Review on arrival and lairage management at pig slaughterhouses

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1. Executive Summary

The general requirement of the **Council Regulation (EC) No 1099/2009 on the protection of animals at the time of killing** is that each pig arriving and handled at the slaughterhouse shall be spared any avoidable pain, distress and suffering. This review highlights the following three key areas relevant for animal welfare: arrival management, handling and moving in lairage, and comfort around resting. After arrival at the slaughterhouse, in addition to preslaughter-stress, pigs are confronted with an entirely new environment which they have to cope with. Technical hazards, such as steep ramps, slippery and uneven floors, and unsuitable pathways but also rough handling in lairage, can cause fear and distress resulting in pigs stopping, turning back, slipping and falling. To maintain a constant speed of the slaughter line, pigs hesitating and stopping can result in staff applying undesirable means to speed up the process, thereby increasing the risk of fear and/or pain and distress for the pigs. Pigs can be slaughtered with or without housing in lairage pens before slaughter. The purpose of lairage pens in slaughterhouses is to give pigs a chance to rest following arrival to the slaughter plant and to provide a reservoir of animals aimed at maintaining a constant speed of the slaughter line, thus avoiding pigs having to be rushed from trucks to stunning. In addition, slaughtering calm and rested pigs has a positive effect on meat quality. The lairage facilities have to be designed in such a way that they meet the pigs' biological needs. Undesirable situations in lairage pens, such as extreme ambient temperatures or poor air quality, lack of supply of water or feed, negative social behaviours caused by mixing or lack of space can lead to fear, pain or distress. Assessing validated animal welfare indicators can improve the standard of inspections in lairage of slaughterhouses as they serve as risk indicators for animal welfare issues. Animal-based indicators such as falling, slipping or turning back represent practical clinical outcome-based measurements for inspectors and business operators and can help to identify and manage animal welfare problems, and support the evaluation of compliance with the legal framework of Council Regulation (EU) No 1099/2009.

2. Introduction

To evaluate compliance with animal welfare requirements, animal welfare inspectors mainly assess resource- and/or management-based indicators in accordance with the Council Regulation (EC) No 1099/2009. In recent years, Welfare Quality® (Welfare Quality®, 2009) protocols and Temple Grandin's slaughterhouse audit system are receiving more attention, as both focus mainly on animal-based indicators applying measurable and objective outcome-based criteria to evaluate welfare. Welfare Quality® refers to the following four areas relevant to farm animals' welfare: good feeding, appropriate behaviour, good health and good housing. These are also relevant for pigs at arrival at the slaughterhouse, during handling and moving in lairage and for comfort around resting in lairage pens.

Pigs shall be unloaded as quickly as possible from trucks aligned with legal animal welfare requirements to prevent prolonged periods on trucks and the associated risk of an increasing degree of distress. Arrival management must be managed accordingly. Concerning animal-human interactions, pigs should be handled as sentient beings, thus respecting their behavioural needs and the stress they are coping with on the day of slaughter. Respectively, the layout and construction of lairage should encourage pigs to move freely within lairage passageways and races to the stunning area. The size of groups being moved, ramps for unloading, the layout of lairage, lighting management, surfaces of floors, the level of noise and airflows and handling of animals are significant for pigs' ease of movement.

The majority of pigs are housed in lairage pens before being moved to the slaughter line. In order to ensure resting and to minimise potential aversive behaviour in lairage pens, climate in lairage, supply of water and food, maintaining familiar pigs in groups and ensuring adequate space are essential prerequisites. It is essential for inspectors and business operators to understand the behaviour and emotional conditions of pigs in order to differentiate between behaviour that can be determined as ' normal coping behaviour' for the circumstances at the slaughterhouse or behaviour that indicates the prevalence of animal welfare issues.

Animal-based indicators are appropriate tools to assess animal welfare in lairage of slaughterhouses for the areas defined in the Welfare Quality® protocol. In this review, the following three relevant key areas and corresponding animal welfare indicators are described: unloading, handling and moving in lairage and comfort around resting in lairage pens. This review does not deal with the stunning and slaughter process itself.

3. Knowledge of pig behaviour relevant for animal welfare inspections at pig slaughterhouses

Inspections take place on a daily basis in slaughterhouses according to Council Regulations (EC) No 853/2004 and No 2017/625, which address the legal requirements, amongst others, for food safety, animal welfare and animal health. Pigs tend to be inspected for the first time upon arrival at the slaughterhouse and during *ante mortem* inspections. Furthermore, the results of *ante* and *post-mortem inspections* and the assessment of animal-based indicators upon arrival at the slaughterhouse reveal standards of housing and handling of pigs prior to slaughter.

Moving: Pigs have a well-developed sense of smell, and their curiosity and poor eyesight are significant biological attributes, which must be considered during handling and for technical constructions and layouts of unloading docks and lairages in slaughterhouses. Pigs have a pronounced exploratory behaviour. Their snout contains a net of sensitive nerves providing an excellent surface with high sensitivity and ability to smell. They apply these senses to investigate their surroundings. Conditions during pre-slaughter processes and at the slaughterhouse are diverse and unknown to pigs and, given the opportunity during unloading and in passageways, they will investigate their surroundings by sniffing and stopping. The pig's sense of vision is less well developed. They have a panoramic vision of 310º and binocular vision of 35-50º. This means that, compared to humans, pigs prioritise their lateral monocular vision which increases their panoramic vision (greater capacity for detecting possible danger, food, other pigs, etc.) and decreases their bifocal vision (greater difficulty for calculating distances) (Dalmau et al., 2009). Therefore, optical irregularities, such as shadows, rays of light or other optical distractions, can have a significant effect on pigs' willingness to move forward.

Pigs are able to locomote by walking, trotting or galloping. Walking is the type of locomotion shown by relaxed animals. They generally prefer to move in small groups (5-7 pigs) beside and behind each other, often lead by a certain pig. This is important to bear in mind when pigs are unloaded from trucks down steep ramps and moving in passageways of the slaughterhouse. If the floors are slippery or uneven or ramps are steep, pigs may have to be pressurised by the staff to move off the truck and, due to stress and fear, may attempt to escape and slip or fall. Pigs may express fear by turning back or through high pitch vocalisation.

Thermoregulation: Pigs are particularly sensitive to high ambient temperatures due to a very limited number of sweat glands, and therefore have a limited capacity to lose heat by evaporation from the skin (Yousef, 1985). Pigs' thermoregulatory ability is further complicated by a thick subcutaneous adipose tissue layer, which impedes heat loss. Thus, pigs depend more on the respiratory route (i.e., panting) for heat dissipation (Collier and Gebremedhin, 2015). An environmental temperature of 18 - 21°C has been found to support optimal productive performance of growing-finishing pigs. In sows, the thermo-neutral zone has been reported to be 15-20 ^{o}C (Black et al., 1993). High humidity will aggravate heat stress due to the reduced ability of the pigs to use evaporative cooling (for further information see review space allowance and climate control during transport).

If the efforts to increase heat loss to maintain thermal comfort are inadequate, pigs will initiate a variety of strategies. The major way pigs thermoregulate is via behavioural adaptation. At high ambient temperatures, pigs seek shade, lie down laterally on cooler surfaces without contact to other pigs, and wallow in mud in order to cool down (Bracke, 2011; Bracke and Spoolder, 2011). Pigs will lie in full lateral recumbent position, i.e. on their side with fully stretched legs (Spoolder et al., 2012). In case of high stocking densities, when animals cannot cool down by lying freely or in full lateral position, pigs may attempt to dog-sit and to lose heat by panting. High ambient temperatures in combination with a high level of humidity and low space allowance on trucks or in lairage will lead to panting.

Pigs are often not accustomed to a range of colder temperatures as they typically have been raised in uniformly acclimatised barns (Peterson et al., 2017). The main adaptive behaviour pigs use to maintain their body temperature under cold weather conditions is social huddling. Here, pigs are lying in close contact to each other in a sternal position. Often, parts of pigs` bodies are covered by other pigs. By huddling, pigs minimise body surface that dissipates heat (Boon, 1981). Young pigs and piglets that lack body fat are more likely to huddle than grown finishers, sows or boars. To maintain their body temperature, young pigs can also react to cold ambient temperature by shivering, especially when their body surface is damp or wet.

Mixing: Pigs are social animals that live in groups in which members know each other individually. Within a group, stable social relationships regulate access to resources, such as food and lying areas. Pigs maintain their social relationships by communication, such as naso-nasal (nose-to-mouth) contacts and vocalisations. Agonistic behaviour, such as fighting and biting, are exhibited when access to resources is limited or if unfamiliar pigs are mixed. After mixing unfamiliar pigs, the establishment of social relationships will usually last for 24 to 48 hours. Individual traits, such as age and/or weight of pigs, are factors strongly affecting the social state of an animal. If pigs within a group differ in age/weight, agonistic interactions are reduced compared to groups of equal age/weight (Rushen, 1987). Establishing social relationships is more difficult in large groups as there are more individuals to which the social state has to be established. Fighting pigs will bite into the ears, the neck and the shoulder of their opponent, resulting in skin injuries on these body parts (McGlone, 1985). Thus, in order to prevent agonistic interactions, the mixing of unfamiliar pigs should be avoided and space in the pen should enable the pigs to retreat and escape from agonistic interactions.

Water: Drinking is one of the basic needs of animals. Water requirements and the frequency of pigs drinking depend very much on climatic conditions, diet, environmental stressors, frequency of water provision and the physiological state of pigs. The duration in which pigs have been deprived of water (before loading and during transportation) combined with ambient temperatures can have a significant

impact on pigs` water demand and thirst. The balance between water intake and water loss are affected by numerous factors, including health status, ambient temperatures and climate, nutrition and the environment.

4. Key areas to focus on during welfare inspections and assessing animal welfare indicators

Based on pigs' biological needs, three key areas can be identified to focus on during welfare inspections in slaughterhouses:

- **Arrival**
- **Moving and handling pigs**
- **Comfort around resting**

The majority of pigs being slaughtered are finishers ranging from 70 to 140 kg. Due to highly standardised finishing procedures, the time of slaughter can be determined well in advance. Finishers are usually picked up from farms, transported and, at the slaughter plant, most often kept in lairage pens in familiar groups. The slaughter of entire males requires specific handling and housing in lairage to maintain good animal welfare standards. Additionally, sows, breeding boars and piglets < 30 kg (mainly runts), may also be slaughtered at the abattoir due to health problems, such as lameness, tail biting, hernias or low finishing rates, provided they are fit to be transported. The risks to animal welfare for these categories of animals differ greatly and should be considered carefully. In the following paragraphs, relevant animal welfare indicators are printed in bold when first described.

4.1 Arrivals at the slaughterhouse

Assessing the health status of every consignment of animals at arrival according to the Council Regulation (EC) No 1099/2009 lies explicitly within the responsibility of the **Business Operator (BO)**. **Animal welfare officers (AWO)** or persons reporting directly to them carry out these inspections and report to the BO and, if required, to an official veterinarian on the plant. Given that the official veterinarian is not present to assess every consignment of pigs (*ante-mortem inspections* in lairage pens), the records taken of animal welfare issues at arrival and measures carried out by the AWO must be evaluated as part of inspections on a regular basis. Pre-slaughter conditions of pigs on trucks, such as water supply, space allowance and mixing, lie within the responsibility of the transport company. According to the legal definition, transportation ends when pigs have been unloaded.

The majority of finishers that arrive at the slaughterhouse are in a healthy and fit state. However, the condition of pigs can vary significantly upon arrival, depending on the circumstances on-farm and during loading, ambient temperatures, duration and circumstances of transport and arrival management.

Arrival management

The slaughterhouse management is responsible for scheduling arrivals and unloading pigs at slaughterhouses as quickly as possible. Strict management for trucks upon arrival in respect to the schedule and the number of pigs being delivered can shorten waiting times of pigs on vehicles (Faucitano and Pedernera, 2016). To prevent delays before unloading, the number of vehicles arriving must be

attuned to the docking stations and the speed of the slaughter line. This applies particularly to slaughterhouses that move pigs from the trucks to stunning and slaughter immediately after arrival without housing them in lairage. The AWO or a deputy must prioritise unloading if there are indications of compromised animal welfare e.g. signs of heat stress, injuries or fighting.

According to Grandin (2019), unloading must begin within a maximum of 0.5 hours of arrival at the slaughterhouse and should be completed within a maximum of one hour. If ambient temperatures are high, unloading should begin immediately after arrival at the slaughterhouse premises to mitigate heat stress. For, stationary trucks often do not provide mechanical ventilation and prolonged periods outside slaughterhouses can lead to critical circumstances for the pigs on the truck within a very short space of time. Waiting time before unloading at the slaughterhouse is a serious risk factor for the clinical condition of finishing pigs and sows (Thodberg et al., 2019; Ritter et al., 2006; Grandin, 2017). Mechanical failure causing the slaughter process to halt is an additional risk to animal welfare as it can lead to an increase of waiting periods on the trucks before pigs are unloaded. Emergency plans must ensure that farms and transport businesses are informed on time to enable trucks to be redirected to other slaughterhouses or to prevent pigs from being loaded for transportation.

Condition of pigs upon arrival

When pigs arrive at the slaughterhouse, the legal requirements for space allowance on trucks for pigs according to the Council Regulation (EC) 1/2005 Annex I Chapter VII D. must be assessed. All pigs must at least be able to lie down and stand up in their natural position. At high ambient temperatures, the space allowance shall be increased, respectively. According to Council Regulation (EC) No 1099/2009 Annex III, Article 2.4., isolation pens for animals that require specific care shall be prepared and available for immediate use before any animals arrive. Pigs that are in need of special care on arrival may show signs of **fatigue** and be non-ambulatory but non-injured (NANI). NANI pigs cannot walk, but do not show any obvious sign of injury, trauma or disease, and, as the case may be, are standing, sitting or more commonly lying down upon arrival. Fatigue in pigs during or after transportation is most commonly caused by circulatory problems due e.g. to nausea, dehydration or heat. Pigs may show signs of **fatigue** and be injured (**fatigue – injured**) and be non-ambulatory (NAI) (McGlone et al., 2014). Animals that are unable to walk off vehicles must under no circumstances be dragged to the place of slaughter, but be emergency killed where they are lying (stunned electrically or via captive bolt and bled). The AWO must assess every truckload of pigs during unloading and decide, depending on the general condition of the animals, whether pigs must rest in isolation pens for recovery.

Most studies have confirmed that the numbers of **Dead on Arrivals (DOA)** and non-ambulatory pigs arriving at slaughterhouses in Europe are generally low. Losses during transportation may be influenced by the environment in the trailer, the space allowance, transit time, waiting periods at the farm (from loading to leaving) and at the slaughterhouse (prior to unloading), and handling procedures (Sutherland et al., 2009). Pigs that walk off the truck may show various degrees of **lameness**. Pigs that show signs of fatigue but are able to walk off the truck must be housed in separate lairage pens with an adequate amount of space to rest and to be given the chance to recover before being moved to the stunning area.

The thermal requirements of pigs have been reviewed by Bracke et al. (2011). The authors reported that most studies on heat stress in pigs have been carried out for on-farm conditions. Additional stressors during transportation, such as low space allowance on trucks or the heat produced from the muscular effort to maintain balance while the truck is moving have therefore not been considered in these studies.

Hence, due to additional stressors during and after transportation, pigs may start **panting** at comparatively low ambient temperatures (Sutherland et al., 2009; Christensen et al., 2007). During hot weather conditions, panting (breathing in short gasps carried out with the mouth open) and skin discoloration (patches of reddish/bluish skin) will be further increased (Ritter et al., 2008; Kephart et al., 2010; Lambooij, 2014). Another animal-based indicator to assess heat stress in pigs is the body surface temperature, which can be measured using infrared thermography (Xiong et al., 2015). Under extreme weather conditions, heat stress can also lead to death. Haley et al. (2008) and Peterson et al. (2017) found the highest number of animals that are dead on arrival (DOA) to slaughterhouses during hot weather in the summer compared to other seasons. They also found that pig mortality was related to the locations in the truck that had the highest ambient temperatures.

If ambient temperatures are low, pigs may show **shivering** or **huddling** on the truck upon arrival. Shivering is widely considered to be a behavioural reaction to cold in mammals (Blumberg et al., 1992; Jones, 1999) and huddling (lying in a pile) is likely to reflect pigs' discomfort when exposed to cold temperatures (Boon, 1981). These physiological reactions to cold ambient temperatures in combination with high humidity apply particularly to young and lean pigs with little insulating subcutaneous fat. During cold ambient temperatures, pigs can show discolorations of the skin caused by frostbite during transportation.

4.2 Handling and moving pigs in lairage

Ramps and floors during unloading

During unloading, steep slopes of more than 20 degrees (36,4% to the horizontal) on ramps (Warriss et al., 1991), uneven conditions of floors and other distractions can render pigs to freeze, attempt to escape, urinate or defecate or be **reluctant to move forwards**, to **turn back** and walk back onto the truck possibly indicating fear**.** Pigs may hesitate to walk due to missing slats on the ramp, which can cause **falling** and **slipping** and turning back (Brandt et al., 2015; Van de Perre et al., 2010). **Lameness** will impede pigs` ability to walk e.g. down steep ramps and in passageways and races in lairage. Lame pigs will be at a disadvantage in lairage pens concerning access to the resources water and food and aggression from pigs ranking higher in hierarchy. *Post-mortem* studies carried out in slaughterhouses by Gareis et al. (2016) have revealed that a high percentage of pigs suffer from claw injuries, resulting from poor housing conditions, which can cause lameness and pain during unloading and moving in lairage. According to the Council Regulation (EC) No 1/2005 Annex I Chapter III, ramps shall be fitted with a system, such as provided by foot battens, which ensure that the animals climb or go down without risks or difficulties. If possible, pigs should walk off the trucks at ground level without an incline as they have difficulties walking down slopes. According to the Council Regulation (EC) No 1/2005 on the protection of animals during transport, ramps must be equipped with devices to ensure animals to have grip to prevent slipping and falling if slopes are stepper than 10 degrees. In addition, solid gates should prevent animals from escaping.

Handling pigs in lairage

Handlers moving pigs must hold a certificate of competence and be trained according to the legal provisions of the Council Regulation (EC) No 1099/2009 Article 7. Staff handling pigs in lairage must be trained and work under the supervision of an AWO or a deputy. Moving pigs in small groups gives the staff a chance to maintain control over the pigs and to limit the risk of them coming to a halt. With larger groups, handlers can lose control of some of the pigs, blocking may occur and the handlers will increase the pressure on pigs to continue movement (Dalmau et al., 2009). Given the choice, pigs will move from trucks to lairage walking and follow the leading pig. Pigs can be guided gently with plastic paddles or

sorting boards (Mc Glone, 2004). Handling pigs roughly will induce stress and may stimulate running, thus increasing the risk of escape attempts, slipping and falling. Submitting pigs to a painful stimulus may render them hyperactive or frightened, causing negative reactions to any stimulus during handling (Dalmau et al., 2009). During unloading and moving from lairage to stunning point, recommended tools will be flags, paddles and plastic boards (EFSA, 2020). (more information on driving tools on www.grandin.com).

According to the Council Regulation (EC) No 1099/2009 Annex III No 1.8.d) the use of prods or other implements with sharp ends causing pain and distress are prohibited. Applying the electric goad for moving pigs is not explicitly prohibited, but its use is legally very restricted as the risk of abuse is high and it causes the pigs considerable pain, fear and distress. However, in passageways that are designed according to the pig's natural behaviour, the use of electric goads should not be necessary. Correa et al. (2010) concluded that to improve animal welfare the electric goad should be replaced with paddles or compressed air goads. According to the Council Regulation (EC) No 1099/2009 Annex No 1.9. the use of instruments which administer electric shocks shall be avoided as far as possible. In any case, such instruments shall only be used for adult bovine animals and adult pigs which refuse to move, and only when they have room ahead of them in which to move. The shocks shall last no longer than one second, be adequately spaced and shall only be applied to the muscles of the hindquarters. Shocks shall not be used repeatedly if the animal fails to respond.

Pigs that experience pain and/or fear caused by the application of electrical goads or rough handling applying other driving devices may express **high pitch vocalisation,** representing a reliable animal welfare indicator for the AWOs and inspectors. According to Schrader and Todt (1998), pigs' vocal behaviour can indicate an activation of the endocrine stress response. The rate of squeal-grunts, characterised by high frequency ranges and short duration, increases with increased concentrations of adrenaline. More information on guidance to handling pigs see chapter 6 of the review.

Moving pigs in lairage and to the stunning area

The Council Regulation (EC) No 1099/2009 Annex II No 2.1. a) requests that pens, passageways and races in slaughterhouses shall be designed and constructed to allow the animals to move freely in the direction required using their behavioural characteristics and without distraction. The lateral vision of the surroundings should be taken into account when moving pigs in passageways and chutes, since even small openings at the sides can cause pigs to halt. It is therefore advisable to close the sides of the chutes completely to stop pigs from being distracted (Dalmau et al., 2009). The risk of animals **slipping, falling** or injuring their feet can be minimised by ensuring adequate floors in the passageways.

From lairage pens, pigs are moved along passageways to the stunning area. Once pigs are in the race leading to the point of stunning, they are either encouraged to move forward manually by handlers or in the case of CO_2 stunning by automatic pushing gates. The stress levels can increase due to the layout of the aisles, distracting factors and handling, including painful stimuli.

Sharp angles, bottlenecks, moving from light to dark areas or uneven floor surfaces can stop pigs from moving forward. Rays of light or reflections (e.g. from water or metal) can cause pigs to hesitate or stop (Grandin, 2010). According to the Council Regulation (EC) No 1099/2009 Annex II 2.4., the race leading to the point of stunning must be designed so that animals cannot be trapped or trampled. Closed sides of the passageways and races prevent pigs from being distracted and such reduce the risk of handlers increasing pressure resulting in injuries, fear and distress.

Electrical stunning usually requires presenting pigs to the stunning device in a single file. In semi-automatic electrical stunning systems, pigs walk into the stunning chamber and are stunned manually whereas in fully automatic systems, V-type restrainers or conveyor belts carry pigs to the stunning area with their feet lifted from the ground. According to Troeger (1989), moving pigs from a free-moving group to a single line of aligned individuals is extremely stressful for pigs. The entrance into the race and the start-and-stop forward motions towards the stunner can cause stress. At the point of isolation, depending on the layout and handling, pigs may attempt to back out, turn back or are reluctant to move forward into the race. **High pitch vocalisation** before stunning caused by fear or the application of electric goads or other rough handling is a significant indicator for assessing animal welfare issues.

In contrast to electrical stunning, before stunning with CO_2 gas, pigs are driven by automatically operating doors in groups of approx. 15 pigs and are loaded in groups of 2 to 8 animals into the stunner. The entry of pigs into the stunner in groups with automatic doors causes less stress for pigs, compared to the isolation of pigs prior to electric stunning (Christensen and Barton-Gade, 1997). However, if the pressure increases due to the high speed of the slaughter line, the raceways may become overloaded and the gates can then be lowered onto pigs' backs or limbs. In order to maintain a constant line speed of slaughter, staff can resort to measures which cause severe stress to the animals: the use of electric goads, putting pressure on sensitive parts, moving them forward using sharp or hard objects or striking or kicking the animals (Jones, 1999). Rough handling will provoke high pitch vocalisation and also lead to pigs slipping, falling or turning back, causing pain and fear and increasing the risk of injuries.

4.3 Lairage and comfort around resting

Purpose of lairage

According to the Council Regulation (EC) No 1099/2009 Annex III No 1.2. animals shall be unloaded as quickly as possible after arrival and subsequently slaughtered without undue delay. Housing pigs in lairage pens after arrival and prior to slaughter can be justified from an animal-welfare point of view (Dalmau and Velarde, 2016). In the majority of pig slaughterhouses, lairage pens are provided as a buffer before slaughter, in order to maintain a constant speed of slaughter and to prevent pigs from having to wait on trucks before unloading or to be rushed from the truck to the slaughter line. Lairage in general provides the slaughterhouse with more flexibility and, given that the slaughter line comes to a halt due to technical defaults, lairage can support animal welfare, as it can prevent animals from having to stay loaded on vehicles for longer than necessary. It has been suggested that lairage should offer at least 1.1 times the slaughter capacity per hour (Handbuch Schlachtung, 2020). Depending on the housing conditions and duration, lairage can have a positive effect on a pig's physical and mental state before slaughter, but under inadequate animal welfare standards, it can increase the risk of enhancing stress and suffering for pigs.

Pigs in lairage pens must have enough space to lie in full lateral recumbency. They must be able to turn around, not be mixed with unfamiliar pigs and have the chance to move away from aggression, walk safely without slipping and reach drinkers without competition. Brandt and Aaslyng (2015) concluded that the pen size, the type of floor and the number of drinkers are significant for the stress level of pigs in lairage. Moreover, Velarde and Dalmau (2012) claim that pigs must be given the chance to perform specific behaviour, such as exploration in lairage pens.

Recovery in lairage pens

The purpose of lairage is not only to keep pigs in stock to maintain the speed of slaughter, however, to give the animals time to recover from the stress of transport and unloading. This recovery phase can be relevant on stunning effectiveness, which amongst other things, depends on the condition of pigs prior to slaughter. According to Bucher and Scheibl (2014), extreme physical or psychological stress impairs the cardiovascular system and thus the efficiency of both electrical and CO_2 stunning. During electrical stunning, in particular, triggering a grand mal seizure, accompanied by loss of consciousness and sensibility, is more difficult if pigs are under stress (Bucher and Scheibl, 2014).

Thermal comfort and climate control in lairage

From an animal welfare point of view, the recommendation for lairage temperatures is 15 - 18°C and for humidity it is 59 - 65% (Honkavaara, 1989) regarding a pig's thermal comfort zone. High ambient temperatures in combination with a high level of humidity and high stocking density in lairage will lead to pigs suffering heat stress**.** At higher ambient temperatures and a high level of humidity, to reduce the risk of heat-stress, the time pigs spend in lairage should be limited to at most 30 minutes. This, in particular, accounts to pigs that are stress-susceptible (Santos et al., 1997; Fraqueza et al., 1998). **If pigs pant**, this behaviour indicates that they are outside their thermo-neutral zone, resulting in thermal stress (see review thermal comfort during transportation). Within their thermo-neutral zone, pigs manage to keep their body temperature constant using behavioural and physiological responses indicative of heat/cold stress such as heat conduction by lying or huddling. Under extreme conditions, according to studies carried out by Fraqueza et al. (1998) for lairage times of 3 h, after the first hour at 35°C, some 75% of the pigs were lying down for conduction whereas at 20°C, only 30% were lying. After 3 h, the percentage of pigs lying down was similar at both temperatures (about 95% of the population). When lying down at 20°C the pigs tended to huddle whereas at 35°C the majority of them were just touching.

Sows are especially sensitive to heat stress. Sows (especially modern breeds) have been bred for very high productivity during recent decades. This means that they are considerably more prone to heat stress than younger/lighter pigs. This sensitivity is an additional risk factor for their welfare on the day of slaughter. If pigs are panting in lairage, the ambient temperature and humidity must in any case be verified.

In lairage, besides an increase in space allowance at high ambient temperatures, thermoregulation of pigs shall be supported by external cooling, such as ventilation and/or sprinkling systems that produce a mist or evaporated water at temperatures above 20°C (Schütte et al., 1996) but not below 10°C (Warriss, 2003). Sprinkling pigs with evaporated water for 5-10 minutes after arrival in pens and subsequently supports thermoregulation for pigs (Handbuch Schlachtung, 2020). Longer periods of sprinkling may lead to puddles forming, thus reducing the space allowance for resting (BSI Schwarzenbek, 2013). Given that there are no explicit legal requirements for maximum temperatures for pigs in lairages of slaughterhouses, during high ambient temperatures and high levels of humidity, space allowance in lairage pens must be increased to improve conduction by lying in lateral recumbency and ventilation and showers should be provided to support pigs' ability to thermoregulate.

According to Brent (1986), to prevent discomfort for pigs in lairage, a maximum ventilation rate of 135 m^2h^{-1} with an air movement below 0.2 m per second appears sufficient to keep the ambient temperatures to rise less than 3°C. A major hazard for pigs in lairage under cold weather conditions is the occurrence of draughts. A draught is defined as the partial impact of a flow of cold air over the surface of the body that disrupts the mechanisms of thermoregulation in warm-blooded organisms (McCafferty et al., 2017). This

leads to reduced body temperatures and cold stress. Younger pigs' thermoregulatory ability is less developed than that of adult pigs. The animal-based indicators for assessing cold stress are **shivering** and **huddling**. Due to their lack of body fat, lean or young pigs are more likely to shiver and huddle than finishing pigs, sows or boars. Draughts, high humidity and wet skin will increase the risk of pigs' thermoregulation failing, resulting in shivering and huddling. Thus, showering or misting can cause animal welfare issues at low ambient temperatures.

Ventilation is not only necessary to regulate heat and humidity, but also to control the rise of CO_2 and other noxious gases, such as ammonia (Weeks, 2008). Lowering ventilation rates in lairage to maintain a temperature within pigs' thermos-neutral zone is likely to have a negative effect on the quality of air. If pigs are housed in lairage without ventilation (especially overnight), elevated ammonia concentrations may become an animal welfare issue. The ammonia concentrations can become aversive to the eyes and respiratory tract of pigs in concentrations above 10 ppm (Wathes et al., 2002).

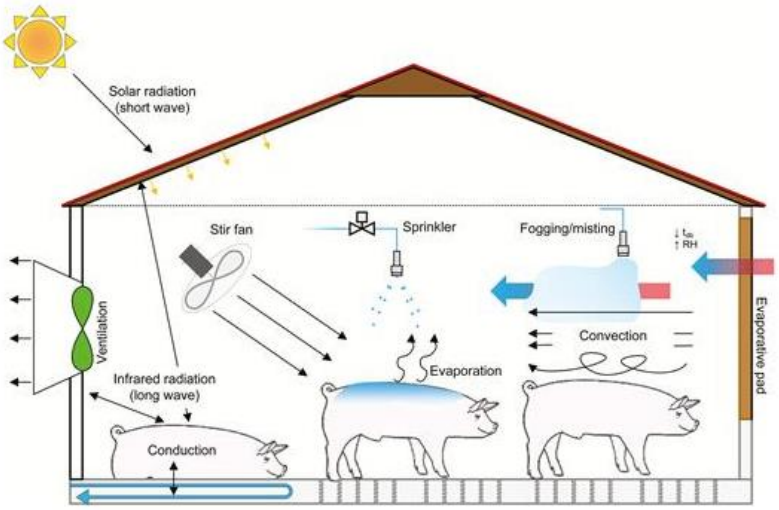


Fig. 1 Thermal (heat) exchange between a pig and its surroundings with prediction of different cooling strategies as they relate to heat exchange (Lance H. Baumgartner, 2018)

For further reading on thermal comfort see review "Climate control and space allowance during transport of pigs".

Access to water and food

To ensure animal welfare, water must be provided to pigs in lairage for *ad libitum* intake (Miranda de la Lama, 2013) in sufficient quantity and of good quality. **Access to water** is an important resource-based animal welfare indicator for slaughterhouses (Grandin, 2019). According to the Council Regulation (EC) No 1099/2009 Annex II 2.3. water supply systems in pens shall be designed, constructed and maintained so as to allow all animals at all times access to clean water without being injured or limited in their movements. Brandt and Aaslyng (2015) and Velarde and Dalmau (2012) concluded that the number of drinkers are significant for the stress level of pigs in lairage. To comply with legal requirement, the German `Handbuch Schlachtung` (2020) recommends one drinker per 12 pigs. Providing that space allowance and mixing are adequate (see space allowance and mixing below), this ratio should ensure access to water for all pigs. Even if the group size lies below 12 pigs per pen, each pen should be equipped with at least two

drinkers to ensure that subordinate pigs are not at a disadvantage. The functionality of the water nipples must be assessed daily before pigs are housed in pens. In addition, the ability of the pigs to drink from the nipples or water supplies shall be checked. In cases of delay in slaughter (e.g. stopped slaughter line) when pigs are kept in passageways or races for a longer period, according to Grandin (2010), a supply of water is recommended after a maximum of 30 minutes. Practical experience suggests that pigs intensively suckling at objects in pens and drinking hastily and without pausing when water is provided have been deprived of water and are thirsty. Furthermore, aggression around drinkers can indicate prolonged thirst.

After a maximum of 12 hours in lairage pen pigs must have **access to food**. The Council Regulation demands that pigs must be fed at the latest after 12 hours in lairage pens and subsequently they are given moderate amounts of food at appropriate intervals.

Space allowance and group sizes in lairage pens

There are no legal requirements concerning space allowance for pigs in lairage pens. A study examining 43 slaughterhouses in Europe and Brazil space allowances that varied from 0.47 to 0.73 m^2 per pig with an average weight of 110 kg (0.53 m^2/110 kg in mean), depending on the country and duration in lairage (Dalmau et al., 2016). Warriss (1996) recommends an average space allowance of 0.5 m^2 per 100 kg to allow pigs to rest and drink. The space needed by pigs depends on their size/weight. The minimum space allowance required for different lying postures (sternum, half recumbency and full recumbency) can be calculated using a formula developed by Petherick (1983):

$A = k \times W^{2/3}$

where
A = area (m^2)
W = live bodyweight of the pig (kg)
k = a constant related to the posture of the animal.

For a pig standing or lying in sternal position k = 0.019. For a pig lying in half recumbency k = 0.033, and for a pig lying in full recumbency k = 0.047.

According to the formula, a finishing pig with a weight of 120 kg will require 0.45 m^2 in sternal position, 0.78 m^2 in half recumbency, and 1.1 m^2 in full recumbency.

A study carried out by Ekkel et al. (2003) scan sampling pigs in pens every 20 minutes for 48 hours at thermal neutral conditions, revealed that the average number of pigs that were lying was 83.3 to 87.5 % depending on their weights ranging from 30 and 100 kg. The study distinguished between pigs lying in sternal, half recumbent and fully recumbent position. During the night 65 to 70 % pigs chose the fully recumbent lying posture without body contact. However, additional space is needed for feeding, drinking, defecating and moving. According to Ekkel et al. (2003) and Petherick (1983) the floor area occupied by lying pigs at thermoneutral conditions should on average be based on the estimated floor area for pigs lying in half recumbency (k=0.033), i.e. 0.78 m^2 per pig of 120 kg. Space allowance should be increased during high ambient temperatures. In order to assess **space allowance** per pig in lairage pens, the size of the pens must be measured. All pigs lying simultaneously in pens in half recumbent position is also a conclusive animal-based indicator for assessing space allowance.

Studies in pig slaughterhouses concerning group sizes in pens revealed that sizes vary from 5 to 230 pigs per pen (mean: 35), depending on the country, national legislation and animal welfare programs involved (Dalmau et al., 2016). According to Rabaste et al. (2007), pigs kept in large groups (30 animals) spend more time standing and fighting and are involved in more agonistic interactions than pigs kept in small groups (10 pigs).

Mixing pigs in lairage

Mixing or regrouping pigs with unfamiliar conspecifics in lairage can lead to a high level of stress due to fighting and can cause **skin lesions** (Aaslyng et al., 2013), resulting in pain and fear. This applies especially to entire males (Barton-Gade, 2004) and adult females (Bonnerup, 2020). The damage based on skin lesions is particularly severe in mixed groups with an increased proportion of boars due to the higher risk of fighting (Warriss, 1996). Fighting may be associated with the development of dark, firm and dry (DFD) meat due to glycogen depletion (Nanni Costa et al., 2002; Čobanović et al., 2017). Skin lesions also may increase in lairages due to inappropriate management procedures and the use of sticks while moving the pigs (Faucitano, 2010). If sows or piglets are housed in lairage pens, they will usually be mixed with non-familiar animals, leading to an increased risk of aggression. Fighting may have considerable consequences in terms of skin lesions, which can be assessed as an animal-based indicator amongst other for fighting and biting.

After pigs have recovered from transportation and handling, usually after 2-3 hours, their activity level in lairage pens will increase. Depending on mixing, the duration of deprivation of food or water, rooting material and space allowance, agonistic behaviour may increase over time. Longer duration in lairage pens, especially overnight, are associated with an increased incidence of skin lesions due to fighting (Warriss, 1996; Nanni Costa et al., 2002; Dokmanović et al., 2014; Čobanović et al., 2017, Driessen et al., 2020). High pitch vocalisation can indicate fighting and aggression in lairage pen.

5. Legal requirements

The Council Regulations (EC) No 1099/2009 and 1/2005 regulate legal requirements for pigs upon arrival at the slaughterhouse, during moving and handling in lairage and for resting in lairage pens. Underlined phrases indicate areas given guidance and improvement measures in chapter 6.

COUNCIL REGULATION (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing, which has been in force in the European Union since 2013, determines the animal welfare conditions for handling and slaughtering livestock in slaughterhouses. According to Art. 26 of the regulation, Member States may have implemented stricter national rules aimed at ensuring more extensive protection of animals at the time of killing. The Member States provide mandatory guidelines for their competent authorities to ensure consistent enforcement of the Council Regulation and the national regulations. These guidelines are notified to the Commission. The regulation addresses the business operator (BO) for assuring animal welfare in slaughterhouses. The BOs shall apply guides of good practice developed by their own organisations to facilitate the implementation of the Council Regulation.

COUNCIL REGULATION (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No 1255/97 determines welfare conditions during transportation of animals. Given that slaughterhouses are bottlenecks for assessing animal welfare not only at the plant, but also for conditions and handling on farms and during transportation, the legal requirements for a minimal space allowance can be assessed upon arrival.

Extracts from the Regulations (EC) No 1099/2009 and 1/2005 that are particularly relevant to animal welfare for the key areas at slaughterhouses are listed below. Underlined phrases indicate areas given guidance and improvement measures in the review or in section 6.

5.1 Legal requirements for lairage in slaughterhouses applying to the three key areas

COUNCIL REGULATION (EC) No 1099/2009:

Article 2 Definitions
(b) 'related operations' means operations such as handling, lairaging, restraining, stunning and bleeding of animals taking place in the context and at the location where they are to be killed;
(e) 'lairaging' means keeping animals in stalls, pens, covered areas or fields associated with or part of slaughterhouse operations;
(i) 'standard operation procedures' means a set of written instructions aimed at achieving uniformity of the performance of a specific function or standard;
(l) 'business operator' means any natural or legal person having under its control an undertaking carrying out the killing of animals or any related operations falling within the scope of this Regulation;
(p) 'restraint' means the application to an animal of any procedure designed to restrict its movements sparing any avoidable pain, fear or agitation in order to facilitate effective stunning and killing;
(q) 'competent authority' means the central authority of a Member State competent to ensure compliance with the requirements of this Regulation or any other authority to which that central authority has delegated that competence;

Article 3 General requirements for killing and related operations. Animals shall be spared any avoidable pain, distress or suffering during their killing and related operations. For the purposes of paragraph 1, business operators shall, in particular, take the necessary measures to ensure that animals:
(a) are provided with physical comfort and protection, in particular by being kept clean in adequate thermal conditions and prevented from falling or slipping.

(b) are protected from injury.

(c) are handled and housed taking into consideration their normal behaviour.

(d) do not show signs of avoidable pain or fear or exhibit abnormal behaviour.

(e) do not suffer from prolonged withdrawal of feed or water.

(f) are prevented from avoidable interaction with other animals that could harm their welfare.

Article 6 Standard Operating Procedures

1. Business operators shall plan in advance the killing of animals and related operations and shall carry them out in accordance with standard operating procedures.

2. Business operators shall draw up and implement such standard operating procedures to ensure that killing and related operations are carried out in accordance with Article 3(1).

Article 7 Level and certificate of competence

1. Killing and related operations shall only be carried out by persons with the appropriate level of competence to do so without causing the animals any avoidable pain, distress or suffering.

2. Business operators shall ensure that the following slaughter operations are only carried out by persons holding a certificate of competence for such operations, as provided for in Article 21, demonstrating their ability to carry them out in accordance with the rules laid down in this Regulation:

(a) the handling and care of animals before they are restrained;

Article 14 Layout, construction and equipment of slaughterhouses

1. Business operators shall ensure that the layout and construction of slaughterhouses and the equipment used therein comply with the rules set out in Annex II.

2. For the purposes of this Regulation, business operators shall, when requested, submit to the competent authority referred to in Article 4 of Regulation (EC) No 853/2004 for each slaughterhouse at least the following:

(a) the maximum number of animals per hour for each slaughter line;

(c) the maximum capacity for each lairage area.

Article 15 Handling and restraining operations at slaughterhouses

1. Business operators shall ensure that the operational rules for slaughterhouses set out in Annex III are complied with.

Article 17 Animal welfare officer

1. Business operators shall designate an animal welfare officer for each slaughterhouse to assist them in ensuring compliance with the rules laid down in this Regulation.

2. The animal welfare officer shall be under the direct authority of the business operator and shall report directly to him or her on matters relating to the welfare of the animals. He or she shall be in a position to require that the slaughterhouse personnel carry out any remedial actions necessary to ensure compliance with the rules laid down in this Regulation.

3. The responsibilities of the animal welfare officer shall be set out in the standard operating procedures of the slaughterhouse and effectively brought to the attention of the personnel concerned.

4. The animal welfare officer shall hold a certificate of competence as referred to in Article 21, issued for all the operations taking place in the slaughterhouses for which he or she is responsible.

5. The animal welfare officers shall keep a record of the action taken to improve animal welfare in the slaughterhouse in which they carry out their tasks. This record shall be kept for at least one year and shall be made available to the competent authority upon request.

Article 19 Emergency killing. In the case of emergency killing, the keeper of the animals concerned shall take all the necessary measures to kill the animal as soon as possible.

ANNEX II LAYOUT, CONSTRUCTION AND EQUIPMENT OF SLAUGHTERHOUSES (as referred to in Article 14)

All lairage facilities:

2.1. Pens, passageways and races shall be designed and constructed to allow:

(a) the animals to move freely in the required direction using their behavioural characteristics and without distraction;

(b) pigs or sheep to walk side by side, except in the case of races leading to the restraining equipment.

2.2. Ramps and bridges shall be equipped with lateral protection to ensure that animals cannot fall off.

ANNEX III OPERATIONAL RULES FOR SLAUGHTERHOUSES (as referred to in Article 15)

1.7. A steady supply of animals for stunning and killing shall be ensured in order to prevent animal handlers rushing animals from the holding pens.

1.8. It shall be prohibited to:

(a) strike or kick the animals;

(b) apply pressure to any particularly sensitive part of the body in such a way as to cause animals avoidable pain or suffering;

(c) lift or drag the animals by the head, ears, horns, legs, tail or fleece, or handle them in such a way as to cause them pain or suffering;

(d) use prods or other implements with pointed ends;

(e) twist, crush or break the tails of animals or grasp the eyes of any animal.

1.9. The use of instruments which administer electric shocks shall be avoided as far as possible. In any case, such instruments shall only be used for adult bovine animals and adult pigs which refuse to move, and only when they have room ahead of them in which to move. The shocks shall last no longer than one

second, be adequately spaced and shall only be applied to the muscles of the hindquarters. Shocks shall not be used repeatedly if the animal fails to respond.

1.11. Animals which are unable to walk shall not be dragged to the place of slaughter but shall be killed where they lie.

2.4. Every day that the slaughterhouse operates, before any animal arrives, isolation pens for animals that require specific care shall be prepared and kept ready for immediate use.

5.2 Legal requirements specific for "Arrival at the slaughterhouse"

COUNCIL REGULATION (EC) No 1099/2009:

ANNEX III OPERATIONAL RULES FOR SLAUGHTERHOUSES (as referred to in Article 15)

1. The arrival, moving and handling of animals:

1.1. The welfare conditions of each consignment of animals shall be systematically assessed by the animal welfare officer or a person reporting directly to the animal welfare officer upon arrival in order to identify the priorities, in particular by determining which animals have specific welfare needs and the corresponding measures to be taken.

1.2. Animals shall be unloaded as quickly as possible after arrival and subsequently slaughtered without undue delay.

Mammals, except rabbits and hares, which are not taken directly upon arrival to the place of slaughter, shall be lairaged. Animals which have not been slaughtered within 12 hours of their arrival shall be fed, and subsequently given moderate amounts of food at appropriate intervals. In such cases, the animals shall be provided an appropriate amount of bedding or equivalent material which guarantees a level of comfort appropriate to the species and the number of animals concerned. This material shall guarantee an efficient drainage or ensure adequate absorption of urine and feces.

1.11. Animals which are unable to walk shall not be dragged to the place of slaughter but shall be killed where they lie.

2.4. Every day that the slaughterhouse operates, before any animal arrives, isolation pens for animals that require specific care shall be prepared and kept ready for immediate use.

COUNCIL REGULATION (EC) No 1/2005:

ANNEX I TECHNICAL RULES (as referred to in as referred to in Article 6(3), Article 8(1), Article 9(1) and (2)(a))

Chapter VII D. All pigs must at least be able to lie down and stand up in their natural position. In order to comply with these minimum requirements, the loading density for pigs of around 100 kg should not exceed 235 kg/m^2. The breed, size and physical condition of the pigs may mean that the minimum required surface area given above has to be increased; a maximum increase of 20 % may also be required depending on the meteorological conditions and the journey time.

Chapter III No 1.3 Facilities and procedures

Facilities for loading and unloading, including the flooring, shall be designed, constructed, maintained and operated so as to:

(a) prevent injury and suffering and minimise excitement and distress during animal movements as well as to ensure the safety of the animals. In particular, surfaces shall not be slippery and lateral protections shall be provided so as to prevent animals from escaping;

1.4. (a) Ramps shall not be steeper than an angle of 20 degrees, that is 36,4 % to the horizontal for pigs, Where the slope is steeper than 10 degrees, that is 17,6 % to the horizontal, ramps shall be fitted with a system, such as provided by foot battens, which ensure that the animals climb or go down without risks or difficulties.

5.3 Legal requirements specific for "Handling and moving pigs"

COUNCIL REGULATION (EC) No 1099/2009:

ANNEX II LAYOUT, CONSTRUCTION AND EQUIPMENT OF SLAUGHTERHOUSES (as referred to in Article 14)

All lairage facilities:

2.1. Pens, passageways and races shall be designed and constructed to allow:

(a) the animals to move freely in the required direction using their behavioural characteristics and without distraction;

(b) pigs or sheep to walk side by side, except in the case of races leading to the restraining equipment.

2.2. Ramps and bridges shall be equipped with lateral protection to ensure that animals cannot fall off.

2.5. Floors shall be built and maintained in such a way as to minimise the risk of animals slipping, falling or injuring their feet.

5.4 Legal requirements specific for "Comfort around resting"

COUNCIL REGULATION (EC) No 1099/2009:

ANNEX II LAYOUT, CONSTRUCTION AND EQUIPMENT OF SLAUGHTERHOUSES (as referred to in Article 14)

1. All lairage facilities:

1.1. Ventilation systems shall be designed, constructed and maintained so that the welfare of the animals is constantly ensured, taking into account the expected range of weather conditions.

1.2. Where mechanical means of ventilation are required, provision shall be made for an alarm and emergency backup facilities in the event of breakdown.

1.3. Lairage facilities shall be designed and constructed so as to minimise the risk of injuries to the animals and the occurrence of sudden noises.

1.4. Lairage facilities shall be designed and constructed so as to facilitate the inspection of the animals. Adequate fixed or portable lighting shall be provided to enable the inspection of animals at any time.

2. Lairage facilities for animals not delivered in containers:

2.3. The water supply system in pens shall be designed, constructed and maintained so as to allow all animals at all times access to clean water without being injured or limited in their movements.

2.4. When a waiting pen is used, it shall be constructed with a level floor and solid sides, between the holding pens and the race leading to the point of stunning and designed so that animals cannot be trapped or trampled.

2.5. Floors shall be built and maintained in such a way as to minimise the risk of animals slipping, falling or injuring their feet.

2.6. Where slaughterhouses have field lairages without natural shelter or shade, appropriate protection from adverse weather conditions shall be provided. In the absence of such protection, these lairages shall not be used under adverse weather conditions. In the absence of a natural source of water, drinking facilities shall be provided.

6. Improvement measures and guidance for interpretation

6.1 The responsibility of the Business Operator to assure animal welfare

The **business operator (BO)** ensures that animals are protected and spared pain and suffering at the slaughterhouse. To achieve this goal, the BO plans the slaughtering procedure in advance according to Art. 6 of the Council Regulation (EC) No 1099/2009, drawing up and implementing **standard operation procedures (SOPs**). According to T. Grandin (2019), the attitude of the BO towards animal welfare is a key factor in establishing and maintaining optimal animal welfare and handling in slaughterhouses. This also refers to the BO`s attitude to the significance of SOPs and the results also depend greatly on the authority delegated to the AWO. With the SOPs, specific procedures for slaughterhouses are defined aligned with the legal requirements for animal welfare.

The designated **AWO** assists the BO in ensuring compliance with the rules laid down in the Council Regulation and defined in the SOPs for the business and holds a certificate of competence. The AWO should be authorised to issue directives to staff handling live animals and train the staff. With a view to conflicts of interest, the BO shall not at the same time be the AWO, as concerns of animal welfare may arise opposed to economic interests of the business. Therefore, the AWO ought to be protected from dismissal and hold a similar status as members of work councils. The Guideline "The Animal Welfare officer in the European Union" offers information on the role of the AWO in slaughterhouses.

https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_slaughter_awo-brochure_24102012_en.pdf

According to Art. 7 of the Council Regulation (EC) No 1099/2009 staff dealing with live animals must hold **certificates of competence** according to their occupation and the species they are handling. The motivation of the employees at the slaughterhouse to comply with animal welfare provisions depends very much on their income, the working conditions and their appreciation within the business. Language

barriers ought to be taken into consideration concerning the SOPs and trainings. Considering staff experience and opinions in context with the development of SOPs can greatly increase the staff`s motivation to comply with legal requirements and the SOPs implemented for the business, respectively.

6.2 Arrival management

Improving arrival management and unloading

Meteorological services provide information on weather forecasts for up to 6 days (in some cases including the expected enthalpy[1]), which can be useful for planning the transportation and slaughter of pigs, especially during heat periods. The welfare of pigs during transport can not only be compromised by high environmental temperatures, but also by the level of relative humidity and enthalpy. Although upper temperature limits have been established to transport pigs in Europe, few indices additionally include relative or absolute humidity maxima or mention appropriate enthalpy ranges (Villarroel et al., 2011). Transportation before sunrise and slaughtering in the early morning while ambient temperatures are still low can prevent severe animal welfare issues caused by heat stress. If pigs arrive at the slaughterhouse in the night, they have the chance to rest in ventilated lairage areas as opposed to being transported at high ambient temperatures with higher risks of traffic obstructions during the day increasing the risk of animal welfare issues for the pigs during the day.

If trucks are not able to unload immediately, during high ambient temperatures, technical measures, e.g. elevating roofs and continuing mechanical ventilation must be ensured. If trucks have to wait at the premises of the slaughterhouse before unloading and have no means of artificial ventilation, the slaughterhouse must provide protected areas and cooling (e.g. ventilated halls) and/or fans.

For multi-tiered vehicles, it is desirable that the decks are adjusted upon arrival at the final destination so that the handler can enter the vehicle to guide the pigs out. Moreover, the use of mobile decks can generate a step between the deck and the unloading ramp. If the height of the step is more than 15 cm, some pigs may hesitate to leave the vehicle voluntarily. It is important to, if possible, avoid obstacles such as steps and gaps, ensure non-slip floors on ramps, install appropriate lighting and ensure that the whole of the back of the vehicle is available for unloading.

Guidance for handling non-ambulatory pigs on trucks

Before unloading pigs from trucks at the slaughterhouse, their health status must be assessed. If pigs are non-ambulatory (NA) upon arrival, they must be protected towards other pigs stepping on them while moving off the vehicle. If necessary, the AWO or the deputy informs the official veterinarian in order to assess and evaluate animal welfare issues of pigs on the trucks. Pigs that need to be emergency killed or slaughtered prioritised, must be stunned and bled on the vehicles. The stunning instruments placed in proximity to the unloading docks must at all times be serviced and ready for use. Emergency killing can only be carried out by staff holding a valid certificate of competence. If pigs show signs of fatigue upon arrival, they can rest in an isolation pen with bedding and sufficient space for recovery.

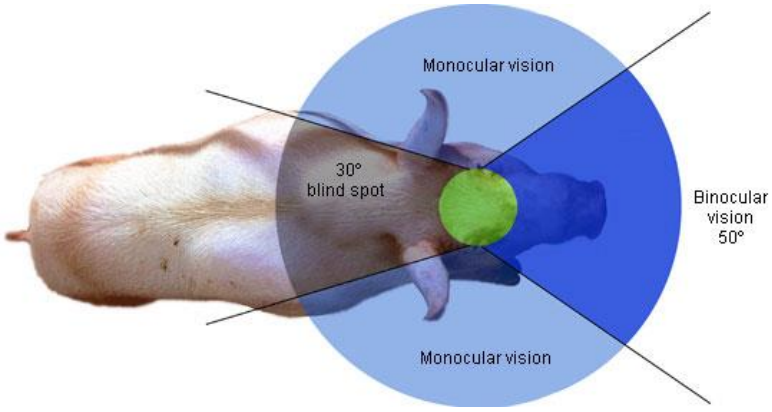
[1] **Enthalpy**, the sum of the internal energy and the product of the pressure and volume of a thermodynamic system (Encyclopaedia Brittannica). Enthalpy can be defined as the total heat content of the air that surrounds an animal and depends on the temperature and humidity (Villarroel et al., 2011).

6.3 Improving handling and moving pigs in lairage

During unloading from the truck and handling and moving in lairage passageways and races, pigs shall be handled with respect and according to their biology to avoid pain, fear and distress.

Guidance for handling pigs

Pigs should be moved applying as little pressure as possible. Handlers need to be trained accordingly and hold a certificate of competence. Electric goads or other devices causing pigs pain, fear and distress should not be used. Boards and flags can be applied to encourage pigs to move, supported by voice and gentle patting. Moving pigs is facilitated if handlers take into account the pigs` mono- and binocular vision, the concepts of 'flight zones' and their point of balance (Fig. 2, 3). Pigs will move or stop depending on handlers standing within or outside the animal's flight zone (Grandin, 2019). Moving in the opposite direction behind the pig's point of balance encourages it to move forward (Fig. 4). The handlers should avoid standing within the blind spot behind the animal. Finally, pigs are usually more willing to walk if they can follow a leading pig in small groups and a pig`s emotional state and temperament can have a significant impact on the willingness of pigs to move forward.



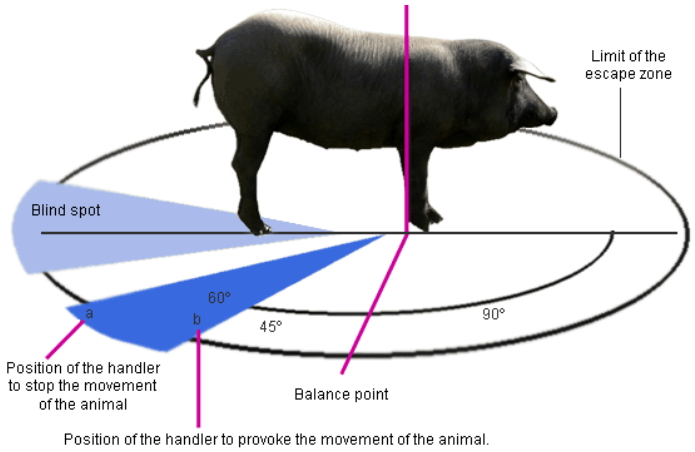


Fig. 2 and 3 Mono- and binocular vision and "point of balance". The point of balance is at the animal's shoulder. Depending on where the handler stands in relation to the point of balance, the pig will move forward or backup (Grandin, 2020).

Layout, floors and lighting

The construction of the lairage area, aisles and technical equipment have a significant impact on the motivation of pigs to walk. The passageways in lairage should be wide enough for pigs to walk next to and behind each other in groups. The direction pigs are intended to walk in shall be clear to them and on a pig's eye level the sides of the aisles should be solid. Pigs prefer to walk up rather than downhill. Thus, the aisles should be level or have an increasing angle of 2 to 3 °. Due to their vision, pigs are prone to confuse shadows and floor irregularities with physical barriers or solid objects and may be reluctant to cross such areas. Illumination management and race systems that eliminate visual distractions and promote the animals' natural following behaviour will therefore encourage pigs to move more easily. Injuries, due to obstacles or sharp edges on floors, in pens or in aisles must be prevented. Temple Grandin`s approach of detecting handicaps and risks for pigs in passageways by walking in the aisles and races outside slaughter hours has shown to be a simple and effective way of detecting hazards for pigs in lairage passageways and races. Sharp edges, obstacles or distractions such as reflections, rays of light, airflow or uneven surfaces of floors can be identified and measures can be taken to improve pigs` motivation to move freely and without injuries. In order to diminish the risk of pigs slipping and falling and becoming agitated during handling in lairage, all areas where pigs move must have non-slip floors. Non-slip flooring can include textured concrete, grooving, and rubber mats (Grandin, 2019).

Moving to the stunning area

A high prevalence of vocalisations due to the use of extensive pressure is directly linked to the design of the slaughterhouse, such as the method of separating and isolating pigs before the stunning file (Grandin, 2019). If electric goads need to be applied to a large number of animals and/or repeatedly while entering the race to stunning, the construction or layout of the race must be reassessed concerning its functionality (BSI Schwarzenbek, 2013). The use of excessive pressure, e.g. use of electric goads, may no longer be needed when applying simple and inexpensive corrective measures thus improving the standard of animal welfare.

Pigs e.g. prefer to move into the light and they react sensitively to head-on airflows and may be resilient to move forward into a draught. Management of light and airflow can reduce the resistance of pigs to move into single files before stunning. Distracting noises should be avoided, e.g. metal banging on metal or noises from hydraulic slaughter apparatus. Rubber coating on metal is a simple way of reducing the level of noise occurring in lairage.

In respect to the construction of the passageways and races, pigs will move more easily from a collection pen into the single-file line if the race is partially empty and there is no risk of pigs jamming at the entrance. An offset step before the race helps to prevent pigs from jamming (see Fig. 5). If the collection pen before the race is not too crowded and the gates are not closed tightly, the collection pen serves as a ´passing through´ pen to the race (Grandin, 2019).

Once again, if handlers walk in the opposite direction of the pigs, thus leaving their flight zone, the pigs will be encouraged to move forward (see Fig. 4). Double races leading to the stunner have the advantage that pigs are not isolated before the race. Walking beside each other in two parallel races will promote the pig's natural behaviour to follow and to walk side by side. The sides in double races should be solid and the middle partition ´see through´ so pigs stay in visual contact with each other (Grandin, 2020).

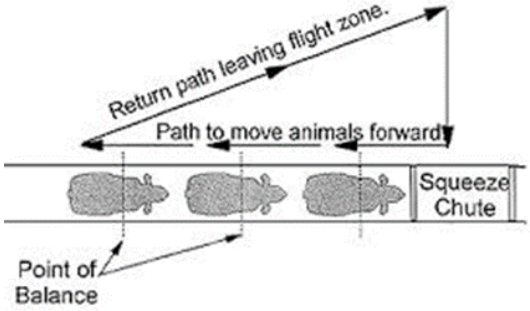


Fig. 4 Handler movement pattern to induce pigs to move forward in a chute or a race (Grandin, 1998)

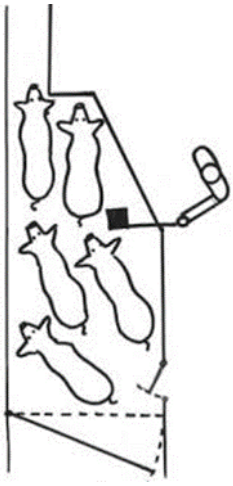


Fig. 5 Off set step before single file race (Grandin, 2019)

6.4 Guidance for "Comfort around resting" in lairage pens

To ensure good standards of animal welfare for pigs in lairage pens, the animal welfare officer or a person having appropriate competences shall assess animal welfare in lairage pens at least once an hour during the day (BSI Schwarzenbek, 2013). If pigs are housed in lairage overnight, it is essential that appropriate conditions are ensured during the last assessment of the pigs before the night. In order to be able to assess the animal welfare standard of every pig, the pens shall be constructed and illuminated, accordingly. If pigs die while being housed in lairage pens, they shall be removed from the pen immediately. Depending on their condition, Ill or compromised pigs can be separated in an extra pen or, if required, must be emergency killed. In order to reduce the risk of aversive behaviour, enrichment materials such as straw or other manipulable materials ought to be provided for pigs that are housed in lairage pens for any length of time.

Thermoregulation

A variety of measures can support pigs` thermoregulation under extreme circumstances. To minimise heat dissipation at low temperatures, sufficient amounts of appropriate bedding material should be provided and the ventilation rates in lairage adapted. At high ambient temperatures, if the slaughterhouse does not provide air conditioning, other means to support the thermoregulation e.g. by increasing space

allowance, must be ensured. Showers can support pigs' ability to thermoregulate at high ambient temperatures. However, experience has revealed that showering the pigs immediately before stunning can have a negative effect on electrical stunning as the current may be conducted over the body surface rather than flowing through the brain, causing an increased rate of stunning failures. This issue requires further scientific investigation.

Water and food supply

Pens for pigs should be equipped with at least one drinker for 12 pigs and at least two drinkers per pen, lowering the risk of deprivation of water for pigs ranking low in hierarchy. Assessing the functionality of drinkers (e.g. height and angle of drinkers) can be carried out while observing pigs in the pens or when the pens are empty. The pens should provide hygienic facilities for drinking and feeding pigs. Feeding systems shall ensure that pigs ranking lower in hierarchy have access to food. Pigs that stay in pens for more than 24 hours must be fed at least twice a day.

Space allowance in lairage pens and group size

In order to be able to recover from transport before slaughter, it should be possible for all pigs to lie in a half recumbent position simultaneously. During high ambient temperatures, space allowance shall be increased, respectively. It is preferable if pens are designed in a long and narrow way, providing as much resting area as possible for pigs along walls (Handbuch Schlachtung, 2020). The German Guidelines recommend housing a maximum of 15 pigs in each pen to reduce the risk of aggression.

Mixing pigs in lairage pens

Maintaining stable pig groups from the farm during transport and in lairage pens significantly reduces stress and the risk of injuries for pigs. Solid sides can prevent aggression between unfamiliar pigs in adjacent pens. Different sizes of groups require different sizes of pens to prevent having to mix non-familiar pigs for an effective utilisation of lairage capacities (Handbuch Schlachtung, 2020). The installation of mobile dividing gates increases flexibility for housing pig groups consisting of different sizes. Pigs that show aggression, have been attacked by other pigs, are injured or show signs of fatigue may temporarily be kept in individual pens.

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