Design of loading facilities and holding pens

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Abstract


Holding pens and loading facilities are used in abattoirs, saleyards, stockyards, and sorting facilities. Long, narrow pens are recommended where animals enter through one end and leave through the other. Constructing the pens on a 60-80° angle eliminates sharp 90° corners. Flooring in holding pens should be non-slip. Indoor holding pens should have even, diffuse lighting that minimizes shadows. Cattle, pigs and sheep have a tendency to move more easily from a dimly illuminated area to a more brightly illuminated area. Facilities should be designed to minimize excessive noise.

In large facilities more than one unloading ramp may be required to facilitate prompt unloading. During warm weather prompt unloading is essential because heat rapidly builds up in a stationary vehicle. Ideally, holding pens should be built at truck height to eliminate ramps.

The maximum recommended angle for adjustable ramps for cattle, pigs, and sheep is 25°. Twenty degrees is the maximum recommended angle for non-adjustable ramps. For pigs, 15° is recommended. Ramps should have a level dock at the top equal to one animal body length. Stairsteps are recommended on concrete ramps. Recommended dimensions are a 30 cm minimum tread width and a 10 cm rise for cattle, and a 25 cm tread width and 5 cm rise for slaughter weight pigs. Both loading and unloading ramps should have solid fences. The crowd pen that leads to the ramp should also have solid sides and it must never be placed on a ramp. Crowd pens must be level. Single file, curved ramps with solid fences are very efficient for loading cattle onto trucks. Ramps used for unloading only should be 2.5 to 3-m wide to provide animals with a clear exit off the vehicle. In Denmark and other Scandinavian countries trucks used for transporting pigs are equipped with a hydraulic tailgate lift. Well designed holding pens and loading ramps can help reduce bruises and stress.

Introduction

Holding pens and loading facilities are used in abattoirs, saleyards, stockyards, and sorting facilities. Well designed facilities will help reduce bruises, stress, and mortality. Bruises and mortality cost the livestock industry millions of dollars annually (Marshall, 1977; Livestock Conservation Institute, 1988a,b). Stress-related meat quality problems, such as dark cutting (DFD) and pale, soft exudative (PSE) meat are also very costly (Canadian Meat Council, 1980). Another advantage of good facilities is an improvement in animal welfare.
The basic principles of design are universal for all facilities but the purpose of the facility will affect certain parts of its design. For example, American and Australian trucks hold more animals than trucks in some European countries. This will affect the size of the holding pens. When a holding facility is designed, space must be allocated for specialized functions such as weighing, sorting, washing, or checking animal identification. To avoid serious design mistakes, the designer must fully understand the specific handling requirements of the country or region where the facility will be located.

**Pen Layout**

Long, narrow pens are recommended in holding facilities where livestock are held for a relatively short period of time (Kilgour, 1971; Grandin, 1980a,b; R. Hoenderken, personal communication, 1981). A major advantage of long, narrow pens is efficient animal movement. Animals enter through one end and leave through the other. To eliminate 90° corners, the pens can be laid out on a 60-80° angle (Figs. I and 2). Each pen gate should be longer than the width of the alley, so that it opens on an angle to eliminate the sharp corner (Fig. 1). Figure 2 is an indoor holding yard at a pig abattoir which slaughters > 5000 pigs/day. Long, narrow pens maximize lineal fence length in relation to floor area. This may help reduce stress (Kilgour, 1978; Grandin, 1980a,b). Cattle and pigs prefer to lie along the fenceline (Stricklin et al., 1979; Grandin, 1980b). Observations indicate that long, narrow pens may help reduce fighting (Kilgour, 1976). Government regulations in some countries may require walkways in between the pens for observation of animals prior to slaughter. The layout remains the same except that a 1-m-wide walkway is placed between every other pen.

![Fig. 1. Long, narrow holding pens, unloading ramps and curved race system for a cattle abattoir.](http://grandin.com/references/design.loading.facilities.holding.pens.html)
Design of loading facilities and holding pens

**Fig. 2. Diagonal holding pens in a large pig abattoir.**

**Group size**

The size of the holding pens required for an abattoir or stockyard is at least partially dictated by size of the trucks. When small groups of animals are handled, block gates can be used in a long, narrow pen to keep different groups separated. Minimum space requirements for holding fattened, feedlot steers for < 24 h are 1.6 m² for hornless cattle and 1.85 m² for horned cattle (Grandin, 1979; Midwest Plan Service, 1980), and 0.5 M2 for slaughter weight pigs and lambs. During warm weather pigs require more space. Wild, extensively raised cattle may require additional space. However, providing too much space may increase stress because wild cattle tend to pace in a holding pen. There must be adequate space for all animals to lie down.

**Mixing**

To reduce stress and preserve meat quality, strange animals should not be mixed shortly before
slaughter (Tennessen and Price, 1980; Grandin, 1983; Barton-Gade, 1985). Solid pen walls between holding pens prevent fighting through the fences (Fig. 2). Solid fences in holding pens are especially important if wildlife such as deer, elk, or buffalo are handled.

Pigs present some practical problems. In the U.S.A., pigs are transported in trucks with a capacity of > 200 animals. However, they are fattened in much smaller groups. Observations at U.S. abattoirs; indicate that mixing 200 pigs from three or four farms resulted in less fighting than mixing 6-40 pigs. One advantage of the larger group is that an attacked pig has an opportunity to escape. Price and Tennessen (1981) found a tendency towards more DFD carcasses and hence more stress when small groups of 7 bulls were mixed, compared with larger groups of 21 bulls.

Pen and alley dimensions

In countries with large trucks, larger pens and wider alleys will be required. Alley and pen widths are also dictated by the number of animals per hour which must move through the facility (Tables I and 2). To avoid bunching and trampling, 25 m is the maximum recommended length of each holding pen, unless block gates are installed to keep groups separated. Shorter pens are usually recommended.

<table>
<thead>
<tr>
<th>Animals handled (h1)</th>
<th>Pen width (m)</th>
<th>Alley width (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4001</td>
<td>2</td>
<td>1.3</td>
</tr>
<tr>
<td>&gt; 4002</td>
<td>3-4.2</td>
<td>2.5-3</td>
</tr>
</tbody>
</table>

1 Or truckloads of less than 80 animals.
2 Or truckloads of more than 150 animals.

<table>
<thead>
<tr>
<th>Method of driving cattle</th>
<th>Pen width (m)</th>
<th>Alley width (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>On foot</td>
<td>3.5-4.2</td>
<td>3</td>
</tr>
<tr>
<td>On horseback and on foot</td>
<td>N/A</td>
<td>3.5</td>
</tr>
<tr>
<td>On horseback</td>
<td>N/A</td>
<td>4.2</td>
</tr>
</tbody>
</table>

1 These recommendations apply to most facilities except a few specialized situations where small numbers of cattle are handled.
2 The alley is too wide for a single person to block cattle turnbacks.

Specialized holding facilities

In Denmark, the design of the pig lairage at the abattoir is very specialized (Fig. 3). Pigs are held in long, narrow pens equipped with manual push gates. A powered push gate moves pigs up the alley to
the stunner. This system was invented by T. Wichmann of the Danish Meat Research Institute. The Danes have also developed automated block gates within the long, narrow pens to keep small groups of 15 pigs in separate groups (Barton-Gade, 1989). When strange bulls are mixed, physical activity during fighting increases DFD meat. The installation of either steel bars or an electric grid over the holding pens prevented dark cutting in bulls (Kenny and Tarrant, 1987). These devices prevent mounting. The electric grid should only be used with animals that have been fattened in pens equipped with an electric grid. In Sweden and other countries where small numbers of bulls are fattened, individual pens are recommended at the abattoir (Puolanne and Aalto, 1981). In some European abattoirs, the holding area consists of a series of single-file races which lead to the stunner. Bulls are unloaded directly into the races and are kept separated by guillotine gates.

![Diagram](http://grandin.com/references/design.loading.facilities.holding.pens.html)

**Fig. 3. Danish pig lairage with push gates and a power crowd gate.**

**Flooring**

Holding and loading facilities must have non-slip flooring (Stevens and Lyons, 1977; Grandin, 1983). For cattle, deep 2.5-cm "V" grooves in a 20 cm square or diamond pattern are recommended. The deep groove pattern should not be used in living quarters for cattle. In pig holding facilities, the wet concrete may be imprinted with a stamp made from expanded steel mesh with a 3.8-cm-long opening (Grandin, 1982).

In abattoirs, concrete slats may be used in livestock holding pens, but the drive alleys should have a
solid concrete floor. Slats or gratings used in pig and sheep facilities should face in the proper
direction. Sheep move more easily when they walk across the slats instead of parallel with them
(Kilgour, 1971; Hutson, 1981). Figure 2 shows the correct orientation of slats in holding pens. The
floor appears more solid when the animals walk across the slats. To facilitate animal movement, the
animals must not be able to see light or reflections off water under the slats.

Animals will balk at sudden changes in floor texture or color. Flooring surfaces should be uniform in
appearance and free from puddles (Lynch and Alexander, 1973). In facilities that are washed, concrete
curbs may be installed between the pens to prevent water in one pen from flowing into another. Drains
should be located outside the areas where animals walk. Livestock will balk at drains or metal plates
across an alley (Grandin, 1987). Flooring should not move or jiggle when animals walk on it. Flooring
that moves causes swine to balk (Kilgour, 1988).

**Bruise Prevention**

Edges with a small diameter such as steel angles and channels will cause severe bruises. Round pipe
posts are recommended and surfaces which come into contact with animals should be smooth and
rounded (Stevens and Lyons, 1977; Grandin, 1980c). Sharp corners should be padded with split tires or
conveyor belting.

All gates should be equipped with tie-backs to prevent them from swinging out into the alley.
Guillotine gates should be counter-weighted and padded on the bottom (Grandin, 1983).

**Lighting and Sound Levels**

Indoor holding pens and loading facilities should have even, diffuse lighting that minimizes shadows
(Fig. 2). Cattle, pigs, and sheep have a tendency to move more easily from a dimly illuminated to a
more brightly illuminated area (Kilgour, 1971; van Putten and Elshof, 1978; Hitchcock and Hutson,
1979; Grandin, 1982). At night or in enclosed facilities, lamps can be used to attract animals into
trucks or races (Grandin, 1982). The lamps must illuminate the floor and must not shine into the eyes
of approaching animals. Loading ramps must never be pointed into the sun (Vowles, 1985). Livestock
are more likely to balk if they are forced to move towards blinding sunlight. Pigs reared indoors under
artificial illumination preferred to walk up a ramp illuminated at 80 Ix (Phillips et al., 1987). This was
similar to the illumination of their living quarters. A ramp illuminated with less than 5 Ix was avoided.
There was also a tendency to avoid an excessively bright ramp illuminated at 1200 Ix (Phillips et al.,
1987).

Livestock have sensitive hearing and they are stressed by excessive noise (Kilgour and de Langen,
1970; Kilgour, 1983). In steel facilities, gate strike posts should have rubber stops to reduce noise. Air
exhausts on pneumatically powered gates should be piped outside (Grandin, 1983). If hydraulics are
used to power gates, the motor and pump should be located away from the animals. Cattle held
overnight in a noisy yard close to the unloading ramp were more active and had greater bruising
compared with cattle held in a quiet pen (Eldridge, 1988).

**Unloading and Loading Layout**
In large stockyards, sale yards, or abattoirs more than one loading or unloading ramp is usually required to facilitate prompt loading or unloading. During warm weather, prompt unloading is essential because heat rapidly builds up in stationary vehicles.

In some facilities, unloading pens (Fig. 1) will be required. These pens enable animals to be unloaded promptly prior to sorting, weighing, or identification checking. After one or more procedures are performed the animals move to a holding pen.

Loading dock height varies depending on the types of vehicles used. If vehicle heights vary by a few centimeters, construction of nonadjustable ramps is recommended, even with the lowest vehicles used. This will enable the crossover bridge that is attached to the higher vehicles to be used more effectively.

**Width**

Facilities used for unloading only should be 2.5-3 in wide to provide the animals with a clear exit to the alley (Grandin, 1980d). The recommended width for facilities used to load livestock into a truck varies depending on vehicle type. A vehicle with a tailgate that opens up to the full width of the vehicle can be loaded with a ramp the same width as the vehicle. The large trucks used in North America usually have a door which is just wide enough to admit cattle in single-file or pigs and sheep double-file. A single-file loading ramp for cattle should be 76 cm wide. For pigs and sheep, a ramp 86 cm wide will enable 2 animals to walk up side by side. A partition down the middle of the ramp improves efficiency because it prevents the pigs from turning around (Grandin, 1987) (Figs. 4 and 5). The partition is made from "see through" wire mesh to promote following. It is a serious design mistake to make a ramp or race 1 1/2 animal wide. This will result in jamming. Recommended widths for single-file ramps used by slaughter weight pigs and sheep will vary from 3.5 to 43 cm depending on animal size.

**Ramp slope**

Ideally a holding facility should be built at truck deck level to eliminate ramps (Fig. 3). Sheep move most easily on a level surface (Hitchcock and Hutson, 1979). Many animals are injured on excessively steep ramps. The recommended maximum angle for cattle and sheep ramps is 25° for adjustable ramps which are raised to the second or third deck of a truck (Grandin, 1979). For fattened slaughter weight pigs a 15° angle is recommended (van Putten, 1981). The maximum angle for nonadjustable livestock ramps is 20° (Grandin, 1979). A pig's heart rate increases with the angle of the ramp (van Putten and Elshof, 1978), and is faster when the pig is climbing than when it is descending a ramp (Mayes and Jesse, 1980). Excessively steep ramps were avoided by pigs in a preference test: 20-24° ramps were preferred to 28-32° ramps (Fraser et al., 1986; Phillips et al., 1988). To reduce the possibility of falls, ramps should have a flat dock at the top. This provides a level surface for animals to walk on when they first step off the truck (Stevens and Lyons, 1977; Grandin, 1979; Agriculture Canada, 1984). The level dock should have a minimum width of one animal body length. A self-aligning dock bumper will help prevent injuries caused by an animal stepping down between the truck and the dock (Rider et al., 1974). Telescoping side gates are also recommended to block the gap. To facilitate entry from the crowd pen into a single-file ramp there should be a level section of race equal to one animal body length at the junction between the ramp and the crowd pen.
Fig. 4. Crowd pen and ramp system for loading pigs onto trucks that have a narrow entrance door.
Ramp surface

Stairsteps are recommended on concrete ramps. Stairsteps are easier to walk on after the ramp becomes worn or dirty. However, in new clean facilities, small pigs expressed no preference between stairsteps or closely spaced cleats (Phillips et al., 1987). The movements in this experiment were voluntary.

Recommended dimensions for stairsteps are a 30 cm minimum tread width and a 10 cm rise for cattle, and a 25 cm tread width and a 5 cm rise for slaughter weight pigs (U.S. Department of Agriculture (USDA), 1967; Grandin, 1980c, 1982). The steps should be grooved to provide a non-slip surface. When cleats are used, they should be spaced 20 cm apart for large cattle and slaughter weight pigs (Mayes, 1978). The 20 cm is measured from the beginning of one cleat to the beginning of the next cleat. For small, 16 kg pigs, maximum cleat spacing is 10 cm apart (Phillips et al., 1987). Spacing the cleats 5 cm apart improved traction. During a choice test, small pigs readily walked up steep ramps with the narrower spacing (Phillips et al., 1990). Possibly, the 20 cm spacing recommended by Mayes (1978) for slaughter weight pigs should be decreased. On outdoor ramps that become covered with ice, closely spaced cleats may be more likely to become slick.

Curved ramps and solid fences

Fig. 5. The "see through" partition promotes following. The outer fences of this loading ramp are solid.
Curved single-file ramps are especially recommended for loading cattle onto a truck (Figs. 6 and 7) (Rider et al., 1974; Grandin, 1980a). A curved ramp with an inside radius of 5 m will work well for both loading and unloading. A shorter radius is not recommended if the ramp is going to be used for unloading. The curve must be laid out as shown in Fig. 6. If the ramp is bent too sharply at the junction between the single-file race and the crowd pen it will appear as a dead end. This will cause livestock to balk (Grandin, 1987). Handler walkways should run alongside the ramp and crowd pen (Grandin, 1987). Overhead walkways should be avoided.

For all species, solid sides are recommended on both the ramp and the crowd pen which leads to the loading ramp (Rider et al., 1974; Brockway, 1977; Grandin, 1980a,b, 1982; Vowles et al., 1984). For operator safety, mangates must be constructed so that people can escape charging cattle. The crowd gate should also be solid to prevent animals from turning back. 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 (Fig. 2) (Grandin, 1980b).

When young pigs were given a choice of ramps, they preferred a ramp with either solid or woven wire sides (Phillips et al., 1987). Ramps with vertical or horizontal barred sides were avoided. The overhead lighting used in the indoor experiment may have made the wire mesh appear solid.

**Crowd pen design**

The crowd pen used to direct animals into a single- or double-file ramp must never be built on the ramp. A sloping crowd pen will cause livestock to pile up against the crowd gate (Grandin, 1979). The round crowd pens shown in Figs. 5, 6 and 7 are very efficient for all species. The recommended radius for round crowd pens is 3.5 m for cattle, 1.83 m for pigs and 2.4 m for sheep.
Fig. 6. Curved, cattle loading ramp with a round crowd pen. A double row of long, narrow holding pens is constructed on both sides of a central alley.

Cattle and sheep crowd pens should have one straight fence and the other fence should be on a 30° angle (Meat and Livestock Commission). This layout should not be used with pigs as they will jam at the ramp entrance. Jamming is very stressful for pigs (van Putten and Elshof, 1978). 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 (Grandin, 1982, 1987). Jamming can be further prevented by installing an entrance restrictor at single-file race entrances. The entrance of the single-file race should provide only 0.5 cm on each side of each pig. The double-race ramp in Fig. 4 also has a single offset step to prevent jamming.

Ramps for double deck trucks

The best adjustable ramps have a level dock which moves up and down (Grandin, 1980d). The ramp must be mounted on rollers so that it will not pull away from the truck when it is raised. The best design for an adjustable ramp is one where the floor and side walls move up and down as a single unit (Grandin, 1979). This design eliminates space between a moving floor and the sides where animals' feet may be caught. This is especially a problem in single-file ramps. Double-deck trucks can also be
Design of loading facilities and holding pens

loaded or unloaded with stationary "over and under" ramps. Animals can be moved onto both truck decks at the same time (G.J. Lapworth, personal communication, 1988).

Tailgate lift

In Denmark and other Scandinavian countries, trucks used for transporting pigs are equipped with hydraulic tailgate lifts (Fig. 8'). The tailgate lift has a folding fence and gates. The use of ramps is eliminated. This system works well in countries where < 100 pigs are transported in each truck. Many trucks in England and Ireland have a tailgate that folds down to form a ramp. Many of these ramps are excessively steep (Weyman, 1987). Livestock loading and unloading could be greatly improved in these countries if stationary unloading platforms were built on farms, abattoirs, and stockyards. Lowering the tailboard down onto a 40-cm-high platform would reduce the angle.
Fig. 8. In Denmark, trucks are equipped with a tailgate lift for loading and unloading pigs.

Conclusion

Well designed loading and holding facilities will help to reduce stress and injuries to livestock. Facilities that incorporate principles of livestock behavior will be more efficient.

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I Oth edn., p. 319. DESIGN OF LOADING FACILITIES AND HOLDING PENS 201


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