest electrical stunning VS- C02 Stunning, respectively) and a higher incidence of DFD (16.1% vs. 8.2%, 2 hours postmortem; 8.0% vs. 3.8%, 7 hours postmortem; head-to-chest electrical stunning vs. C02 stunning, respectively). The latter results agree with the report of Barton Gade (1992) who observed a higher incidence of PSE (10% to 19%) in plants equipped with electrical stunning than in plants equipped with C02 stunning (2% to 6%).

Grandin (1998f) concluded that: (a) Ultralean hybrid pigs tend to display higher incidences of bloodsplash and broken backs during slaughter; some plants are considering adopting C02 stunning to lessen such incidences in very lean pigs. (b) C02 stunning will reduce PSE pork incidence and excessive drip loss in pork in pigs that carry the stress gene, especially those that are handled roughly and shocked with electrical prods; unfortunately, though, pigs that are free of the stress gene may produce more PSE pork when stunned with C02. (c) An improved C02 stunning system has been developed that works like a rotary milk parlor, stunning five pigs at a time (90 seconds) at a chain-speed of 1,000 pigs per hour with sufficient exposure to kill the animals while providing both practical, meat quality and humaneness advantage.

Good management combined with modern electronically controlled electric stunning equipment will reduce the advantages of CO_2 stunning on pork quality. Electronically controlled systems prevent damaging amperage surges. Short stunning times combined with higher electrical frequencies will reduce both PSE and bloodsplash compared to long stunning times at 50 to 60 Hz. Bloodsplashing can be reduced by avoiding double stunning and keeping the electrode in firm contact with the animal. The electrode must be energized

AFTER it is in firm contact with the animal. Sliding of the electrode during the stun must be avoided. In good animal welfare, the electrode must be positioned so that the current will pass through the brain. Many plants have greatly reduced bloodspashing by replacing stunner switches and electrical cords every few weeks. Worn switches or damp cords will cause electrical current fluctuations. Fluctuating current increases bloodspashing. Frequent cleaning of the electrodes is essential.

When CO_2 stunning is compared to the very best electrical stunning it may be difficult to justify the high installation cost of CO_2 stunning. Operating and maintenance costs are also much higher for CO_2 stunning. Pig genetics has a greater effect on PSE than the method of stunning.

EFFECT OF STUNNING PROCEDURE/PROTOCOL ON OCCURRENCE OF BRAIN TISSUE IN CATTLE HEARTS

Schmidt et al. (1998) characterized blood clots and brain tissue found in a total of 1,980 beef hearts at 8 plants that used pneumatic-powered air-injection stunners, 3 plants that used pneumatic-powered stunners and 4 plants that used cartridge-fired stunners. They observed large blood-clots in the right ventricle in 33%, 12% and 1%, respectively, and segments of spinal cord in 2 hearts at one plant, none in any plant and none in any plant, respectively, in plants that employed pneumatic-powered air-injection stunners, pneumatic-powered stunners and cartridgefired stunners. These researchers demonstrated that use of an ELISA test for detection of glial fibrillary acidic protein (GFAP), found only in central nervous system (CNS) tissue, is a valid and repeatable method for detection of CNS tissue contamination of blood, meat or other variety meats with a limit of detection of 1 nanograrn (Schmidt et al., 1998; Schmidt, 1999).

EFFECT OF STUNNING PROCEDURE/PROTOCOL ON BEEF BRUISING

Grandin (1992c) discussed use of captive-bolt guns and electricity for stunning slaughter cattle, especially with regard to achieving an unconscious state, but did not suggest that differences in type of stunning or method of application of stunning was related to beef quality measures. In a subsequent article, Grandin (1993) discussed electric stunning of cattle and reported that: (a) Electric stunning of cattle was being used with great success in many New Zealand slaughter plants. (b) To prevent blood-splash in the meat, the electrodes must be pressed firmly against the animal so that the stunning current is supplied by constant amperage. (c) The increased reliability of electrical stunning (failure rate of <1%) in comparison to captive bolt stunning (failure rate of 1% to 5%) provides a definite advantage from a humane standpoint.

The first study reporting the possibility of bruising of cattle occurring at the stunning stage of the slaughtering/dressing process was by the Australian Meat Board (1954). Later, in the United States, Rickenbacker (1959) and Hamdy et al. (1957) established that an animal could be bruised up until its blood pressure approached zero, which indicated that damage could be done and bruises could occur after stunning. Meischke et al. (1974) noticed that carcasses were more bruised on the left side than on the right side; further investigation revealed that the left side was the side cattle fell on after stunning when released from the knocking box. Meischke and Horder (1976) studied bruises on cattle in six abattoirs in Australia and determined that differences in carcass bruises were related to the way in which each carcass was ejected from the knocking box; the site distribution of bruising on each side corresponded with those areas observed to receive the initial impact on release from the knocking box.

RESEARCH ON BRUISING OF SLAUGHTER CATTLE

Grandin (1981 b) studied bruises on carcasses of slaughter steers and heifers and reported that: (a) One of 9 cattle were bruised, with 45% of bruises on the loin and 23% of bruises on the back. (b) When 50 or 51 cattle were on a truck, 10.2% of them had carcass bruises; when 48 or 49 cattle were on a truck, 5.3% of them had carcass bruises. (c) When feedlots had a manpower shortage (a man short) and a bad day loading cattle at the feedlot, 19.7% of the cattle were bruised; on good days with a full complement of workers, 12.8% of the cattle were bruised. (d) Feedlots that practiced "rough" handling of cattle experienced a 15.5% rate of cattle bruising while those with "good" handling of cattle had 8.3% of cattle bruised. (e) When the terms of sale were "cash cattle," 14% of the carcasses were bruised; when cattle were sold "in-the-beef" the incidence of carcass bruising was 8%. Grandin (1995 a,b) believes that 50% of the things that contribute to bruising of cattle occur prior to the time the cattle arrive at the packing plant (at the feedlot; during hauling) while errors at the packing plant (rough handling; facilities and equipment problems) are responsible for the other 50%.

Meischke et at. (1974) evaluated presence of horns in cattle on carcass bruising following groups that were hornless, horned or mixed (half hornless; half horned) and reported that the weight of bruised tissue trimmed from the carcasses of horned cattle was approximately twice that trimmed from hornless cattle while the weight of bruise trim from mixed groups was intermediate between that from the hornless and horned groups. Ramsay et al. (1976) found that bruise trim weights for cattle with tipped horns were approximately twice as high as were those for dehorned cattle and that tipping of horns will not reduce the amount of bruised tissue trimmed in comparison to the amount trimmed from carcasses of horned cattle. Shaw et al. (1976) reported that the weight of bruised tissue trimmed from the carcasses of the cattle in the horned groups was significantly greater than that trimmed from the carcasses of the cattle in the hornless groups. When horned and hornless cattle were mixed, the hornless animals in the mixed group sustained significantly more bruising than animals in a group consisting solely of hornless animals while the horned animals in a mixed group have a similar degree of bruising to cattle in a group consisting solely of horned animals (Shaw et al., 1976). Winks et al. (1997) reported that heavy tipping, as a means of reducing bruising trim is of questionable value because, based upon their own study and those of two other researchers, level of bruising trim in steers with tipped horns, was of the same magnitude as that of horned steers. Wythes et al. (1979) compared bruising of cattle with untipped, tipped and no horns and concluded that: (a) Tipped and untipped cattle had similar bruising whether sent for slaughter as separate groups or together. (b) Tipping was ineffective in preventing bruising. (c) Hornless cattle had significantly less bruising than horned cattle when consigned as separate groups; however, this advantage was lost when hornless cattle were mixed with tipped or untipped cattle.

Armstrong et al. (1998) compared incidence of bruises on slaughter steers/heifers in the U.S. and in Canada using results of the 1991 National Beef Quality Audit (NBQA-1991), the 1995 National Beef Quality Audit (NBQA-1995) and the 1996 Canadian Beef Quality Audit (CCFA-1996); their conclusions were: (1) Incidence of slaughter steers/heifers that had one or more bruises was 39% for NBQA-1991, 48% for NBQA-1995 and 78% for CCFA-1996. (2) In the CCFA-1996 study, as contrasted with results of the NBQA-1995, there were many more cattle with two bruises (24% vs. 13%), three bruises (16% vs. 4%), four bruises (12%

vs. 1%), bruises on the chuck (31% vs. 16%) and bruises on the loin (41% vs. 29%). (3) Value losses due to bruises for each slaughter steer/heifer harvested in Canada was $2.87 (CCFA- 1996) and in the U.S. was $4.03 (NBQA-1995).

Interestingly, in the 1994 National Non-Fed Beef Quality Audit (Smith et al., 1994), the total loss due to bruising for each cull cow/bull harvested in the U.S. was nearly $12.00 (with $3.91 attributed to errors by producers and the remainder attributed to the marketing/transporting sector and the packing sector). Bruises are an especially significant problem for salvage cows and bulls for a number of reasons, many of which are related to management, including: (1) Non-fed cattle have little outside fat cover. (2) Frequency of horns in cows/bulls is higher than in fed cattle. (3) Many non-fed cattle are marketed when they are lame, which substantially increases the numbers of bruises (Smith et al., 1994). The strategies for overcoming bruising problems are simple and straightforward, said Temple Grandin in the 1994 National Non-Fed Beef Quality Audit report (Smith et al., 1994), "Producers should dehorn calves when they are still young and market lame cattle in an expeditious manner-long before their condition progresses to the point where difficulties arise in transporting and harvesting these animals." In the 1995 National Beef Quality Audit it was stated that bruises can easily be addressed by producers, feeders, truckers and packers by working together to eliminate much of the problem (Smith et al., 1995); producers should dehorn cattle and producers/truckers/packers should take care in loading and unloading animals.

Eldridge and Winfield (1988) concluded that space allowance for cattle during truck transport can significantly affect the level of bruising, carcass weight and risk of injury to animals. Bruise scores in the low space (0.89 m 2 /animal) and high space (1.39 M2 /animal) allowance treatments were 4 and 2 times greater, respectively, than in the medium space (1.16 m 2 /animal) allowance treatment, perhaps because more animals at the medium space allowance aligned themselves across the direction of travel than at either of the other space allowances (Eldridge and Winfield, 1988).

Armstrong et al. (1998) studied effects of the Livestock Safety Cushion™ which is padding applied around the rear door and in twelve additional places within the trailer, on incidence of bruises on 4,690 slaughter steers/heifers hauled up to 188 miles to the packing plant. For padded vs. unpadded trucks, respectively, total bruises were 30.1% vs. 39.5%, bruises per load were 11.9% vs. 15.9%, animals with one bruise were 8.0% vs. 10.6%, and animals with two bruises were 2.7% vs. 4.1%, respectively. Use of the Livestock Safety Cushion™ (a) Significantly reduced loin bruises, and (b) Reduced trim losses from bruises by $0.39/animal which would save $1.05 million per year in Canada (Armstrong et al. (1998). One interesting finding in the Armstrong et al. (1998) study was that "feedlot of origin" was the most important factor determining extent (incidence) of bruising.

Grandin (1992a) made the following observations regarding bruising of slaughter cattle at packing plants: (a) If there is a sudden occurrence of bruises, look for recent changes in personnel and/or for broken equipment. (b) Back bruises almost always are caused by gate, truck deck or personnel problems. (c) Loin bruises result from horns on cattle, narrow entryways, protrusions into alleyways or rough handling. (d) Shoulder bruises are caused by horns on cattle, protrusions into alleyways or rough handling. (e) Cattle can still be bruised after stunning and prior to bleeding. Livestock Conservation Institute (1999) characterizes recommended practices to reduce bruising in cattle as follows: (a) Horns-dehorn all cattle; tipping doesn't help; don't crowd or overload during trucking. (b) Gates - don't throw a gate into an animal's path to stop it; have gates high/wide enough when trucking. (c) Protruding Objects-eliminate board, wire, nail, bolt protrusions; pad sliding gates and corners. (d) Fencing-pad protrusions; install belly rails. (e) Bruise Hazard Zone-the area 28 to 52 inches from the floor. (f) Flooring provides good footing; cut 8-inch diamonds in concrete; grid with 1-inch re-bar; put cleats on inclines; use nonslip material in trucks.

RESEARCH ON HANDLING OF CATTLE AND QUALITY OF BEEF

Mojto et al. (1998) found that the effect of antemortem stress generated different responses in bulls vs. steers. In comparison to steers, bulls are physically more active in the loose housing at the slaughterhouse during the night and more of the glycogen reserves are depleted, the pH values of meat are higher and the occurrence of dark, firm and dry meat is more frequent (Mojto et al., 1998)

Bauer et al. (1998) compared quality parameters of beef from cattle that were conventionally fattened vs. cattle produced under free-range conditions; these researchers concluded that it was very doubtful that the small differences in beef quality that were observed were related to husbandry practices.

Butchers et al. (1998) studied interactions between preslaughter handling of steers and low voltage electrical stimulation (LVES) of their carcasses as they affected beef quality and concluded that: (a) The stress from trucking a relatively short distance and a 24 hour fast prior to slaughter was sufficient to slow down the rate of postmortem pH decline and avoid toughening of the beef. (b) Steers kept on feed until slaughter had a sufficiently rapid rate of glycolysis so that LVES of the carcass was not necessary to increase the rate of postmortem decline and avoid toughening of the beef.

RESEARCH ON DARK-CUTTING BEEF

Epley (1975) reported that the national incidence of dark-cutting beef was 0.5%. Incidence of dark-cutting beef in the 1991 National Beef Quality Audit (Smith et al., 1992) was 5.0%, in the 1993 Strategic Alliance Field Study (Eilers et al., 1993) was 0.24%, in the 1994 National Non-Fed Beef Quality Audit (Smith et al., 1994) was 13.7% in cull cows and 40.5% in cull bulls, and in the 1995 National Beef Quality Audit (Smith et al., 1995) was 2.7%. The 1995 National Beef Quality Audit (Smith et al., 1995) revealed that dark-cutting beef resulted in a loss to the U.S. industry of $6.08 for each slaughter steer/heifer harvested.

Tyler et al. (1982) studied incidences of bruising and dark-cutting beef and concluded that the temperament and susceptibility to bruising of individual animals have more influence on the severity of bruising than does type of cattle-Zebu vs. British-and that British cattle had a higher incidence of dark-cutting beef than did Zebu cattle. Grandin (1979) and Price and Tennessen (1981) both reported that fighting among cattle that are strangers would increase the incidence of dark-cutting beef. When cattle that are strangers are mixed together, they fight to determine a new dominance hierarchy (Grandin, 1995). Grandin (1995) believes that 80% of the things that contribute to dark-cutting beef occur prior to the time the cattle reach the packing plant but that it is the plant factors (e.g., rough handling, excessive lairage-starter cattle, weekend cattle) that are the "straws that break the camel's back" and cause dark-cutting beef in carcasses.

Jones and Tong (1987) reported that: (a) The frequency of dark-cutting beef increased as transportation distance from the farm to the slaughter plant changed (from less than 60 miles to more than 180 miles). (b) Steers had a higher incidence of dark-cutting beef than did heifers. (c) Mixed loads of cattle had a significantly higher frequency of dark-cutting beef than unmixed loads. (d) The frequency of dark-cutting beef differed widely among packing plants-from a low of 0.26% to a high of 1.79%. (e) The highest monthly frequencies of dark-cutting beef were in March and April while the lowest frequency was in December.

The transport and handling procedures imposed on beef cattle during the normal course of marketing can be a significant stressor with factors like time off feed, water deprivation, mixing and the resulting behavioral problems, transport movement, unfamiliar noise, and inclement weather are often present and collectively result in live weight and carcass losses as well as degraded meat quality (Schaefer et al., 1997). Schaefer et al. (1997) studied the role of oral electrolyte therapy in attenuating transport and handling stress in cattle and reported improvements in both live and carcass weights (less shrink) of up to several percent in treated animals as well as a reduction in meat quality degradation (reduced dark cutting). Wilson (1999) found that providing livestock with electrolyte-restoring liquids (similar to sports drinks for humans) before and during transport can reduce shrinkage in pigs, lambs and calves. While all animals lost weight during transport, electrolyte-fed animals lost less weight than water-fed animals (Wilson, 1999).

Scanga et al. (1998) reported that dark-cutting beef results from preharvest stress, which depletes muscle glycogen stores and thus reduces the glycogen needed to produce the lactic acid that reduces the pH of postmortem muscle. Hedrick et al. (1959), Grandin (1992), Smith et al. (1993), Shackelford et al. (1994) and Voisinet et al. (1997a) have identified antemortem stress, weather (dark-cutting beef incidence is highest during very cold weather combined with precipitation-which induces "shivering"), genetics (largely related to temperament), fright (which induces "shivering"), gender, growth promotants and handling practices. Scanga et al. (1998) said that incidence of dark-cutting beef was affected by differing management philosophies, facilities construction and cattle-handling practices at specific feedlots; those findings agreed with Hedrick et al. (1959), Grandin (1992) and Smith et al. (1993) who determined that production/management practices such as handling and working procedures can be stressful to cattle and thus can cause increased occurrence of dark-cutters in slaughter steers/heifers.

Scanga et al. (1998) used feedlot data from a three-year period of time from nine commercial feedyards (15,439 pens of cattle; 2,672, 233 total cattle) to study factors contributing to the incidence of dark-cutting beef. The primary findings of the Scanga et al. (1998) study are as follows: (1) Heifers yielded a higher percentage of dark cutters than steers. (2) Management practice, structure and handling policy differences among feedyards generated large differences in incidence of dark-cutting beef. (3) Mean incidence of dark-cutting beef, as related to use of growth promotants, was highest in heifers given a combination (androgen plus estrogen) implant at the start of finishing and in heifers given an estrogen implant as re-implantation prior to harvest. (4) Mean incidence of dark-cutting beef, as related to use of growth promotants, was highest in steers given a combination (androgen plus estrogen) implant at the start of finishing and in steers given a combination (androgen plus estrogen) implant as re-implantation prior to harvest. (5) Occurrence of dark-cutter epidemics ("blow-outs"; incidence of 6% or more of animals in a pen) in heifers was highest in heifers given an estrogen implant at the start of finishing and in heifers given an estrogen implant as re-implantation prior to harvest. (6) Occurrence of dark-cutter epidemics ("blow-outs"; incidence of 6% or more of animals in a pen) in steers was highest in steers given a combination (androgen plus estrogen) implant at the start of finishing and in steers given a combination (androgen plus estrogen) implant as reimplantation prior to harvest. (7) Ambient temperatures higher than 95 F during 24 to 48 hours prior to shipment for harvest increased incidence of dark-cutting beef in both steers and heifers. (8) Ambient temperatures lower than 32 F during 24 to 48 hours prior to harvest increased incidence of dark-cutting beef in heifers but not in steers. (9) Fluctuations greater than 10 F between the high and the low ambient daily temperature in 24, 48 or 72 hours prior to shipment for harvest increased incidence of dark-cutting beef in both steers and heifers. (10) Holding cattle on-feed for 100 days or more past re-implantation reduced the incidence of dark-cutters per pen by an average of 38% among heifers and of 69% among steers. (11) Dark-cutting beef can be minimized further by employing feedlot management practices that incorporate seasonal climatic trends (hot weather and large temperature changes) at the time of harvest when determining implant administration, by using good handling practices, by having well-designed facilities and by promoting use of proper shipping practices (Scanga et al., 1998).

CAN ELECTROLYTES OR CHROMIUM DECREASE WEIGHT LOSSES OR IMPROVE MEAT QUALITY-

Oral electrolyte therapy (Nutri-Charge™) has been reported to reduce physical stress of cattle during transport and handling. A report in Beef Feeder (1997) suggested that cattle fed Nutri-Charge™ sustained 1.8% less liveweight loss, had 1.3 to 2.1 percentage points higher dressing percent and produced half as many (1.9% vs. 3.8%) dark-cutting beef carcasses, compared to control cattle. eMerge Vision Systems, Inc. (1999), in a bulletin describing results of studies of more than 2,000 feedlot cattle, reported advantages for cattle fed Nutri-Charge™ vs. controls in dressing percent, percent Choice, percent Prime and percent dark-cutting beef of +0.7, +10.3, +3.0 and -0.8 percentage points, respectively.

Smith and Wilson (2000) used lambs, pigs and calves to determine effects of transportation (2 trips of 45 miles each) and of administering water alone or water plus electrolytes on behavior, distress and performance traits. Weight loss was reduced substantially, very slightly and not significantly, for pigs, calves and lambs, respectively, that were given water plus electrolytes rather than water alone. Differences in behavioral traits and activities were substantially in favor of calves given water plus electrolytes versus water alone in the proportion of time spent '41ying"; all other behaviors/activities ("lying," “drinking," "eating") were not different in any meaningful fashion for pigs, lamb or calves administered water alone versus water plus electrolytes.

Hanson et al. (2000) proposed that the feeding of supplemental chromium (an essential mineral that plays a role in glucose metabolism and which may increase glycogen deposition by increasing the efficiency of insulin) to cattle may aid in increasing glycogen reserves and which, in turn, may reduce the depletion of glycogen prior to slaughter. Heifers subjected to induced stress (estrus and social interaction) were fed or not fed a high-chromium yeast product (400 ppb of chromium for 62 days prior to slaughter) but the stress treatments were insufficient to generate dark-cutting beef, so the benefits of chromium feeding could not be assessed. Stress, though, reduced tenderness and redness of the ribeye muscles from these heifers (Hanson et al., 2000)

PROBLEMS WITH LAMENESS IN SLAUGHTER CATTLE

The 1994 National Non-Fed Beef Quality Audit (Smith et al., 1994) concluded that lameness represents a major cost to producers and packers and can contribute significantly to quality problems in carcasses and cuts. Temple Grandin said "Mildly disabled cattle can be prevented from progressing to severely disabled cattle (sometimes referred to as 'downers') by prompt and timely marketing of these animals" (Smith et al., 1994). Many non-fed cattle are marketed when they are lame which substantially increases the number of bruises, the amount of trim loss and the probability of whole-carcass and cut condemnations. Attempting to salvage cattle that are severely lame, especially if they are "downers," can create impressions among people in the general population that producers have mistreated animals (causing ambulatory problems in animals), that producers and packers do not care about the rights or welfare of farm animals, and/or that producers/packers are so crass and so interested in squeezing the last penny from meat animals that they will allow anything-however disabled, deformed and diseased-to enter commerce and wind up in the general beef supply. The accumulative effects of allowing consumers to believe such things, especially when - periodically - the media covers such occurrences in expose fashion, contributes to the decline in market share of beef in comparison to the market-share of other sources of protein.

ANIMAL HANDLING AND BACTERIAL CONTAMINATION OF MEAT

Whether or not it can be substantiated by scientific data, packers have historically desired to harvest cattle and pigs that are clean, fasted and well-rested. Conventional wisdom holds that: (a) Cleaner animals yield cleaner carcasses following slaughtering/dressing, (b) fasted animals have proportionally smaller gastrointestinal tracts lessening the possibility of burst intestines during evisceration, and (c) well-rested animals are less likely to have had microbes migrate backward (across intestinal walls, into lymph or blood fluids) and into the meat. Cleanliness of animals is a much greater concern now than it was in the past because of concerns in the 1990s about foodborne pathogens on carcasses and meat. Research results of Kam et al. (1998) in the New York Cull Dairy Cow Study and Sofos et al. (1999a,b) in the Microbial Mapping I Study demonstrate convincingly that dirtier animals at harvest are must more likely to produce carcasses that have Salmonella on their surfaces.

It has been documented in slaughter steers/heifers, that the more animals are stressed, the more likely they are to shed bacterial pathogens (e.g., Salmonellae, E. coll 0157:H7) in their feces; and, their feces contaminates them as well as other cattle in the same pen or truck. Unsanitary handling facilities, alleyways, sideboards of trucks, chutes and restrainers contribute bacterial pathogens to the external surfaces of animals. Research has determined that external animal surfaces (hide, hair, hooves, switches, etc.) are a much more important source of contamination on cattle than are the contents of the gastrointestinal tract with respect to the bacterial contaminants that are likely to be transferred from cattle, to carcasses.

For cull cows/bulls-too-the greater the stress, the more likely will be the shedding of enteric pathogens in the feces; and the greater the extent of bacterial pathogen shedding, the more likely will be the contamination of external animal surfaces. Again, subjecting slaughter animals like cull cows/bulls to more heavily contaminated facilities-as they move from the farm to the auction market and subsequently to the packing plant-will increase the likelihood that a given animal has bacterial pathogens on its hide, hair or hooves. Lameness, especially if an animal is a "downer," further increases the probability of occurrence of pathogens on external animal surfaces.

Colorado State University and Cornell University conducted a study entitled "Detection And Control Of External Pathogens: Microbial Mapping In The New York Cull Dairy Cow

Project" (Kam et al., 1997) in which 80 dairy cows were selected for differences in condition, lameness and hide cleanliness. The incidences of E. coll 0157:H7 and Salmonellae, in fresh feces were 0% and 0%, on hide surfaces were 0% and 13.8%, and on carcass surfaces were 0% and 1.2%, respectively. Significant correlations with Aerobic Plate Counts were with lameness and hide cleanliness but not with condition, with Total Coliform Counts were with lameness but not condition or hide cleanliness, and with Escherichia coll Counts were not with any of the factors -- condition, lameness or hide cleanliness (Kam et al., 1997).

Clapp (1999), discussing "areas for consideration" as FSIS reformulates its policy, says the agency must consider these two (among six) queries: (a) If FSIS finds that E. coli 0 1 57:H7 occurs with some regularity on hides and carcasses of feedlot cattle but not on cattle raised under different production practices, should the pathogen be considered a hazard "reasonable likely to occur" only in slaughter and processing operations that use feedlot cattle- (b) How effective are voluntary producer actions in providing animals with reduced levels of E. coli 0157:H7 to plants, and should these voluntary activities, if effective, affect slaughter plants' strategies and FSIS policy-

For market hogs and for cull sows/boars it is presumed, but not known, that similar relationships hold-between handling conditions, stress, shedding (in this case, of Salmonella, Campylobacterjejuni and Yersinia entercolitica) and contamination of external animal surfaces and carcass surfaces-as have been documented for slaughter steers/heifers and for cull cows/bulls. EVALUATION OF ANIMAL HANDLING UNDER PRACTICAL CONDITIONS If a problem is occurring with animal handling at a packing plant, the exact cause of the problem needs to be determined so that the problem can be easily corrected. There are five basic causes of animal handling problems. If the exact cause of an animal-handling problem is known, it can be easily remedied: (1) Distractions which impede animal movement (e.g., sparkling reflections on a wet floor, high pitch noises or seeing people up ahead) can ruin the performance of a well-designed system (Grandin, 1996). (2) Equipment design problems (e.g., a stunning box that is too wide). (3) Lack of employee training or poor supervision of employees. (4) Poor maintenance of equipment (e.g., stunners) or worn, slick floors. (5) Poor condition of animals arriving at the plant (e.g., cripples or non-ambulatory animals). Grandin (1998b,c; 1997) has developed an easy-to-use system for objectively scoring animal handling in slaughter plants; this system can be used to assess animal welfare and handling to maintain good meat quality. One of the most important measurements is scoring of vocalization (Grandin, 1998b,c; 1997). Several studies have shown that squealing in pigs and bellowing in cattle is correlated with physiological stress (Warris et al., 1994; Dunn, 1990). The variables that are scored in the Grandin (1998b,c; 1997) system are: (1) Percentage of animals stunned correctly on the first attempt. (2) Percentage of animals rendered insensible on the bleeding rail. (3) Percentage of animals slipping and falling during handling. (4) Percentage of cattle or swine vocalizing during handling and stunning. (In a pork plant, the percentage of pigs squealing can be estimated and efforts can then be made to make changes that will reduce squealing). (5) Percentage of animals prodded with an electric prod.

TRANSPORTATION OF CATTLE AND PIGS TO THE SLAUGHTER PLANT

Grandin (1981a), in the Livestock Trucking Guide developed for the Livestock Conservation Institute, says that each year, 80,000 hogs leave the farm but never reach market because they perish on the way to market; many of them could be saved by care in loading-, attention to the temperature, a better ride or more careful handling. Cattle losses during transit are not as great, but more care could reduce shrinkage and help reduce stress-related losses (Grandin, 1981a). Hot weather and high humidity are deadly to hogs because they lack functioning sweat glands; wind chill can kill hogs so they must be protected from the cold wind (and especially from freezing rain and temperatures around freezing) during truck travel and lairage at the packing plant. The Porcine Stress Syndrome (PSS) is the leading cause of death of hogs during transport; hogs showing the PSS symptoms (panting, trembling, splotchy skin) must be allowed to rest or they are likely to die. Even though cattle and sheep have long hair coats or wooly fleeces, they can be subjected to wind chill when they become wet; wetting the hair coat destroys its ability to insulate the animal from cold (Grandin, 1981 a). Death losses in cattle are often greatest when the temperature is near freezing and either rain or freezing rain is falling, During extremely cold weather it may be advisable to withhold water for a few hours prior to loading to prevent wind chill caused by animals soiling each other (Grandin, 1981 a).

Trucking tips to cut cattle bruising, based on material gathered from Beef (1997), Livestock Conservation Institute (1999) and Mies (1999) include: (a) More than 50% of all bruises are due to rough and careless handling. (b) Two-thirds of loin bruises result from loading/unloading from trucks. (c) 7 to 9% of fed cattle have severe (resulting in $20 trim losses) loin bruises. (d) The most common cause of bruising is a hard bump from a protruding object or cattle horn. (e) Cows bruise more easily than do fed steers/heifers. (f) Cattle that go through stockyards have more bruises than do those sold directly to packing plants. (g) Cattle sold on-the-rall have one-half as many bruises as those sold on a liveweight basis. (h) A study of market cows/bulls, at three plants in Texas, revealed that truck driver differences (stops, starts, speeds, cornering) accounted for most of the variability in bruise incidence/severity.

To reduce shrink and stress of cattle during trucking, Livestock Conservation Institute (1999) recommends following these guidelines: (a) During hot weather, haul at night or in early morning. (b) Try not to mix strange animals; fighting during the 24-48 hours prior to slaughter can increase "dark-cutters" in steers and mixing strange bulls can cause "dark cutters" in 90 minutes. (c) Don't ship wet animals when weather is cold, to prevent death due to wind chill. (d) Don't ship animals full of green feed. (e) Provide water up to the time of trucking and upon arrival at the packing plant; half of the shrink of cattle hauled 373 miles is actual carcass (tissue) shrink. (f) Rest-stop cattle if the trip exceeds 48 hours.

CONCLUSIONS

With regard to the need for proper handling of cattle and swine as they leave ranches, feedlots and farms, as they are marketed (through auction markets or buying stations), as they are transported to packing/processing plants, and as they are held, assembled and harvested at the packing plant, there are opportunities to improve productivity, quality and profitability for those in the production and packing sectors. Proper handling is the responsibility of people in several sectors of the beef and pork industries. If beef or pork carcasses are bruised, those responsible could be producers, auction market or buying station employees, truckers and/or packers. If too many beef carcasses are dark-cutters or if too many pork carcasses are pale, soft and exudative, those responsible could be producers, auction market or buying station operators, truckers or packers. Joint responsibility for proper handling ... that's the key to providing high-quality products from cattle and swine.

A full copy of this paper and list of references is available at:
http://www.grandin.com/meat/hand.stun.relate.quality.html

Lowering Stress To Improve
Meat Quality and Animal Welfare In Cattle.

Stress induced meat quality problems such as dark cutters cause large monetary losses to the livestock industry. The National Beef Quality Audit estimates that dark cutters cost the beef industry $5.00 for every fed animal slaughtered. Dark cutting beef is darker and drier than normal and has a shorter shelf life. Good quality beef has a final pH value close to 5.5. At pH values of 5.8 and above, both the tenderness and keeping quality of the fresh chilled meat is adversely affected. High pH meat is unsuitable for the premium trade in vacuum-packed fresh meats, and, depending in the commercial use of the product, dark-cutting meat may be discounted by 10% or more (Tarrant,1981). High meat pH is caused by an abnormally low concentration of lactic acid. Post mortem production of lactic acid requires an adequate content of glycogen in the muscles at slaughter. Ante mortem glycogen breakdown is triggered by increased adrenaline release in stressful situations, or by strenuous muscle activity.

To reduce stress, prevent fighting and preserve meat quality, strange animals should not be mixed shortly before slaughter. A majority of the dark-cutting in cattle is due to mounting behaviour, and when strange bulls are mixed, the physical activity during fighting increases dark-cutting as well.

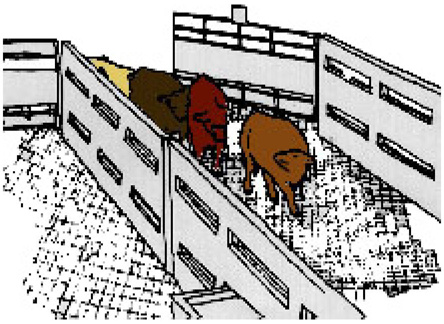
Good reviews on dark cutting beef can be found in Fabiansson et al.,(1988) and Hood and Tarrent(1981).

High financial losses are incurred by the livestock industry as a result of carcass bruising (Dow,1976; Hails,1978; Grandin,1980; Wythes and Shorthose,1984; Eldridge and Winfielddd,1988). Bruising is an impact injury that can occur at any stage in the transport chain and may be attributed to poor design of handling facilities, ignorant and abusive stockmanship, and poor road driving techniques during transportation (Grandin,1981). **Contrary to popular belief, livestock can be bruised moments before slaughter and stunned cattle can be bruised until they are bled.**

Preventing Injuries and Bruises on Cattle, Pigs, and Sheep

Updated January 2011

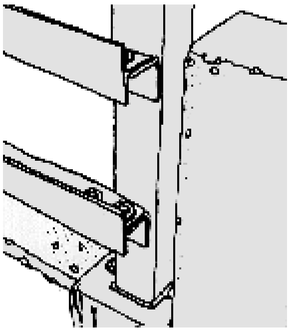
Non-slip flooring is essential to prevent falls and crippling injuries. Humane, efficient handling is impossible on slick floors. All areas where livestock walk should have a non-slip surface. Existing floors can be roughened with a grooving machine. On scales, crowd pens and other high traffic areas, a grid of one-inch steel bars will provide secure footing. Construct a 12-inch (30cm) by 12-inch (30cm) grid and weld each intersection. Use heavy rods to prevent the grid from bending. The grid must lay flat to prevent hoof injuries. Do not criss cross the rods on top of each other. Mats constructed from woven tire treads are also effective.



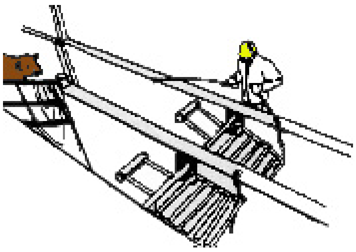
A good example of a non-slick surface for livestock.

New concrete floors for cattle should have an 8-inch diamond or square pattern with 1 1/2 inch (3.5cm) x 1 1/2 inch (3.5cm) V grooves. For pigs and sheep, stamp the pattern of 1 1/2 inch (3.5cm) raised expanded metal into the wet concrete. A rough broom finish will become worn smooth. Floors should be grooved. It is also essential to use the right concrete mix for maximum resistance to wear.

Example of a bad fence corner. Notice the protruding sharp edges that could cut an animal as well as cause serious bruising. Cattle can be severly bruised with no visible damage to the hide.



Gates, fences and chutes should have smooth surfaces to prevent bruises. Sharp edges with a small diameter, such as angle irons, exposed pipe ends, and channels, will cause bruises. Round pipe posts with a diameter larger than 3 inches (7.6cm) are less likely to bruise. Vertical slide gates in chutes should be counter-weighted to prevent back bruises. The bottom of these gates should be padded with cut tires or conveyor belting. The gate track should be recessed into the chute wall to eliminate a sharp edge that will bruise. Gates in drive alleys should be equipped with tie backs to prevent them from swinging out into the alley. Livestock are easily bruised if they become caught between the end of the gate and the fence. This is a common cause of bruises in the valuable loin area.



Gates should be tied back to prevent balking as animals are entering the lead up chute. Once the animals are in the chute, the gates should be lowered to prevent the animals from backing out of the chute.

Pressing up against a smooth flat surface such as a concrete chute fence will not cause bruises. However, a protruding bolt or piece of metal will damage hides and bruise the meat. Bruise points can be detected by tufts of hair or a shiny surface. Contrary to popular belief, livestock can be bruised moments before slaughter, and stunned cattle can be bruised until they are bled. The entrance to the restrainer should be inspected often for broken parts with sharp edges.

Surveys show that groups of horned cattle will have twice as many bruises as polled (hornless) cattle. A few horned animals can do a lot of damage and tipping horns does not reduce bruises.

A full copy of this paper and list of references is available at:

http://www.grandin.com/behaviour/principles/preventing.html

Dark Cutters (DFD)

Dark cutting beef is caused by a combination of factors which stress the animal and deplete glycogen (muscle energy source) from it's muscle. Some of the factors which contribute to dark cutting and make cattle more susceptible are:

- Rapidly fluctuating temperature.
- Excessive use of growth promotive implants.
- Genetic factors - Some types of cattle are more susceptible.
- Rough handling.
- Bulls have more dark cutters than steers, cows, or heifers.

Preventing DFD (Dark, Firm, Dry meat) in Cattle.

1. DO NOT mix strange cattle together prior to slaughter at the plant. Fighting increases dark cutting.
2. Handle animals quietly and reduce or eliminate electric prod usage.
3. Unload trucks promptly.
4. Cattle should not be held overnight in the stockyards at the plant.

Factors Contributing to the Incidence of Dark Cutting Beef[1]

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ABSTRACT: The 1995 National Beef Quality Audit reported that dark cutting beef (dark cutters) cost $6.08 per animal harvested in the United States. Feedlot data were obtained over a 3-yr period from nine commercial feedyards (15,439 pens of cattle; 2,672,223 total cattle). Feedyard, gender, implant treatment, days from final implant to harvest, maximum and minimum daily temperatures, and temperature fluctuations from 2 d before harvest to the day of harvest all contributed ($P < .05$) to the incidence of dark cutters. Heifers yielded a higher ($P < .05$) percentage of dark cutters per pen and, when reimplanted a second time with an estrogenic implant, produced greater ($P <.05$) mean percentages of dark cutters per pen than heifers reimplanted with either androgens or combination (androgen and estrogen) growth promotants. Furthermore, heifers produced higher ($P < .05$) mean percentages of dark cutters per pen than steers during periods of hot (> 35°C) weather 2 to 1 d before harvest. Steers, when treated with a combination (androgen and estrogen) implant when entering the feedyard and as a reimplant, produced higher ($P <.05$) mean percentages of dark cutters per pen when compared to other moderate growth-promoting implant strategies. When producers opted to implant steers with estrogenic growth promotants, either as the cattle entered the feedlot or as a final reimplant before harvest, the occurrence of dark cutters was reduced from 9.2 per thousand cattle shipped to 2.0 and .5 per thousand cattle shipped, respectively. Producers that reimplanted heifers before harvest with products that were not primarily estrogenic reduced the occurrence of dark cutters from 10.4/1,000 cattle shipped to 5.2/1,000 cattle shipped when androgen-based growth promotants were used and to 3.5/1,000 cattle shipped when combination (androgen and estrogen) implants were administered. In addition to implant selection, those producers that held cattle on feed over 100 d past reimplantation reduced the incidence of dark cutters per pen by an average of 38% among heifers and 69% among steers. By reducing the occurrence of dark cutters, there is an opportunity for beef producers to realize large economic savings.

Key Words: Beef, Quality, Management, Values

Introduction

The 1995 National Beef Quality Audit (NBQA) reported that dark cutting beef carcasses (dark cutters) result in a loss of $6.08 per animal harvested in the United States (Smith et al., 1995). Dark cutters result from preharvest stress, which depletes muscle glycogen stores and thus reduces the glycogen needed to produce the lactic acid that reduces the pH of postmortem muscle. The abnormally high pH (>6.0) increases the light-absorption and water-binding abilities of postmortem muscle and results in an undesirable, dark, firm, and dry cut lean surface (Lister, 1988). Even though this is understood at the clinical level, the stress factors that induce the condition are not as clear. Weather, growth promotants, genetics, disposition, and handling practices before harvest all may play a role in creating the dark cutting condition (Hedrick et al., 1959; Smith et al., 1993; Voisinet et al., 1997).

Grandin (1992) and Smith et al. (1993) reported that the occurrence of dark cutting beef (DCB) is highest during very cold weather combined with precipitation, which increases the rate of body-heat loss and elicits shivering. The incidence of DCB is also high in very warm weather or when large fluctuations in temperature occur over short periods of time.

Hedrick et al. (1959), Grandin (1992), and Shackelford et al. (1994) reported that control of antemortem stress through proper management would be the most effective method to reduce the incidence of DCB.

Hedrick et al. (1959), Grandin (1992), and Smith et al. (1993) identified animal gender, biological type, use of growth promotants, and handling as potential contributors to an increased incidence of DCB. Therefore, the objective of this study was to use a large commercial database to identify and quantify management (biological type, implant type, and implant administration) and environmental factors that affect the incidence of DCB and to develop decision trees for use in the reduction of losses in carcass value as a result of DCB.

Experimental Procedures

Proprietary feedlot data were obtained from nine large commercial feedlots. Included in the database were pen size (number of cattle), on-feed weight, average daily gain, dry matter intake, growth promotant history (type and strategy), time from final implant to harvest (days), number of days on feed, hot carcass weight (HCW), USDA quality and yield grade distribution, and the number of dark cutters that resulted from each pen of fed cattle. Added to the database were climatic factors corresponding to each individual feedyard, such as minimum and maximum ambient air temperatures and precipitation on the day of harvest and at 1, 2, and 3 d before slaughter, that may have affected the incidence of dark cutters before harvest. Growth promotants were classified as androgen (Synovex-H®, Implus-H®, Finalplix-H/S® and Heiferoid®); estrogen (Synovex-S®, Ralgro®, Implus-S®, Compudose®, and Steeroid®); combination (Revalor-H/S®); double androgens (Finaplix® and Synovex-H®); and estrogen/combinations (Synovex-S®/Revalor®). Implantation strategies were determined by production combinations used in the surveyed feedlots and classified according to Beef Customer Satisfaction (BCS) (NLSMB, 1995). Intact heifers within this database were supplemented with melangesterol acetate at .05 mg/heifer/d during feeding with no withdrawal period before harvest.

Data were compiled for the period between June 1, 1993, through July 31, 1996 (n = 15,439 pens of cattle), encompassing 2,672,223 total cattle, which produced 18,106 dark cutters, and equaling $4,024,058.50 in losses ($1.51 per steer, heifer, or spayed heifer harvested in this study) as a result of nonconformance (USDA-AMS, April 14, 1996).

Statistical Analysis

Data were transformed using a square root function to eliminate heterogeneity of subclass variance during analysis. Transformed data were evaluated using the mixed models analysis of variance procedures of SAS (1996). Means and quantitative data are reported in the unit of measure in which data were collected (e.g., percentage of dark cutters per pen). Data were analyzed in a model that included the percentage of dark cutters per pen as the dependent variate, fixed independent effects of feedyard, gender, on-feed implant, reimplantation just before harvest, implantation strategy, and biological type (Brahman, British, Continental, Dairy [includes purebred dairy cattle and Holstein x Angus crossbred] and Mexican) and the random effects of time from final implant to harvest, maximum daily temperature, minimum daily temperature, and daily fluctuation between high and low temperatures (day of and 1, 2, and 3 d before slaughter). Continuous random variables (days from reimplantation to harvest, temperature, and precipitation) were grouped into fixed effect subclasses for analysis using frequency distributions that allowed determination of subclass ranges for each variate that represented natural points of segregation in the normal incidence of dark cutters (i.e., days from last implantation to slaughter and average high and low temperatures). Because of computing resource limitations, it was not possible to evaluate the simple ANOVA model that would have included all aforementioned variables and their interactions. Therefore, all effects were tested as single main effects and then sequentially entered into higher-order interaction models, partitioning single interactions within gender subclasses. Interactions were limited to third-order interactions for mean separation purposes; however, a fourth-order interaction was used to develop schematic management diagrams. Means were separated using pairwise comparisons of means SAS (1996).

Results

Feedyard

Mean percentages of dark cutters per pen differed ($P < .05$) between individual feedyards. This demonstrated that the incidence of dark cutters was partially due to different management philosophies or to structural attributes of the feedyards and suggests that, under proper management techniques, the incidence of dark cutters could be reduced (Table 1).

Table 1. Least squares means and confidence intervals for percentages of dark cutters per pen by individual feedyard

Feedyard	Percentage of dark cutters	95% Confidence interval
A	.64[w]	.53-.75
B	.20[x]	.17-.22
C	.44[w]	.36-.53
D	.08[yz]	.06-.10
E	.42[w]	.33-.52
F	.08[y]	.06-.11
G	.05[z]	.04-.06
H	.07[z]	.05-.09
I	.09[y]	.07-.11

[w,x,y,z] Means lacking a common superscript letter differ (P <.05).

gender

gender, which dictates numerous management practices, also contributed ($P < .05$) to the incidence of dark cutters (Figure 1). Intact heifers produced higher ($P < .05$) mean percentages of dark cutters across all pens and feedyards, which indicated a higher susceptibility for heifers to dark cutting than steers and spayed heifers. Owing to confounding of gender with other management decisions, all subsequent analyses were conducted by partitioning fixed and interactive effects within gender.

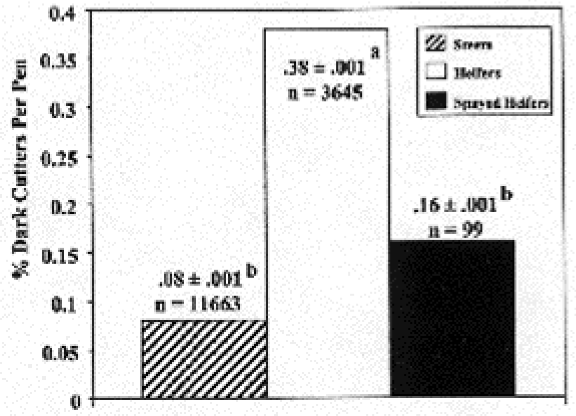


Figure 1. Least squares means for the incidence of dark cutters within an individual pen for steers, heifers, and spayed heifers. Means lacking common superscript letters differ ($P < .05$).

Implantation

Implants were classified similarly to those used in the Beef Customer Satisfaction project (NLSMB, 1995). Effects of the initial implantation, as cattle entered the feedyard, or the last, before harvest (reimplantation), on the incidence of dark cutters per pen were evaluated (Table 2).

Item	LS Mean ± SE for DC[b], %	No. of pens	Percentage of pens > 6% DC[f]
On-feed implant			
Steers			
Combination[c]	.84[y] ±.003	201	6.5
Estrogen[d]	.09[z] ±.001	968	.1
Heifers			
Androgen[e]	.60 ±.003	263	1.9
Combination	.65 ±.094	8	0
Estrogen	.27 ±.044	28	3.6
Reimplant given just before harvest			
Steers			
Androgen	.09[x] ±.001	4,455	.7
Combination	.20[w] ±.001	1,772	2.1
Estrogen	.03[y] ±.001	581	0
Heifers			
Androgen	.52[z] ±.001	1,177	5.6
Combination	.35[z] ±.029	31	3.2
Estrogen	1.04[y] ±.005	203	6.9

Table 2. Least squares means ± SE[a] for the percentage of dark cutters per pen by type of implant administered to steers and heifers as they were placed in the feedyard and underwent reimplantation before harvest.

[a] Standard error of the least squares means.
[b] Dark cutters (DC).
[c] Implants contained androgen and estrogen.
[d] Implants contained mostly estrogen.
[e] Implants contained mostly androgens.
[f] Pens with a greater than 6% incidence of dark cutters were considered epidemics and termed "blowouts."

Within steers, pens of cattle that were treated with implants containing androgens and estrogens (combination implants) as they entered the feedyard resulted in higher ($P < .05$) mean percentages of dark cutters per pen and a numerically higher proportion of pens that had a 6% or higher incidence of DCB than did steers treated solely with estrogen implants as they entered the feedyard. On-feed implants did not affect ($P > .05$) the mean percentage of dark cutters per pen within heifers (Table 2); however, heifers given an estrogenic implant as they entered the feedyard were associated with a numerically higher proportion of pens that produced a 6% or higher incidence level of DCB.

Table 3. Least squares means ± SE[a] for the percentage of dark cutters per pen by implantation strategy for steers and heifers and the proportion of pens above a 6% incidence level[b]

Implantation Strategy[c]	No. of pens	LS Mean ± SE of % DC[d]	Pens > 6% DC %
Steers			
Combination[e]/Combination[f]	165	.86[y] ±.003	7.88
Estrogen/Estrogen	553	.08[z] ±.009	0
Estrogen/Combination	61	.19[z] ±.008	1.64
Heifers			
Double Androgen/Androgen	6	.67[yz] ±.096	0
Androgen/Double Androgen	11	.26[z] ±.052	0
Androgen/Androgen	129	.54[yz] ±.001	3.1
Androgen/Combination	10	.54[z] ±.084	--
Androgen/Estrogen	46	1.66[y] ±.033	0
Estrogen/Estrogen	12	.92[yz] .134	8.33

[a] Standard error of the least squares means.
[b] Pens with a greater than 6% incidence of dark cutters were considered epidemics and termed "Blowout" pens.
[c] See Table 5 for strategy composition.
[d] Dark cutters (DC).
[e] Implant given as the cattle came on-feed.
[f] Implant given as reimplants before harvest (final implant).
[y,z] Means within gender class lacking common superscript letter differ ($P < .05$).

Pens of steers that were reimplanted with combination implants (androgens and estrogens) as the final implant before harvest exhibited a higher ($P < .05$) incidence of dark cutters and a greater numerical proportion of pens with more than a 6% incidence rate of dark cutters than did pens of steers that were administered either androgen or estrogen implants as the final implant before harvest (Table 2). Additionally, steers that were reimplanted with androgen had a higher ($P <.05$) mean incidence of DCB per pen than steers reimplanted with estrogen. Intact heifers treated with estrogenic implants as the reimplant produced higher ($P <.05$) mean percentages of dark cutters per pen and a greater proportion of pens with a 6% or higher incidence level of dark cutters than pens of intact heifers that were treated with either androgen or combination (androgen and estrogen) implants as the final implant before harvest (Table 2).

Implantation strategies were constructed using the on-feed implant type and reimplant type, thus developing implantation strategies administered during the time on feed. Mean percentages of dark cutters per pen by implant strategy are reported in Table 3. Steers treated with combination on-feed implants, followed by combination reimplants, showed a higher ($P <.05$) mean percentage of dark cutters per pen and a higher percentage of pens over a 6% incidence level of DCB than either steers given a estrogen on-feed implant followed by a estrogen reimplant or given an estrogen on-feed implant followed by a combination (androgen and estrogen) reimplant. Implantation strategies using estrogen as the reimplant in heifers had a higher ($P <.05$) percentage of dark cutters per pen than strategies that used either combination or double androgen reimplantation treatment. Moreover, 8.3% of heifers treated with an estrogen on-feed implant followed by an estrogen reimplant before harvest had over a 6% incidence level of DCB.

As the duration between final implant and harvest increased (>100 d), mean percentages of dark cutters per pen declined ($P < .05$) across all genders and implant types, except for steers reimplanted with androgens and heifers administered estrogen as a reimplant before harvest (Table 4). Pens of steers implanted with androgens less than 100 d before harvest had lower ($P <.05$) mean percentages of dark cutters than pens of steers left on feed longer than 100 d from receiving the last implant. Overall, these data indicated that cattle tended to have a lower incidence of DCB per pen when the duration from reimplantation to harvest was longer than 100 d.

Table 4. Least squares means ± SE[a] for the percentage of dark cutters per pen by the reimplant treatment before harvest and the time between the reimplantation and harvest for steers and heifers

	Mean percentage of dark cutters per pen	
Last Implant	**< 100 d[b]**	**> 100 d**
Steers		
Androgen[c]	.02[z] ±.021	.19[wx] ±.02
Combination[d]	.32[w] ±..001	.17[x] ±..001
Estrogen[e]	.09[y] ±.001	.07[z] ±.001
Heifers		
Androgen	.58[u] ±.001	.42[v] ±.001
Combination	1.74[s] ±.011	.50[uv] ±.003
Estrogen	.92[t] ±.002	.78[t] ±.002

[a] Standard error of the least squares mean.
[b] Time (d) from receipt of final implant to harvest.
[c] Implants contained androgens and were admimstered when cattle were placed in the feedyard.
[d] Implants contained androgen and estrogen and were administered as cattle were placed in the feedyard.
[e] Implants contained estrogen and were administered when cattle were placed in the feedyard
[s,t,u,v,w,x,y,z] Means within and across subclass lacking common superscript letters differ ($P < .05$).

Environment

For intact heifers, maximum temperatures from 2 d and 1 d before harvest were averaged, and, during periods when this measurement was above 35°C, they produced higher ($P <.05$) percentages of dark cutters per pen than when the average maximum temperatures 2 d to 1 d before harvest were below 35°C (Figure 2). Among steers and spayed heifers, average maximum temperatures above 35°C from 2 d to 1 d before harvest increased the percentage of dark cutters per pen as compared with periods when the average maximum temperatures 2 d to 1 d before harvest were below 35°C; but these differences were not ($P> .05$) significant. When average temperatures were below 0°C 2 d to

1 d before harvest, heifers had a higher (P < .05) incidence of DCB than when temperatures were above 0°C and only when precipitation was greater than 5.0 mm. Average temperatures below 0°C 2 d to 1 d before harvest had no effect (P > .05) on the incidence of dark cutters within steers (Table 5).

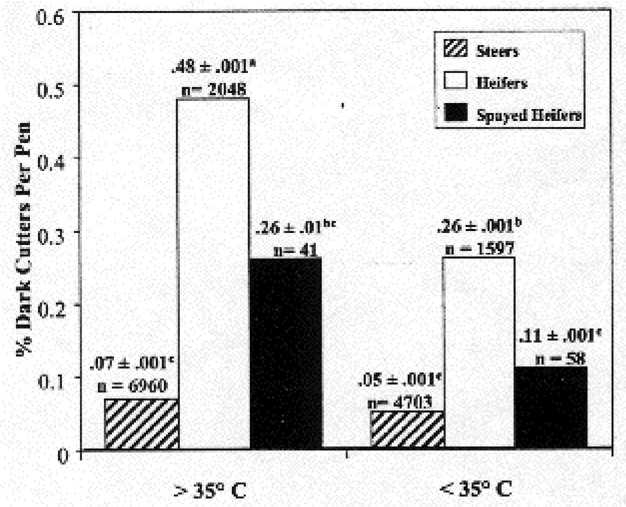


Figure 2. Least squares means for the incidence of dark cutters within an individual pen during periods of hot (>35°C), average, and high daily temperatures from 2 to 1 d before harvest for steers, heifers, and spayed heifers. Means lacking common superscript letters differ (P < .05).

Table 5. Least squares means ± SE[a] for the percentage of dark cutters per pen stratified by average minimum air temperatures and accumulated precipitation 2 to 1 d before harvest

Item	Temp.[b] > 0°C, Prec.[c] < 5.0 mm	Temp. > 0°C, Prec. > 5.0 mm	Temp. < 0°C, Prec. < 5.0 mm	Temp. < 0°C, Prec. > 5.0 mm
Steers	.07[z] ±.001	.04[z] ±.002	.06[z] ±.001	.08[z] ±.002
Heifers	.39[yz] ±.001	.21[z] ±.001	.46[y] ±.005	.50[y] ±.001
Spayed Heifers	.13[z] ±.001	.33[yz] ±.001	.27[yz] ±.006	.02[z] ±.068

[a] Standard error of the least squares means.
[b] Average minimum daily temperature (above or below 0°C) 2 to 1 d before harvest.
[c] Total accumulated precipitation (above or below 5.0 mm) 2 to 1 d before harvest.
[y,z] Means across and within subclasses lacking common superscript letters differ (P < .05).

Temperature fluctuations at 1, 2, and 3 d before harvest are presented in Table 6. Twenty-four hours before harvest, when the absolute difference between the daily high and low temperature was greater than 5.6°C, the incidence of dark cutters within steers was higher (P < .05) than in periods when the absolute difference between the daily high and low temperature was less than 5.6°C. At both 2 and 3 d before harvest, when daily temperature fluctuations were above 5.6°C, heifers showed a higher (P <

.05) mean incidence of dark cutters per pen, which indicated that large temperature changes over a short period of time (1 to 3 d) induce stress and increase the incidence of dark cutters.

Table 6. Least squares means ± SE[a] for the percentage of dark cutters per pen stratified by absolute daily temperature fluctuation at 1, 2, and 3 d before harvest

	1 d[b]	2 d	3 d
Steers			
< 5.6°C[c]	.03[z] ±.001	.03[y] ±.002	.04[z] ±.002
> 5.6°C	.07[y] ±.001	.07[y] ±.001	.07[z] ±.001
Heifers			
< 5.6°C[c]	.30[x] ±.004	.12[y] ±.006	.21[y] ±.005
> 5.6°C	.39[x] ±.001	.40[x] ±.001	.40[x] ±.001

[a] Standard error of the least squares means.
[b] Time (days) before harvest fluctuations were measured.
[c] Absolute temperature difference between daily high and low temperatures.
[x,y,z] Means within time period lacking common superscript letters differ ($P < .05$).

Discussion

Owing to the significant effect of feedyard on the incidence of dark cutters per pen, it became apparent that DCB was affected by differing management philosophies, facility construction, and cattle-handling procedures. These findings were consistent with those of Hedrick et al. (1959), Grandin (1992), and Smith et al. (1993), who identified management practices that are unique to feedyards, such as handling and working facilities, as factors that are potentially stressful to cattle. Therefore, improved facilities, handling practices, and cattle management can reduce the occurrence of dark cutters in commercial feedlots.

Factors in this study that had the greatest influence on the incidence of dark cutters seemed to be gender and the aggressive use of growth promotants. It was clear that heifers present a higher inherent risk of becoming dark cutters than do steers or spayed heifers. Studies by Fleming and Luebke (1981), Voisinet et al. (1997a), and Voisinet et al. (1997b) all found that females had a more excitable temperament and that fearfiilness was greatest in nulliparous females. Additionally, Voisinet et al. (1997) found that heifers had a higher ($P < .05$) incidence of 'borderline" dark cutters. This could explain why females, especially those given exogenous estrogen, in the present study seemed to be much more susceptible to dark cutting epidemics (pens > 6% DCB). Flemming and Luebke (1981) associated this behavior with the fact that estrogen secretion in parous females is lower than estrogen secretion in nulliparous females, which were found to be more excitable.

Implants have been under suspicion for promoting carcass quality defects since their introduction (Grandin, 1992). Because implants modify growth curves, rates of gain, and nutrient requirements of beef cattle through hormonal changes, adding other sources of stress to hormonal shifts ultimately could increase the risk of dark cutters. Administering combination (androgen and estrogen) implants to steers and estrogen implants to heifers, especially as reimplants before harvest, seemed to inflate the manifestation of stress and ultimately lead to an increase in the incidence of dark cutters.

Environmental factors also played a role in the occurrence of dark cutters. These results paralleled reports by Smith et al. (1993) and Grandin (1992), who reported higher incidences of dark cutters during periods of adverse weather conditions. Management decisions should include environmental factors that could be encountered at the time of harvest, such as extremely hot or cold weather or large temperature fluctuations, and cattle should be managed accordingly to reduce the risk of incurring DCB.

The factors evaluated in this study all additively increased the risk of incurring dark cutters and must be comanaged to optimize these findings. Taking into account all of the factors found to influence the occurrence of dark cutters, decision trees were developed for steers and heifers that present the risk of incurring dark cutters out of 1,000 cattle given specific production factors (Figures 3 and 4). These flow diagrams provide a quick reference for quantifying the risks associated with gender and implantation decisions and the impact that hot (>35°C) weather has on the occurrence of dark cutters. For instance, high risk takers that feed steers would utilize a combination onfeed implant followed with a combination reimplant before harvest. In addition to aggressive use of growth promotants, the time period from reimplant to harvest would be less than 100 d. This management scheme would increase the risk of incurring dark cutters from .8 per 1,000 steers shipped to 13 per 1,000 steers shipped. Furthermore, this could be compounded if the average maximum temperature 2 d to 1 d before harvest is above 35°C; the risk is again increased by 3 per 1,000 steers shipped, totaling a risk of incurring dark cutters of 16 per 1,000 steers shipped (a 20-fold increase in risk). Even though it is an apparently low-percentage risk (1.6%), real economic losses will continue to mount, potentially 20-fold greater than if the incidence of DCB is minimized.

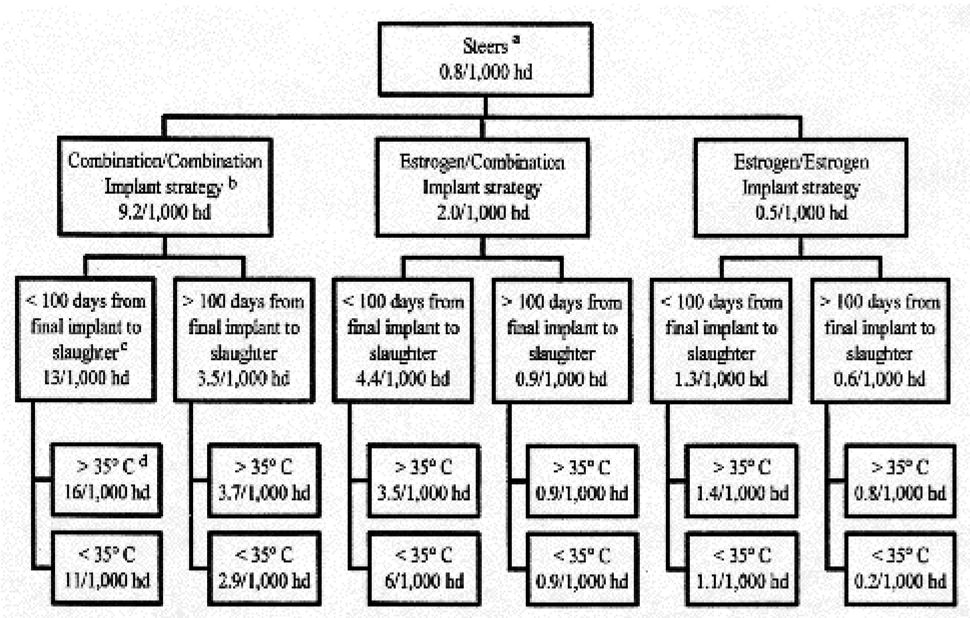


Figure 3. Management guidelines that indicate the risk of incurring dark cutters per 1,000 steers shipped under individual management schemes. The hierarchy utilized [a]gender, [b]implant strategy, [c]days from final implant to harvest, and [d]average maximum daily temperature 2 to 1 d before harvest.

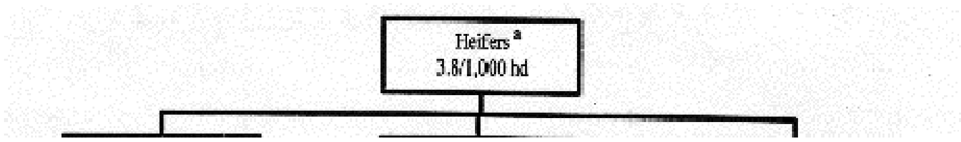


Figure 4. Management guidelines that indicate the risk of incurring dark cutters per 1,000 heifers shipped under individual management schemes. The hierarchy utilized [a]gender, [b]final implant, [c]days from final implant to harvest, and [d]average maximum daily temperature 2 to 1 d before harvest.

Implications

These data suggest that the use of estrogenic reimplants before harvest in heifers and combination (androgen and estrogen) implants used singly in steers, either as they enter the feedlot or as reimplants before harvest, or the use of combination onfeed, combination reimplantation strategies increases the risk of incurring dark cutting beef (DCB). Additionally, the time from reimplantation to harvest should extend past 100 d to minimize carcass nonconformance that results from DCB. Feedlot management practices should also incorporate seasonal climatic trends (hot weather and large temperature changes) at the time of harvest when determining implant administration. In addition, the use of good handling practices, well-designed handling facilities, and proper shipping practices must also be used. By optimally combining these factors, producers can continue to optimize growth performance with the use of moderate growth-promoting implants but at the same time reduce economic losses and carcass nonconformance that are due to DCB.

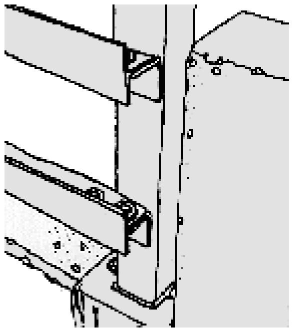
A full copy of this paper and list of references is available at:
http://www.grandin.com/references/dark.cutters.html

Economic Advantages of Good Animal Welfare

Careful, quiet handling of livestock by trained people in good facilities will reduce bruising and help maintain meat quality.

- Bruises cost the U.S. beef industry $1.00 per animal on feedlot beef and $3.91 per animal on cows and bulls (Colorado State University, 1992; 1995).

  Example of a bad fence corner. Notice the protruding sharp edges that could cut an animal as well as cause serious bruising.



- In Australia, bruises cost the beef industry $36 million annually (Blackshaw et al., 1987).
- The U.S. pork industry loses $0.34 per pig due to PSE and $0.08 per pig due to bruises (National Pork Producers' Association, 1994).
- Improvements in pig handling and reductions or elimination of electric prods will reduce petechial haemorrhages (Calkins et al., 1980).

Instead of prods, the handler is using a plastic paddle.

Cattle being moved effectively with plastic ribbons tied to the end of a stick instead of an electric prod.

- Improving animal welfare can also improve employee safety because calm cattle are less likely to run over employees or rear up.

Corporations Can be Agents of Great Improvements In Animal Welfare and Food Safety and the Need for Minimum Decent Standards

By
Temple Grandin, Ph.D.
Paper presented at National Institute of Animal Agriculture, April 4, 2001

In 1996 I conducted a survey for the USDA in handling and stunning practices in 24 federally inspected plants in 10 different states. Ten beef packing plants were surveyed. Out of these 10 plants only 3 of them (30%) were able to stun 95% or more of the cattle with a single shot (Grandin, 1997a). Four plants (40%) did poorly due to poor maintenance of stunning equipment. There was much evidence of a lack of management supervision in the stunning room. In three beef plants (30%) there was severe abuse of cattle. There was excessive use of electric prods, paralyzing bulls with electricity to hold them still and shoving downed, crippled cows with a forklift (Grandin, 1997a). Conditions improved greatly when McDonald's Corporation started their plant auditing program.

McDonald's Audits

In 1999 McDonald's Corporation started auditing handling and stunning practices in the plants that supply them with beef. They used a scoring system that I developed for the American Meat Institute (Grandin 1997b) and I trained the HACCP food safety auditors from their grinder suppliers to do handling and stunning audits. The results of the McDonald's audits clearly showed huge improvements (Grandin 2000). Now 90% of the plants were able to stun 95% or more of the cattle with a single shot (www.grandin.com, www.mcdonalds.com). Most of the very abusive behavior of employees has stopped and in many plants electric prod use has been reduced or eliminated. Electric prods have been replaced with other driving aids such as flags. The year 2000 audits clearly indicated that the improvements have been maintained.

I have been working in the meat industry for more than 25 years and I saw more improvements in 1999 than I have seen in my entire career. I have designed handling facilities and have consulted on animal handling for most of the major meat companies. During 1999 I visited 27 pork and beef plants to conduct McDonald's audits and train auditors. The good news is that the vast majority of plants did not have to make expensive capital improvements to pass the audits. Small changes such as installation of a non-slip floor grating in a stunning box or changing lighting to reduce the frequency of animals balking and backing up were often the only equipment changes needed (Grandin 1998c, 2000b). Over half of all the improvements were brought about by motivating management to actively supervise handling and stunning. There were also benefits in reduced bruises, less PSE (pale, soft pork) and fewer gaps in the production line.

The industry became serious about improving handling and stunning after McDonald removed one large plant from the approved supplier list and suspended several others for varying lengths of time. Both McDonalds and Wendys are conducting audits of handling stunning. During my travels in the U.S. I have observed that the cleanliness of meat plants is better in plants that are audited by McDonalds or Wendys compared to plants that are not audited. Audits by restaurant companies have raised both food safety and animal welfare standards.

Handling and Stunning Audit Procedures

The American Meat Institute guidelines use a critical control point approach for objectively scoring handling and stunning. This objective method provides more uniform results between different auditors than welfare audits that contain no hard data. Depending on the size of plants, 50 to 100 cattle or pigs are scored on the following variables:

1) 1) Percentage of animals stunned correctly on the first attempt.
2) 2) Percentage of animals that remain insensible and unconscious on the bleed rail. Fail if less than 100%.
3) 3) Percentage of cattle that vocalize (moo or bellow) during movement through the chutes and stunning. Vocalization is a measure of distress or aversive events such as prodded with an electric prod or missed stuns (Dunn 1990, Grandin 1998b, 2001, Warriss et al., 1994, Watts and Stookey, 1998 and White et al., 1995).
4) 4) Percentage of animals prodded with an electric prod.
5) 5) Percentage of animals that slip or fall.

Each variable is scored on a yes/no basis for each animal. The auditors also walk through the yards and unloading area and note problems with poor maintenance, overcrowded holding pens, slick floors, etc. A good auditing system should have a combination of hard data scores and a more subjective "walk through" evaluation. The American Meat Institute has conducted training seminars on handling, stunning, and implementing the guidelines during the last three years.

Third Party Auditing

Currently each restaurant company is conducting their own audits for both food safety and animal welfare. In other countries, auditing companies have been formed to perform the audits so that a plant is not inundated with auditors from many different companies. Third party auditing will evolve. Currently, I have compiled data from the last two years of McDonald's audits and have published a summary of the results which presents an overall state of the industry. Individual plant names are kept confidential (www.grandin.com). During 2000 and 2001 I have continued to work with several companies to train auditors. To keep this auditing system calibrated, I plan to pick several meat plant names at random from their restaurant supplier lists for audits that I will conduct. I favor random choice of these calibration plants so that my knowledge of the industry does not influence where I go.

What Would the Public Think?

Being a practical person I base standards of animal treatment on what would the general public accept. I have taken many non-meat industry people to a well run slaughter plant and most people found it was acceptable. It is essential to fully explain disturbing sights such as stunned animal movement. It is important that the visitor has the opportunity to watch cattle going up the ramp for at least 15 minutes so that they see that the cattle remain calm. Producers need to ask themselves what would the public think? How would ten people picked at random from an airport or bus station react to animal rearing, transport or slaughter practices?

My background in working with animals is in cattle and pigs. When I visited a large egg layer operation and saw old hens that had reached the end of their productive life, I was horrified. Egg layers bred for maximum egg production and the most efficient feed conversion were nervous wrecks that had beaten off half their feathers by constant flapping against the cage. Half naked hens are not going to be acceptable to most people. This operation would fail the people from the airport or bus station test.

I showed a picture of the half naked spent hens to over 100 undergraduate students in animal science and biology classes. Before the slide was shown I asked the students to vote for one of the following categories: 1) totally ok, 2) somewhat disturbed or 3) totally grossed out. The students voted two-thirds somewhat disturbed and one-third totally grossed out. One girl raised her hand and said, "I worked at layer farms, those are good spent hens." Only one biology student thought the spent hens were totally ok. When I showed the pictures I was careful not to bias the students. I explained the voting categories while I was showing a slide of nice looking young hens in a battery cage.

Some egg producers got rid of old hens by suffocating them in plastic bags or dumpsters. The more I learned about the egg industry the more disgusted I got. Some of the practices that had become "normal" for this industry were overt cruelty. Bad had become normal. Egg producers had become desensitized to suffering.

There is a point there economics alone must not be the sole justification for an animal production practice. When the egg producers asked me if I wanted cheap eggs I replied, "Would you want to buy a shirt if it was $5 cheaper and made by child slaves?" Hens are not human but research clearly shows that they feel pain and can suffer.

Need for Balanced Approach

Fraser (2001) states that some scientists who defend animal practices tend to gloss over the ethical issues. He provides the example of North and Bell (1990) which is a textbook on egg production. This book fails to address the ethical concerns of the death losses which occur when feed deprivation is used to force molt hens. Fraser (2001) is a very thoughtful and objective article which discusses the need to obtain accurate information and to stop simplistic polarized views on both sides of welfare and environmental issues. Below is the abstract of Fraser's paper.

"A growing popular literature has crated a "New Perception" of animal agriculture by depicting commercial animal production as 1) detrimental to animal welfare, 2) controlled by corporate interests, 3) motivated by profit rather than by traditional animal care values, 4) causing increased world hunger, 5) producing unhealthy food and 6) harming the environment. Agricultural organizations have often responded with public relations material promoting a very positive image of animal agriculture and denying all six of the critics' claims. The public, faced with these two highly simplistic and contradictory images, needs knowledgeable research and analysis to serve as a basis for public policy and individual choice. Scientists and ethicists could provide such analysis. In some cases, however, scientists and ethicists have themselves produced misleading, polarized, or simplistic accounts of animal agriculture. The problems in such accounts include the repetition of unreliable information from advocacy sources, use of unwarranted generalizations, simplistic analysis of complex issues, and glossing over the ethical problems. The New Perception debate raises important and complex ethical issues; in order to provide useful guidance, both scientists and ethicists must consider these issues as research problems that are worthy of genuine investigation and analysis." (Fraser 2001)

Minimum Decent Standards

Throwing live hens in the garbage is a practice that the vast majority of the public would condemn. I predict that animal welfare standards will evolve into two categories. A minimum decent standard for large scale commercial use and higher welfare standards for niche markets with higher income consumers. Throwing live hens in the trash violates most people's idea of minimum decent standards. It is my opinion that the new McDonald's standards for egg laying hens are a minimum decent standard that the egg industry really needed. Previously each hen was provided with the space equal to a half of sheet of paper. The new space standard for caged layers provides enough space for all the hens to roost at one time and feed deprivation to induce molting is banned.

An example of a higher welfare standard for hens would be free range hens. The acceptable ratings published in the American Meat Institute guidelines is another example of a minimum decent standard. Minimum decent standards need to be implemented worldwide.

The Sow Stall Question

Whereas throwing live hens in the trash or beating an animal are clear-cut violations of most people's idea of a minimum decent standard the issue of sow stalls is less clear-cut.

I conducted informal conversations with airline passengers who sat beside me on the subject of sow gestation stalls. People are disturbed by the fact that the sow cannot turn around. A typical comment was it just "does not seem right." Each passenger was shown photos of gestation stalls and pictures of pigs housed in groups on a concrete slotted floor. Most people thought that the pigs on the concrete slotted floor were acceptable. Opinions on the gestation stalls were: 1/3 (no opinion); 1/3 (mildly opposed) and 1/3 (very opposed to the stalls) which prevented the sow from turning around.

There are many issues where decisions will have to be made to determine what will be acceptable for a minimum decent standard. Science can provide many answers, but ethics must also be considered. It is my opinion that an animal not being able to turn around for most of her life is not going to be acceptable to the public.

Barnett et al. 2001 provides an excellent review of the scientific literature on welfare of sows in different housing systems. This paper has over 200 references. They conclude that "The consequences for welfare of housing pigs in stalls for varying durations should be evaluated. Because stalls housing is a controversial issue from the view of public perception,, but may have reproductive and welfare advantages, housing in stalls for a defined period that is considerably less than the period of gestation may be a reasonable compromise." The main criticism I have of Barnett et al. (2001) is that genetic factors on behaviors such as aggression are not reviewed. Indoor group housing systems are likely to have greater success if less aggressive types of pigs are used. The author has observed that different genetic lines of group housed sows in the same building will have different amounts of injuries and abnormal behavior such as belly rubbing and ear sucking. Large groups of over a hundred sows may help reduce aggression. The author has observed that large groups of over a hundred finishing pigs, which have been mixed from different pens, engage in relatively little fighting. After the pigs arrive at the packing plant, they usually lie down quickly. There is a need for research on genetic factors. However, practical experience has shown that group housing systems will be more successful if pig genetics is taken into consideration.

Summary

1. 1. Corporate purchasing power has been used to greatly improve conditions for animals.
2. 2. The American Meat Institute guidelines are being successfully used to objectively score conditions in slaughter plans by McDonald's and Wendy's. A good auditing system uses a combination of objective scores and subjective measures.
3. 3. Animal welfare standards will evolve into two categories:
   - a. a. Minimum decent standards which would be acceptable to most members of the public. Examples – McDonald's laying hen guidelines and American Meat Industry guidelines at the acceptable level.
   - b. b. Higher welfare standards for niche markets with higher income consumers such as free range hens.
4. a. Improving welfare during handling, slaughter and transport is a win-win situation. Where there is often an economic advantage. A combination of audits and incentive programs can be used to reduce damage to animals.

   b. Implementing minimum decent standards for animal production may have economic costs and reasonable economic costs should be considered a cost of doing business. Both scientific data and ethical concerns should be used to make decisions about animal housing.

A full copy of this paper and list of references is available at: http://www.grandin.com/welfare/corporation.agents.html

2005 and 2006 McDonald's Animal Welfare Audits of Stunning and Handling of Beef Cattle in Australia and New Zealand

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The performance of the beef plants in Australia and New Zealand is very similar to the U.S. A summary of the average scores on the five core criteria are shown in Tables 1 and 2.

Table 1: Summary of Australia Beef Animal Welfare Audits

	2002	2003	2004	2005	2006
Stunning Efficiacy First Shot	95.9%	98.0%	98.1%	97.2%	98.3%
Vocalization	0.0%	4.3%	2.6%	2.4%	2.7%
Bleed Rail Insensibility	100.0%	100.0%	99.9%	99.9%	100.0%
Dragging of Sensible Animals	0.0%	0.0%	0.1%	0.0%	0.0%
Slipping or Falling During Handling	0.5%	0.9%	0.2%	0.4%	0.3%

Use of Electric Prod	24.3%	16.6%	17.9%	13.7%	15.0%

Table 2: Summary of New Zealand Beef Animal Welfare Audits		
	2005	**2006**
Stunning Efficiacy First Shot	98%	99%
Vocalization	2%	2%
Bleed Rail Insensibility	100%	100%
Dragging of Sensible Animals	0%	0%
Slipping or Falling During Handling	1%	0%
Use of Electric Prod	20%	22%

The average percentage of cattle stunned correctly on the first shot is almost identical in the U.S. and Australia. However, out of 39 Australia beef plants, 2 plants (5%) had a serious problem with stunning, and less than 90% of the cattle were stunned on the first shot (Table 3).

Table 3: Stunning Efficacy First Shot					
	2005		**2006**		
Stunning Efficacy First Shot	**Number of Plants**	**% of Plants**	**Number of Plants**	**% of Plants**	**Variance from 2005**
99% to 100% - Excellent	17	45%	20	74%	29%
95% to 98% - Acceptable	16	42%	5	19%	-24%
90% to 94% - Not Acceptable	3	8%	1	4%	-4%
Less than 90% - Serious Problem	2	5%	1	4%	-2%

Both Australia and New Zealand did a good job of making sure that all the cattle were insensible. In both Australia and New Zealand the eye reflexes are routinely checked before plugging the weasand (esophagus). Their procedures for blocking the weasand are not done in the U.S. The three Australian beef plants I visited had stunning scores of 100%, 95%, and 98%. All cattle (100%) were rendered insensible. The five Australian plants that did poorly on the stunning audit may have done so partially due to small sample sizes. In small plants sometimes less than 20 cattle are scored. Eighty-eight percent of the Australian plants passed the vocalization audit (Table 4).

Table 4: Vocalization					
	2005		**2006**		
Vocalization	**Number of Plants**	**% of Plants**	**Number of Plants**	**% of Plants**	**Variance from 2005**
0% to 1% -	17	44%	14	52%	8%

Excellent					
2% to 3% - Acceptable	12	31%	8	30%	-1%
4% to 5% - Borderline Acceptable	5	13%	2	7%	-5%
6% to 10% - Not Acceptable	3	8%	2	7%	0%
Over 10% - Serious Problem	2	5%	1	4%	-1%

The three beef plants I visited had vocalization scores of 1%, 0%, and 7%. The 7% score was in a plant that handled newly weaned pasture raised veal calves weighing about 400 lbs (180 kb). They had been removed from their mothers before coming to the plant. Their vocalizations were mostly not associated with an obvious aversive event such as electric prods.

Table 5 shows a combined slipping and falling score. Only one plant failed in slipping and falling. In the three plants I visited, the scores for falling were 0%, 0%, and 0%.

Table 5: Slipping or Falling During Handling

	2005		2006		
Slipping or Falling During Handling	**Number of Plants**	**% of Plants**	**Number of Plants**	**% of Plants**	**Variance from 2005**
0% to 1% - Excellent	35	90%	26	96%	7%
2% to 3% - Acceptable	2	5%	1	4%	-1%
4% to 5% - Borderline Acceptable	1	3%	0	0%	-3%
6% to 10% - Not Acceptable	1	3%	0	0%	-3%
Over 10% - Serious Problem	0	0%	0	0%	0%

Table 6 shows the scores for electric prod use. Ninety-two percent of the Australian plants passed. In the three plants I visited, the electric prod scores were 19%, 0%, and 8%.

Table 6: Use of Electric Prod

	2005		2006		
Use of Electric Prod	**Number of Plants**	**% of Plants**	**Number of Plants**	**% of Plants**	**Variance from 2005**
Under 5% -	10	26%	4	15%	-11%

Excellent					
6% to 25% - Acceptable	26	67%	18	67%	0%
26% to 50% - Not Acceptable	3	8%	5	19%	11%
Over 50% - Serious Problem	0	0%	0	0%	0%

Tables 1 and 2 show the average electric prod scores for New Zealand were slightly higher than in Australia. This may be partially due to large numbers of Holstein dairy cattle. These animals are slower and sometimes more difficult to move. This is the reason why the guideline allows an electric prod to be used on 25% of the animals.

Areas That Need Improvement

The pattern of how practices improve is similar in the U.S. and Australia. Handling in the stunning chute is the first area to improve because it is being scored. In both the U.S. and in Australia the monitoring of truck drivers was the next area that had to be improved. In two of the plants I visited, training of truck drivers needed improvement. They need to be taught that a non-electrified tool should be their primary driving tool. Electric prods should be banned for unloading trucks; but they may still be required to move stubborn cattle into the stun box. Unloading ramps also need to be inspected more carefully. In one plant, a non-slip floor grating had been built wrong and it pulled off the animals' due claws. The rods on a non-slip floor grating must be welded so that the entire rod mat lays flat. This design prevents damage to hooves and dewclaws. The rods must never be criss-crossed on top of each other.

Another area that needs improvement is weaning methods for pasture raised veal calves. Weaning by putting them on a truck is highly stressful. Pre-weaning methods need to be developed. This will have to be done carefully to avoid an increase in sickness. This is one area that will need to be researched. The use of low stress weaning methods such as fenceline weaning needs to be investigated.