Farm Structures
FACTSHEET

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FREE STALL DESIGN

INTRODUCTION

It is generally agreed in the dairy industry that free stall housing is superior to loose bedded-pack or tie stall housing, especially in larger operations of 50 cows or more.

Advantages over loose housing include lower capital investment due to higher possible animal densities, decreased bedding use and decreased labour for maintenance. Cows are cleaner, gentler, and experience fewer teat and udder injuries. Compared to tie stall systems, free stalls provide a more natural, less restrained environment for cows, allowing them to feed and exercise at will.

Free stall housing is not without its disadvantages. Some of these include the necessity to handle manure as a liquid, the requirement to clean alleys once or twice daily, and the need for some regular bedding and cleaning maintenance of the stalls themselves.

ANIMAL COMFORT

In a pasture with a level surface, all circumstances for standing up and lying down are optimum and natural for cows. These include good footing, no obstructions and a relatively soft bed.

It is impossible to provide the same conditions in a free stall barn. A free stall is then somewhat of a compromise between maximum animal comfort and restrictions intended to assure proper animal position.

The ideal stall should provide a stress-free environment for the animal and a low-cost, low-care facility for the operator. In the past, too much attention was often given to the strength, durability and life of stalls. The needs of the cow were overlooked. A free stall should be more attractive and comfortable than any other resting location within the barn. A good design will provide:

- A relatively soft, clean, flat bed with good footing
- Adequate space for animals to lunge forward to rise
- Relatively free movement of the head
- Freedom and space for body movement while in the lying position
- Ample room for the hips when resting, but enough restriction to prevent the cow from lying partly crosswise
- Good shoulder support in the area where some restriction is desirable
- Strength and durability
- Efficient use of overall space
- Minimum construction and maintenance costs

The best partition design cannot compensate for the problem of a slippery floor. A slippery floor, as can be the case with wet, smooth concrete, is highly objectionable. When a cow lies down, its back end more or less drops to the floor in the last phase of movement. On a slippery floor, this movement is accelerated. Feet can slip out from under her, and slowing the rate of fall becomes impossible. This can result in severe injury to the animal, particularly to the hip bones, the ribs or the legs. Well-designed free stalls, therefore, must also be accompanied by a good bed, not only because cows lie in them 10 to 14 hours a day, but also because they will get up or lie down as much as 10 times a day. There is no such thing as a perfect stall; however, with proper construction, utilization and care, a high degree of both comfort and cleanliness can be economically provided.

DESIGN CONSIDERATIONS

Although animals prefer soft beds, hard beds are preferred to maintain slopes and clearances in the stall, and to reduce bed maintenance. Ample space for the largest animal in a group to freely enter, lie down, lunge forward, and rise without injury is very important (see Figure 1). Positioning the animal, whether standing or lying down, so that manure and urine are deposited behind the stall bed is also a prime consideration. Furthermore, the free stall should be injury-free, trap-free, maintenance-free and durable.

While there is no consensus on the best free stall design, experience and research has provided certain guidelines which should be followed, particularly with regard to stall component dimensions. Considered in any free stall design are cow-to-stall ratios, dividers, stall base and drainage, restrainers, stall size and bedding

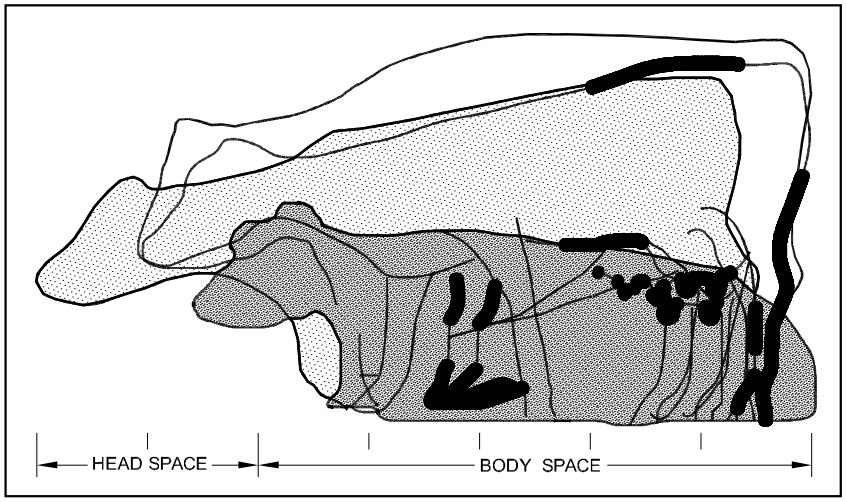

Figure 1 To achieve natural movement while rising, a cow must have room to lunge forward.

COW-TO-STALL RATIO

Because dairy cattle typically spend half of the day resting, it is ideal to have one stall for each cow. Experience shows, however, that operators have no problems with barns housing 10%–15% more cows than stalls.

STALL DIVIDERS OR PARTITIONS

The stall divider, or partition, separates adjacent resting spaces and serves to control the position of the cow without unduly restricting her movements. Dividers must be designed to withstand loads imposed by 1600 lb (725 kg) animals leaning and rubbing on them.

Stall dividers can be made of wood or galvanized steel pipe. Pipe is recommended since wood stalls require more maintenance. Wood stalls are not as open as steel pipe stalls, a factor important when encouraging natural ventilation in a barn. A proven wood partition design is shown in Figure 6. Pipe stall dividers of various shapes may be:

- Supported by two free standing posts, and are often called mushroom stalls (Figure 2)
- Supported by front hinged attachments and a concrete brisket curb, and are often called pivot stalls (Figure 4)
- Supported from the stall front assembly and a rear post in or near the curb (Figures 5, 6)
- Suspended from the stall front assembly, and are commonly called loop stalls (Figures 7, 8, 9)

Costs for loop stalls are higher than for stalls with dividers attached at the curb and the headboard because heavier pipe is required. Post-type stalls, however, tend to rust off where the post enters the curb (from exposure to manure and urine), and are more easily damaged by tractor scrapers.

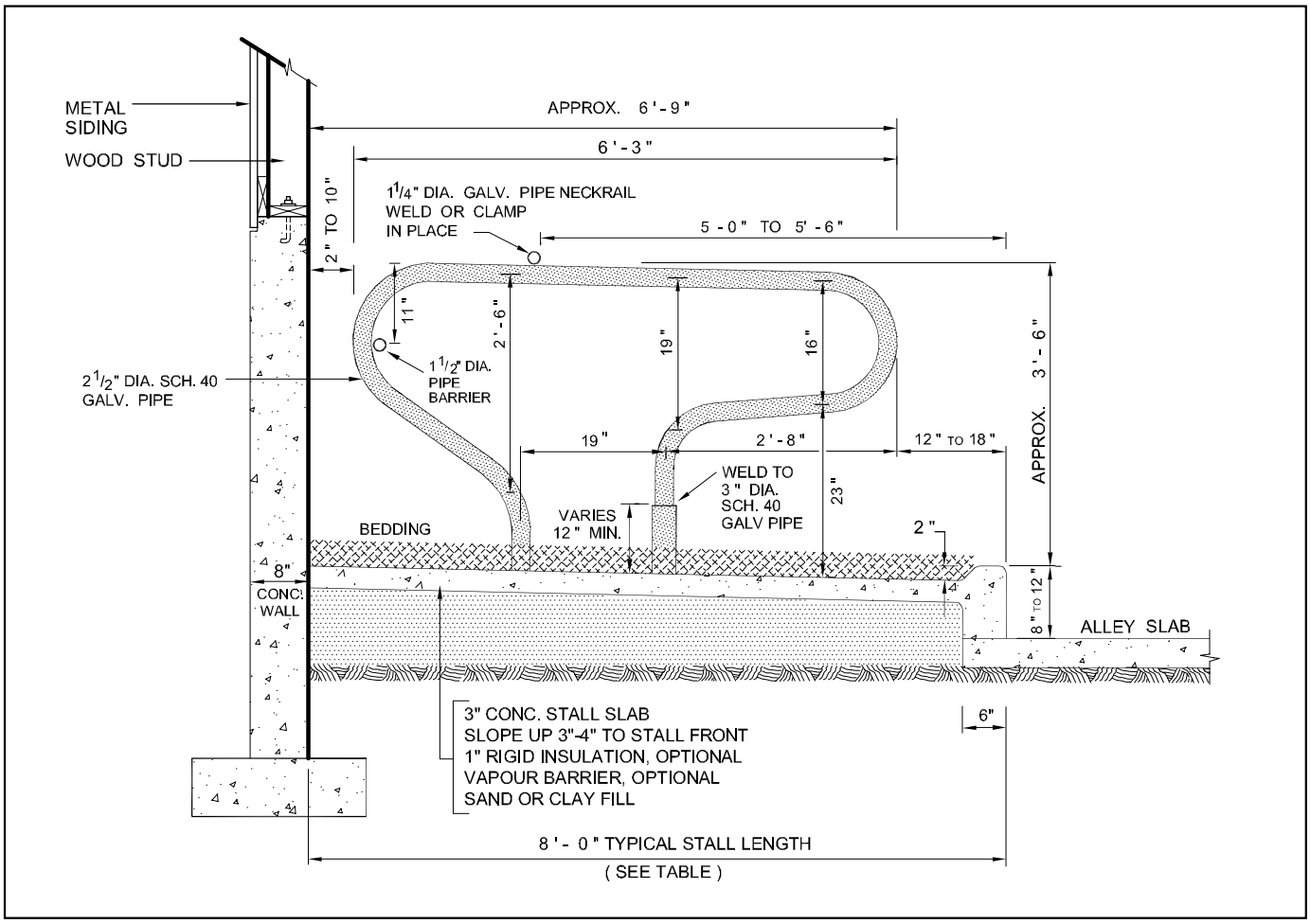

Figure 2 Mushroom style divider with concrete base and solid pipe neck rail

Adequate pipe size and anchoring are very important to ensure low maintenance and repair. This is especially true of loop stalls where forces at attachment locations can be very high (see Figure 3). Some designs include spring-loaded or hinged attachments, such as used in the pivot stall (see Figure 4). Easy removal of any style of divider should be a consideration in case of emergency.

Critical dimensions of any stall include length, height, space between the bottom rail and the stall bed, and space between divider rails.

The distance from the back end of the loop divider to the alley side edge of the curb should not exceed 18 inches to discourage animals from standing crosswise on the bed at the back of the stall. Similarly, loop dividers should be kept at least 12 inches back from the curb to prevent rib and hip injuries caused by cows walking past the stalls.

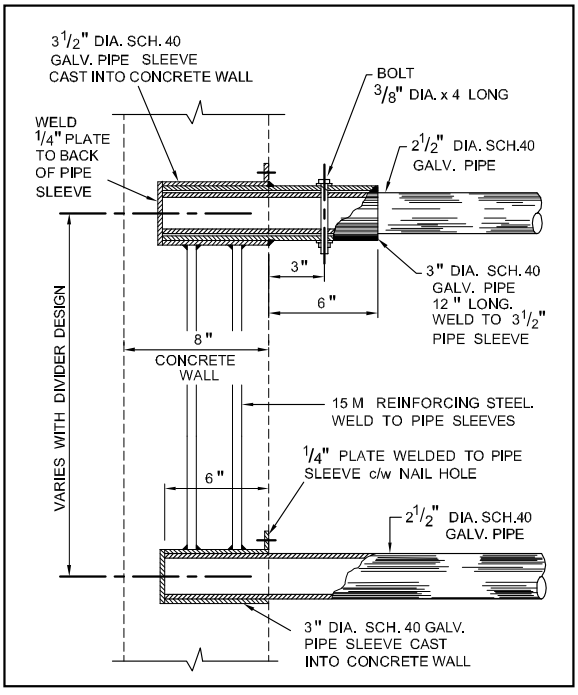

Figure 3 Pipe sleeve connection for loop stall divider

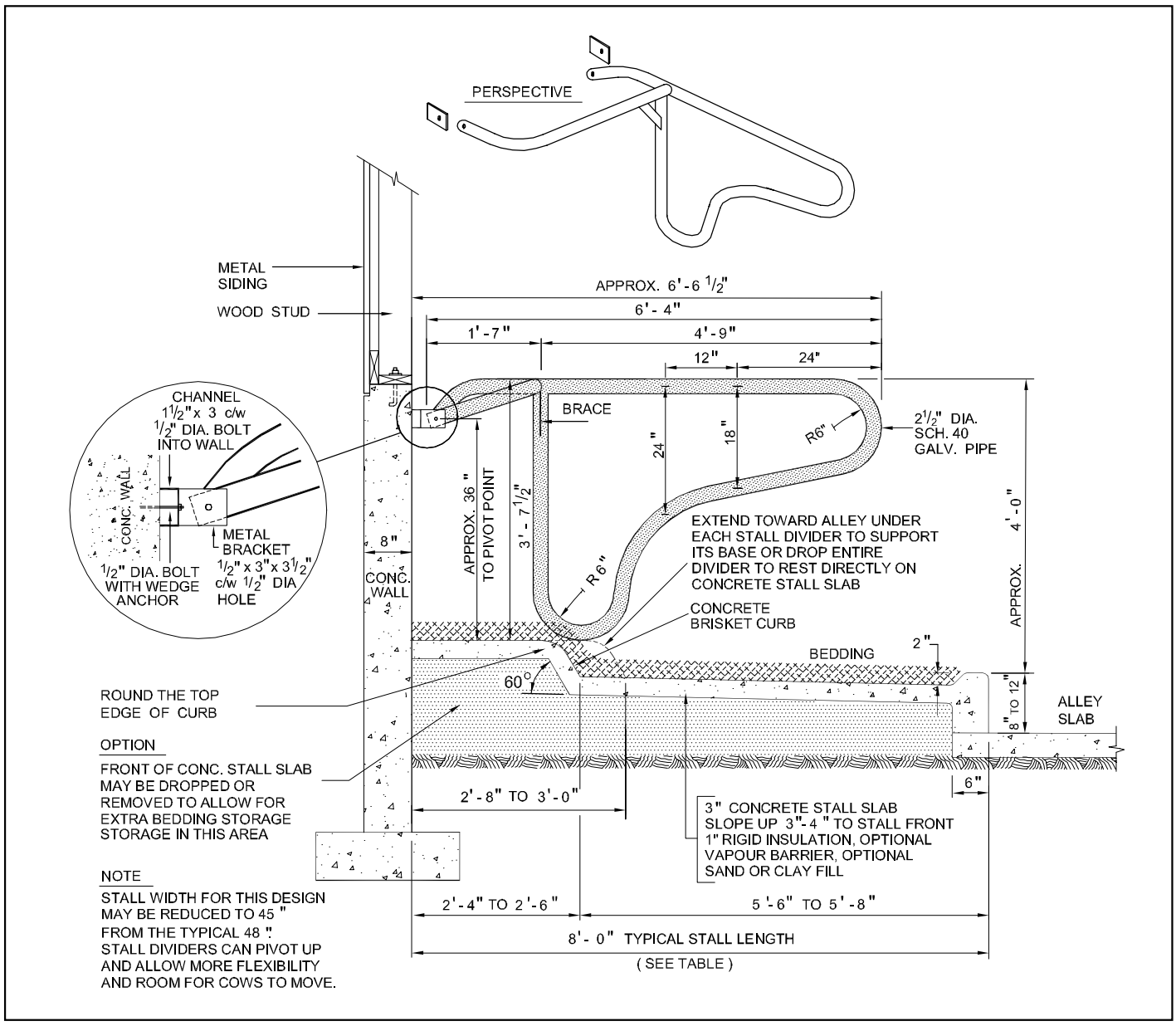

Figure 4 Pivot style divider with front hinge attachment and concrete brisket curb

Top rail height should be sufficient to keep cows from turning around. The bottom rail should be 12"–18" above bedding height to prevent leg and hip injury, yet low enough to prevent cows from partially lying underneath. If inadequate space is provided ahead of the cow as she lunges forward to stand, the bottom rail design should allow her to thrust her head into an adjoining stall.

Stall Fronts

The stall front prevents cows from moving too far forward, defecating, and urinating within the stall. It often provides support for the front end of the stall divider as well. The stall front may be an exterior building wall or a separate interior partition. Some designs for facing stalls provide open space to allow cows to share the same head space. Interior stall fronts must be high enough to discourage a cow from positioning her head over the front and standing too far forward. A front that is too low has the same effect as making a free stall longer.

Open stall fronts are recommended wherever possible. Not only are they preferred by cows, but they allow a farmer a better view of the barn to observe animals in heat, and to more easily spot injured, sick, and prematurely calving cows. Open fronts along sidewalls and in centre stalls also enhance ventilation crossflow in barns.

Stall Posts

Free stall designs which use vertical posts are most vulnerable at the curb line where manure and moist bedding accelerate corrosion.

For rear post designs, a polyethylene sleeve or boot placed prior to pouring concrete, and into which the post is slipped, will reduce the rate of corrosion, extending the life of the metal divider.

Stall Curbs

The stall curb serves to separate the stall area from manure and water in walking alleys. It also holds the stall base within the stall area and may be used to space and anchor the rear post of the stall divider.

Curb height is a compromise between what a cow will comfortably step over and what is needed to keep stalls clean. The curb should be high enough to discourage a cow from lying partly in the stall. A curb that is too high may cause udder injury when cows enter and leave.

Acceptable heights are from 8" to 12". Curbs of 8" are adequate for slotted floor or automatic alley scrape systems. Curbs of 10"–12" are recommended in flush systems or in barns where tractor scraping is done only once a day. The higher 12" height is recommended for barns with long alleys where manure is scraped for long distances. Cows have no trouble stepping into or backing out of a 12"-high curb. The top of the stall-side of the curb must be rounded for animal comfort, and to prevent possible udder or skin abrasion.

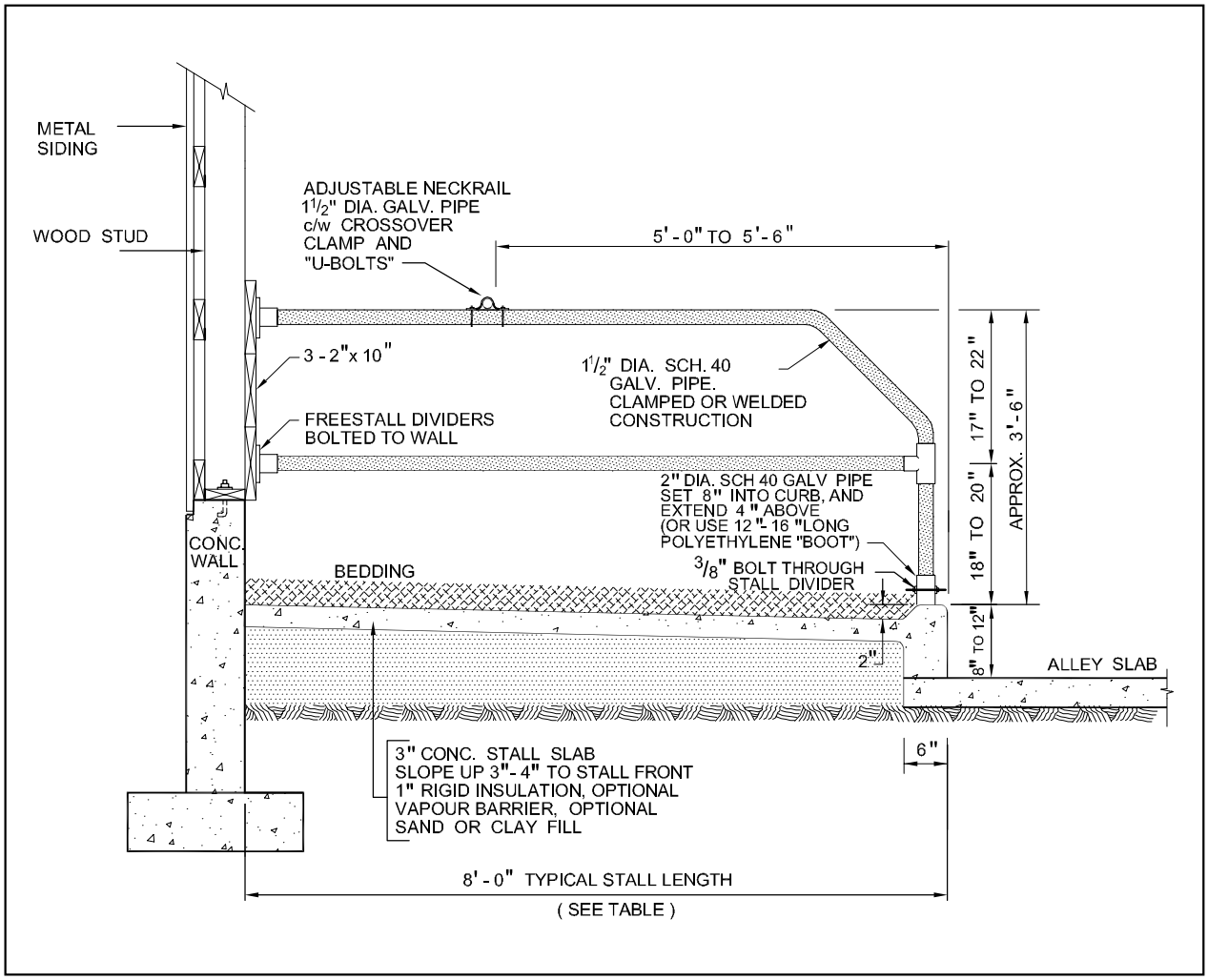

Figure 5 Post style divider with concrete base and adjustable pipe neck rail

STALL BASE AND DRAINAGE

The earliest versions of free stalls used earth, sand or clay as a base (see Figure 6). While cows definitely prefer such bases, maintenance is an annoying and constant problem. Hollows dug in such stalls through normal usage contribute to buildup of manure or urine and are often sources of mastitis. Injuries and trapped cows in poorly maintained stalls are frequent nuisances. Furthermore, sand kicked out of stalls is very abrasive on mechanical manure handling equipment.

Marl (clay or earth mixed with lime and/or cement) is often used as a base and offers some resistance to hollowing-out problems.

Bedding boards may be embedded part way into stall base earth, directly under and parallel with the stall divider. Such boards running full length from the stall front to the rear post or curb may reduce hollowing of soft stall bases and reduce the potential for an animal to get trapped under dividers. The bedding board must be high enough to prevent leg and ankle injury yet low enough to release a cow if required.

While not quite as comfortable to the animal, cleated wood, rubber tire, partial concrete, or full concrete bases used in conjunction with bedding afford the best compromise.

Free stall bases can also be constructed with a 3% slope from side to side to encourage all animals to lie the same way, thereby reducing the chance of udder or teat injury caused by neighbouring cows.

Concrete bases should slope up at least 3"–4" toward the front of the stall (see Figures 2, 4 and 5). This makes for a more comfortable resting position for the animal, discourages cows from lying backward, ensures that

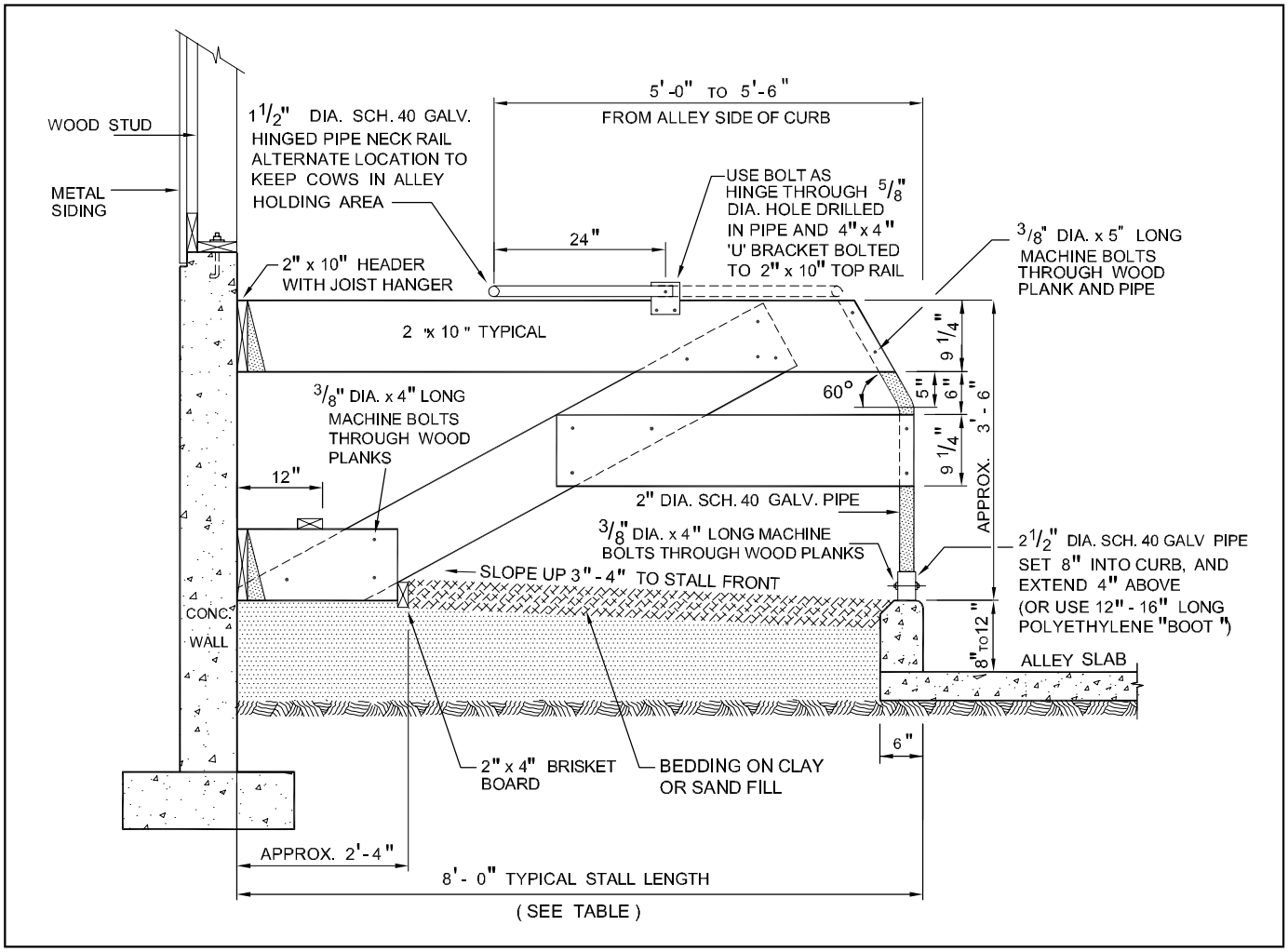

Figure 6 Wood style divider with clay or earth base and hinged pipe neck rail

bedding gradually works toward the back of the stall, and encourages drainage. A continuous drainage slot between the back of the base and the curb can drain excess urine into the sand or gravel substrate below, or into the alley through drainage pipes placed in the curb.

Wooden planks, as shown in Figure 7, can also be used to surface free stalls. Two by eights spaced ¾" apart over sand-filled free stalls are ideal. Planks are started at and placed parallel to the curb, with end joints under stall partitions. A 2"x 4"x 6' board with ⅜" lag screws is fastened to the top of the planks under each partition for anchorage and stability. This base may be bedded over with chopped straw or wood shavings.

Wood free stall bases are an economical alternative for producers seeking a solid base for free stalls. Such stalls, if properly installed, require little maintenance and last for years.

STALL SIZE

The free stall must be wide enough for the cow to lie comfortably, but narrow enough to keep the cow from turning around. It must be long enough to allow the cow to rest comfortably on the platform without injury, yet short enough that manure and urine fall into the alley. Calves can be trained to use free stalls immediately after weaning. Larger groups and greater age differences within groups can be tolerated with properly planned facilities. Some grouping, however, is necessary to match animal size to stall size and provide for different feed requirements.

Recommended stall dimensions for various sizes of cattle are given in Table 1.

RESTRAINERS

Neck Rails

A restraining device that is commonly used in free stalls is the neck rail. It is placed along the top and toward the front of the free stall to prevent cows from *standing* too far forward and manuring at the back of the stall. However, the neck rail must not be positioned too far back in the stall to hinder the ability of the cow to rise.

Pipe neck rails can be clamped to top rails of dividers with sturdy ductile iron cross clamps to allow for adjustment and to provide divider strength and stability (see Figure 5). Spring-loaded cables passing through short pipe guides welded or bolted to the top rail and sheathed with polyethylene tubing can also serve as neck rails (see Figure 8). Sheathing is necessary to prevent neck injuries caused by frayed cables.

Table 1 STALL DIMENSIONS FOR DAIRY CATTLE

SIZE AND AGE OF CATTLE TO BE HOUSED		STALL WIDTH	STALL LENGTH		NECK RAIL POSITION (diagonal distance from alley side of curb to neck rail)	HEIGHT (top of back curb to top of divider)
			unpaved	paved		
CALVES: 300 lb average:	3 to 6 months (range 250 - 350 lb)	2' - 3"	4' - 0"	3' - 9"	---	2' - 4"
CALVES: 500 lb average:	6 to 10 months (range 400 - 550 lb)	2' - 8"	5' - 0"	4' - 9"	---	2' - 8"
HEIFERS: 700 lb average:	10 to 15 months (range 600 - 800 lb)	3' - 6"	6' - 9"	6' - 6"	---	2' - 10"
HEIFERS: 1000 lb average:	15 to 24 months (range 800 - 1200 lb)	3' - 6"	7' - 0"	6' - 9"	5' - 6"	3' - 0"
COWS:	1200 to 1400 lb	3' - 9"	7' - 6"	7' - 3"	6' - 2"	3' - 4"
COWS:	over 1400 lb	4' - 0"	8' - 0"	8' - 0"	6' - 4"	3' - 6"

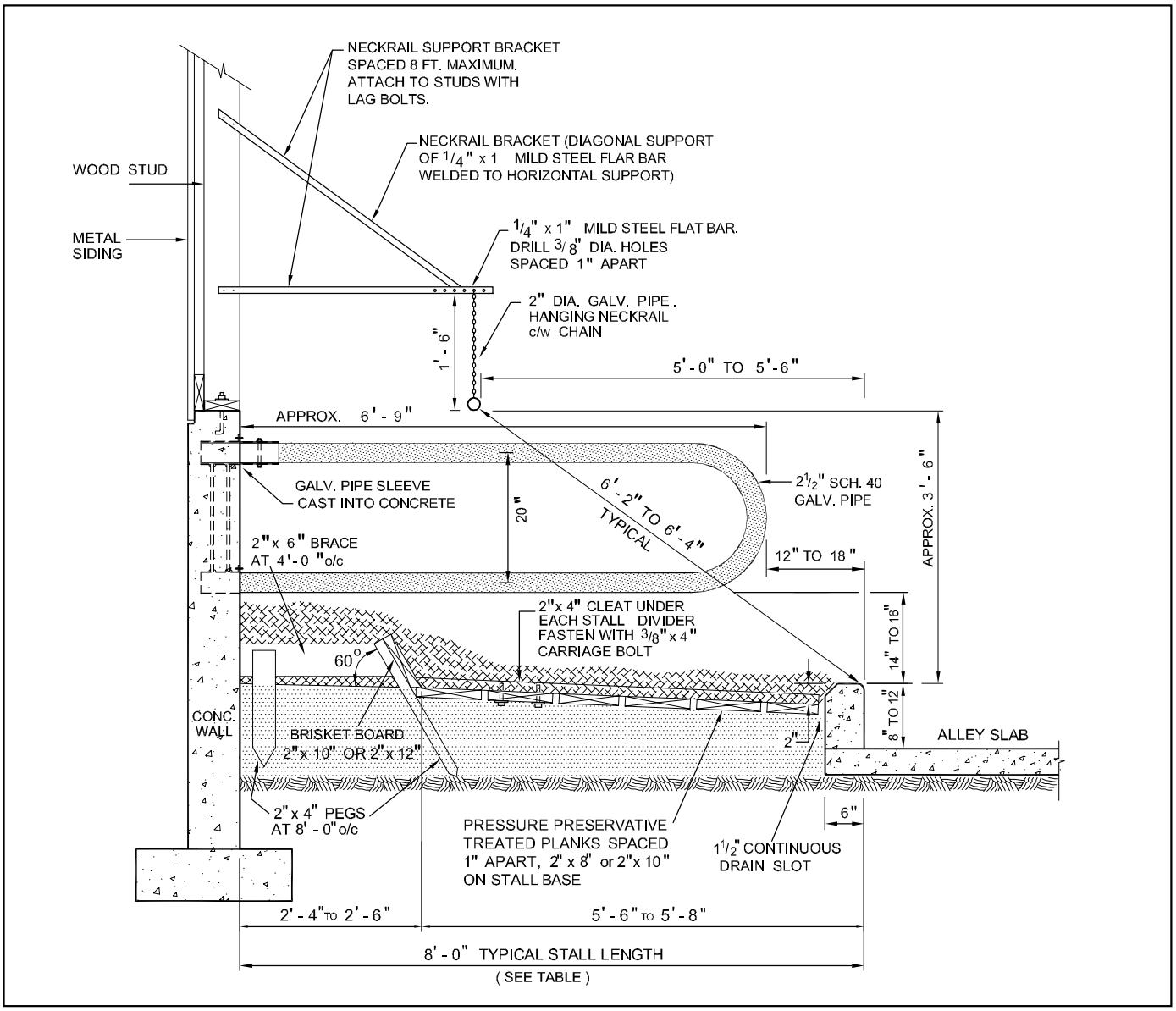

Figure 7 Loop style divider with hanging neck rail, brisket board and wood plank base

Another variation is the suspended pipe (see Figure 7) which has the added advantage that it discourages cows from placing their heads over conventional lower neck rail restraints and standing too far forward. The average horizontal distance to rails should be 5'- 0" to 5'- 6" from the alley side of the rear curb. Some adjustments may be necessary to fit specific stall designs and animal sizes. An alternative "rule-of-thumb" for mature cows is to position the neck rail at a distance of 6'- 2" to 6'- 4" diagonally from the alley side of the curb. Table 1 provides some dimensions for neck rail position.

Brisket Boards

Part of any good free stall design includes restraining devices such as brisket boards (see Figure 7). They are placed at stall floor level and toward the front of the free stall to prevent cows from *lying* too far forward and defecating or urinating in the stall. The space in front of the board can also serve as extra bedding storage. Brisket boards are commonly made of wood, although rubber belting can be used as well. Boards are placed 5'- 6" to 5'- 8" from the alley side of the curb for mature cows.

BEDDING

Bedding is used to provide insulation and a cushion between the cow and the base material and to absorb moisture.

Many types of bedding can be used in free stalls, depending on availability and cost. Good dry sawdust or shavings are ideal due to their easy handling qualities and moisture absorbing capabilities. Wood products, such as cedar that secrete toxins causing possible udder health problems or skin irritation, should be avoided. Other suitable bedding materials include chopped hay or straw, composted manure solids, and shredded newspaper or building construction paper products.

Any bedding should be soft and absorbent, should not easily support bacterial growth, and should not be easily removed from stall beds through normal cow traffic. A minimum of one to three inches of bedding should be used on any type of surface with an increased depth of three to four inches on hard surfaces.

Rubber mats are also used as free stall beds on concrete surfaces. A recent innovation is the use of straw or sawdust-filled woven polypropylene mattresses (or pillows) on an earth or sand base. Finely shredded rubber filling is increasingly being used as well. Success of rubber mat and mattress beds depends on careful installation. In both cases, a small amount of conventional sawdust, straw or paper bedding is necessary to keep surfaces dry.

The use of bedding and discarded tires buried in an earth base also provides good cow comfort and requires less care of stalls than in those with earth bases alone.

RUBBER MATS

When installing mats, it is best to use one piece of matting for an entire row of stalls. This prevents cows from working bedding under the mat. Also, rather than using a bedding keeper (which can trap moisture and lead to mastitis), the mat should be set 2" below the top and 1" in front of the curb. This allows any water or urine to drain down into the base material and leaves the bedding dry. Mats can become very slippery when wet. Bedding placed over them will reduce this hazard, making the stall more enticing to the cow.

MATTRESSES

The most recent innovative approach to improving cow comfort in place of concrete surfaced free stalls is to use a plastic, woven burlap-like material as a mattress-like cover filled with sawdust, chopped straw, or shredded rubber on a sand or earth base (see Figure 8).

To install the beds, the woven material is placed on the surface of the free stall and then folded over a layer of bedding to form a mattress. This can be done by unrolling, for example, a 10’ wide roll in the free stall area, 3’ in the stall and 7’ in the alley. Four to five inches of sawdust (or other bedding) are placed on the bottom layer and the remaining 7’ are folded over, bringing it forward to the front edge of the stall. The material can be sandwiched between a 2"x6" and 1"x6" nail strip secured along the front of the stalls and nailed in place every 12 inches. Polyethylene pipe, to which a small rope is attached, placed at the front of the stall through mattress loops (as shown in Figure 8) is a more convenient attachment option.

Over-filling may cause the mattresses to bulge when cows lie down. Sometimes these bulges are torn by cows or tractor scraping. Positioning the mattress three to four inches from the curb edge minimizes the chance of this happening.

A light layer of bedding should be deposited on the top of the mattresses once or twice a week. The rear of the bed surfaces can be swept clean during milking time.

Some advantages of using free stall mattresses are improved udder health, less bruising, swelling and soreness; reduction in amount of bedding used; less soiled bedding filling up the manure pit; and easy installation. Life expectancy depends on installation and maintenance practices and is typically three to four years.

TIRES

Tires of the same size should be used so that they will nest together well (see Figure 9). Tires are placed with most of the tread imbedded in the stall base and the sidewall facing up. Larger tires are more secure as they have a wider tread area allowing a deeper setting into the base. Also, drilling 5 or 6 holes 1½" in diameter in the tire near any low points will allow drainage of any possible unwanted collected water.

When placing the tires, those toward the front of the stall should be higher. A 3" or 4" slope from front to rear is ideal. The tires at the rear of the stalls should be about 2" below the curb to help keep bedding in the stall.

Compared to conventional earth or concrete base stalls, bedding use in free stalls with tires typically is reduced by 50% to 75%. Cows have no problem adapting to these stalls and, when given the choice, prefer these to many other bases since they are warmer, softer and more flexible.

Both whole and cut tires can be used. If whole tires are available, smaller diameters are preferred because a greater area of side wall is exposed, creating a more comfortable bed.

Whole tires can be laid onto a pregraded surface and then filled to about two-thirds of their depth with earth. Soils with some clay are ideal because they pack best. Sandier soils can be used with success but will require somewhat more maintenance. The major disadvantage to filling whole tires is that some digging by cows is possible, resulting in the shifting, tilting or lifting of a tire, a situation which requires total removal to correct. Tires should be placed so that they touch each other. Thirteen- or fourteen-inch diameter tires fit stall spaces best, but larger truck sizes can be used. The top is then filled with normal bedding.

Cut tires can be nested together to provide significantly more exposed surface area of the side wall. The tire is cut in two steps. First, the tire is cut in half with the cut through the middle of the tread along its circumference. Second, the created half-tire is cut into a one-half or one-third section, as a pie would be cut. Placing these sections with the arc up and the two ends down allows liquid to flow down and into the stall substrate, preventing any collection of water in the tire casing.

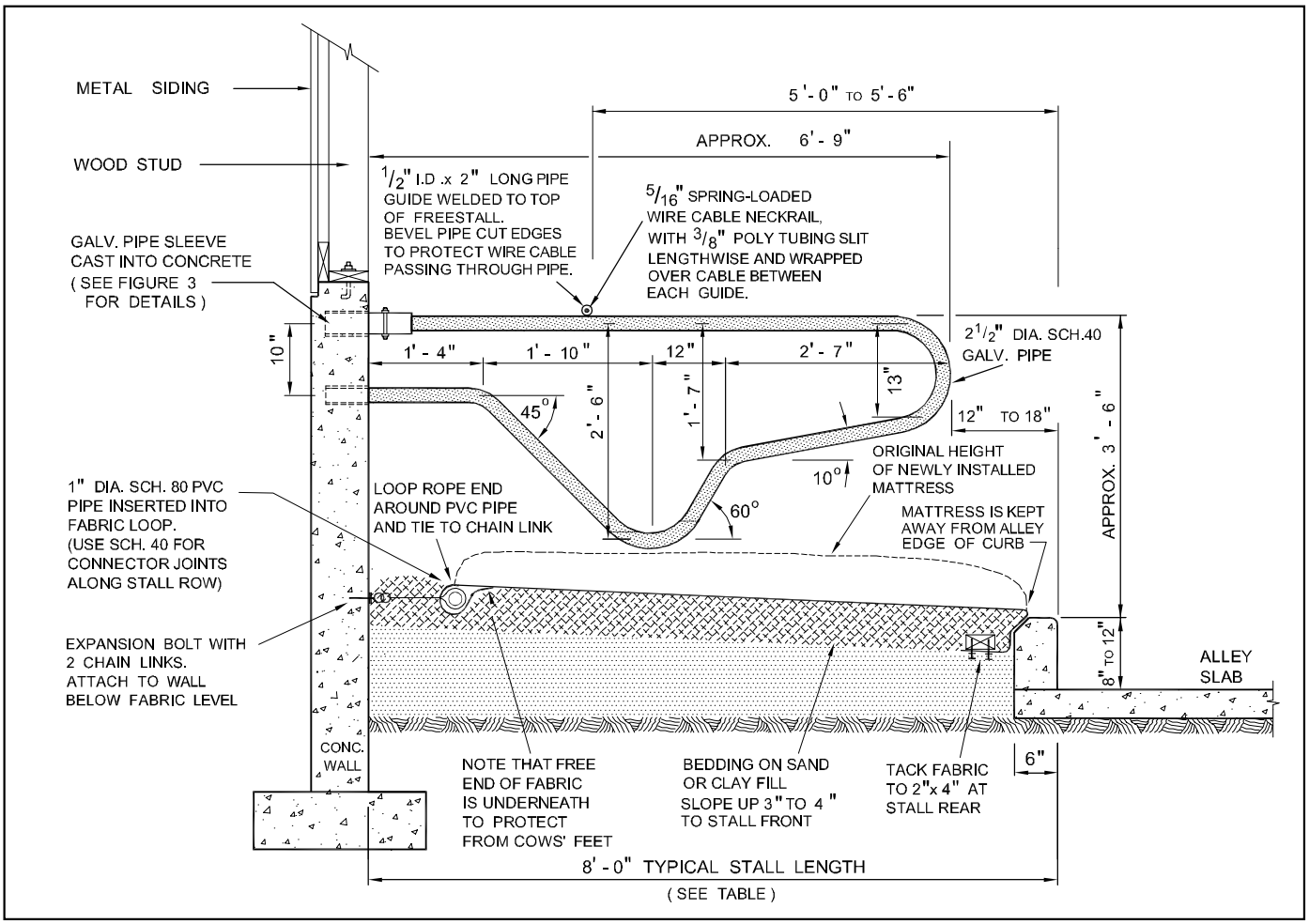

Figure 8 Michigan style divider with mattress bed and sheathed cable neck rail

BEDDING KEEPERS

Bedding keepers aid in keeping bedding materials in surface stalls where deeper bedding is required to prevent abrasion. A board or pipe along the rear of the stall can serve this purpose. Drainage is not as good, and manure or dirty bedding removal is not as easy with keepers, but they are necessary to maintain a uniform layer of bedding without excessive loss. A smoothly rounded inside curb edge dropping 2" to 3" to the concrete base serves equally well.

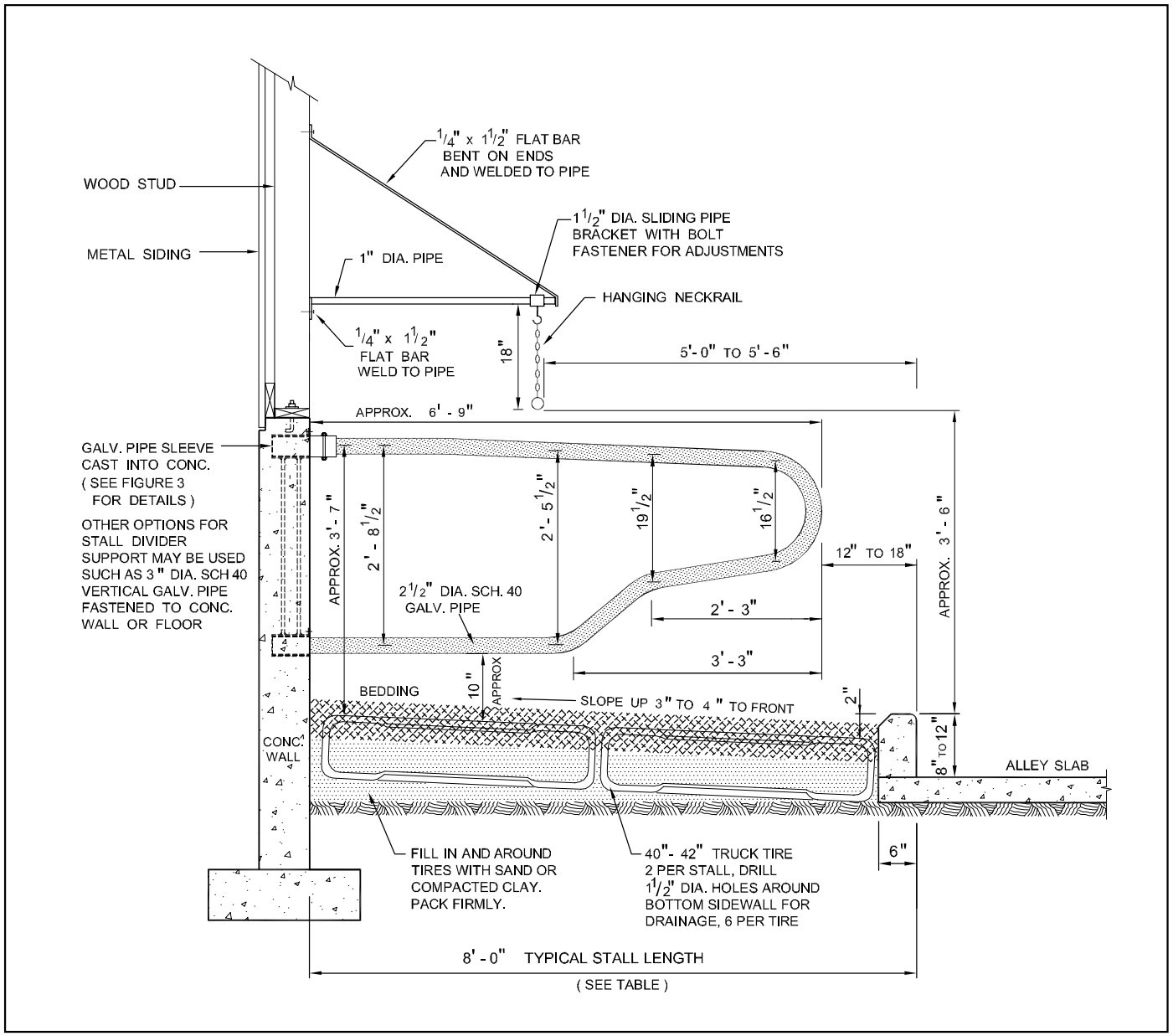

Figure 9 Super Comfort style divider with tire bed and hanging neck rail

MANAGEMENT

A good free stall design is not a substitute for good management. There are several regular duties required to keep free stalls in top condition:

- Clean manure and urine deposits from free stalls twice daily. It is best done after cows have been moved to the parlour for milking.
- Level stall bases or bedding once a day. Restore earth bases to their original slope at least every six months.
- Clean manure alleys, preferably twice per day, to reduce the amount of manure tracked into stalls from cows' feet. Because cows invariably return to free stalls to lie down after milking unless enticed to bunks by fresh feed, manure scraping in alleys during milking will improve underfoot cleanliness and help keep stall beds clean. This is vital since cows' teat canals remain relatively open after milking and are most vulnerable to infection for a half-hour subsequent to milking.
- Add clean bedding to stalls as conditions require, usually once or twice weekly, to provide a clean, comfortable base. Replace wet bedding promptly. In some stall designs, it is possible to place additional bedding at the front of the stall which will be worked back gradually by natural cow activity. Placing most bedding at the front of the stall will also help in reducing the amount kicked out of stalls the first few days after bedding. Spreading agricultural lime at the back end of free stalls prior to bedding may provide an environment in which bacterial growth is inhibited.
- Free stalls need repair occasionally despite sturdy and durable construction. Neglected repairs or adjustments often lead to cow injury, dirtier stalls and more mastitis. Broken dividers should be repaired immediately.

SUMMARY

Advantages of Free Stalls

- Less barn space is required per cow.
- Cows are cleaner and less udder cleanup before milking is required.
- Less total labour is needed for cleaning and bedding cows.
- Less bedding is required. Research and experience show that, for winter, 8 to 10 bales of straw per cow are needed with free stalls, compared to 40 to 50 bales with loose housing. Similar savings can be realized for sawdust bedding.

Limitations of Free Stalls

- Alleys must be scraped often, preferably twice each day.
- Manure must be handled as a slurry.
- Added investment is necessary for stall dividers and alley pavement.
- Number of stalls limits the number of cows in a building.
- Barn ventilation is more critical as cows have no choice but to use the barn as a rest area.
- Young stock must be grouped separately from milk cows and have stall dimensions sized accordingly.

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FOR FURTHER INFORMATION CONTACT
John Luymes, Farm Structures Engineer
Phone: (604) 556-3114
Email: John.Luymes@gems7.gov.bc.ca

RESOURCE MANAGEMENT BRANCH
Ministry of Agriculture and Food
1767 Angus Campbell Road
Abbotsford, BC CANADA V3G 2M3