MO-FLEX FARROWING
BUILDING PLAN

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Developed by: Joseph M. Zulovich, Ph.D., P.E.
Commercial Agricultural Engineer
Animal Structures Specialist
University Extension - Commercial Agriculture Program
Agricultural Engineering Department
University of Missouri

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- assurance of compliance with local codes and regulations;
- development and/or review of specifications for materials and equipment;
- selection of proper site providing adequate natural resource base;
- supervision of site preparation, bid letting and construction;
- development of a manure storage system and manure management plan;
- and provisions for utilities, roads and/or other access.

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APPENDICES

Acknowledgments

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MO-FLEX FARROWING BUILDING PLAN

The MO-Flex Swine Building System was developed to provide Missouri's independent swine producers with a comprehensive, standardized building plan package using current technology. The MO-Flex Farrowing Building is one production stage in the MO-Flex Swine Building System. Plan packages have been developed for each of the four stages of swine production; farrowing, nursery, grow-finish, and breeding-gestation. A plan package includes 20 - 17" x 22" sheets of construction drawings and a manual. The drawings show how a building should be built. This accompanying manual provides additional construction and specification details as well as a discussion of the design, operation and maintenance requirements of the building system.

The MO-Flex Farrowing Building is designed as a multiple room facility. The basic floor plan has a common hallway on one side to provide access to the individual farrowing rooms. The three rows of crates within an individual room are oriented with the length of the building. The number of crates within any room and number of farrowing rooms in one building can be tailored to fit the needs of an operation. The three row arrangement allows for the farrowing building to be easily converted to a nursery facility with tree rows of pens in each room.

Sizing a MO-Flex Farrowing Building

The size of a MO-Flex Farrowing Building will depend upon the sow group size and farrowing schedule of an operation. The size of a farrowing room will depend upon the sow group size and management preferences. The number of rooms a building will have depends on the weaning age of the piglets and on the farrowing frequency which is the interval between successive farrowings as well as other possible operational preferences. All-in/All-out management (AIAO) should be planned for with any new farrowing building. AIAO reduces the risk of disease because a given room or building is emptied and cleaned before any new sows are brought into the room.

Size of Farrowing Rooms

The size of a given farrowing room will be dictated by the size of the group of sows that will farrow together. Management preferences will determine whether the group of sows farrowing together is all from one sow group or is part of a larger sow group. The MO-Flex Farrowing Building Plan has seven different room sizes available: 12, 15, 18, 21, 24, 27, and 30 crate rooms. The floor plans of the various room sizes are shown on Sheet 2 of the drawings. A room alley is shown on the left end of each room. However, an alley can be located on either of the end of a room or on both sides if desired. The room lengths shown in the drawings are approximate because the actual room lengths for a building are determined after all building layout decisions are completed.

Number of Farrowing Rooms

The minimum number of farrowing rooms required for an operation uses the values for farrowing frequency and weaning age. An additional management decision must be made which is the number of days to turn a farrowing room. Turning a farrowing includes weaning, moving sows out, cleaning room, and moving close-up sows in to farrow. Typically, the days to clean and move with respect to farrowing ranges from 1 to 7 days. Using values based on the various management decisions, the minimum number of farrowing rooms can be determined as follows:

$$MNFR = \frac{WA + C\&M_{FARR}}{FF} \qquad \text{Eq. 1}$$

where: MNFR = Minimum Number of Farrowing Rooms,
WA = Weaning Age (in days),
$C\&M_{FARR}$ = Clean & Move for Farrowing (in days),
FF = Farrowing Frequency (in days).

Using a 21 day weaning age and a 7 day Clean & Move for Farrowing value, some common minimum number of farrowing room requirements for different farrowing frequencies include: 4 rooms for weekly farrowing; 2 rooms for bi-weekly farrowing; and 1 room for monthly farrowing.

The number of farrowing rooms as calculated using equation 1 assumes that only one farrowing room is used during each farrowing. An operation may chose to have multiple rooms available during each farrowing. If so, the minimum number of rooms from equation 1 is multiplied by the number of rooms used during each farrowing. For example, if an operation is farrowing weekly and chooses to use two rooms during each farrowing, then the actual number of farrowing rooms required is eight. Equation 1 determines the minimum number of farrowing rooms an operation requires based on the scheduling and weaning management decisions.

Manure Removal Impact

Manure should be removed from any swine building on a regular basis. When manure is removed from the building on a frequent basis, the ventilation system can be simplified because pit ventilation (air removal from manure/waste storage area) is not needed to help maintain indoor air quality.

Flushing under crates is the preferred manure removal system. No pit ventilation is required if flushing frequency for each gutter in a building is two hours or less. The flush system selected will have an impact on building length. Flush systems using flush tanks located inside the building require additional building length. A siphon flush tank design (MO Siphon Tank) developed by Agricultural Engineering at the University of Missouri is included with this plan. This MO Siphon Tank is constructed as an integral part of the building, so it minimizes additional building length. Other available flush tanks having the same capacity as the MO Siphon Tank typically require more building space. This building plan allows for a minimum of 8' additional building length for other available flush tanks. One needs to determine the space requirement of the selected flush tank to insure that enough space is allowed for the tank during this initial building sizing phase. Another flush system design uses overhead pipe storage and therefore does not require additional building length for the system. This overhead storage flush system allows for the absolute minimum building length for the number of crates in facility.

Other manure removal systems available with this plan include pit recharge and gravity drain gutters ("Pull-plug" systems). The pit recharge system is a shallow pit the is filled with a minimum of 12" of recycled water from an anaerobic lagoon after the pit is drained on a regular basis. The gravity drain gutter system is a reversing hairpin gutter that drains the liquid manure either to an outside manure storage or an anaerobic lagoon. These two manure removal options should have mechanical pit ventilation systems. However, these two manure removal options generally do not impact on the length of the building.

Another consideration for manure removal impact includes the possible manure storage options available at the site a building will be constructed. Flush systems and pit recharge systems assume an anaerobic lagoon is available for manure storage. The gravity drain gutter system can be used in conjunction with an anaerobic lagoon or a liquid manure system. If an anaerobic lagoon cannot be built near the building site, the gravity drain gutter system is the manure option for the building.

Determining Building Length

Individual farrowing rooms are combined into a building(s). The room sizes are selected to fit operational needs and management preferences. The overall length of a building would be the sum of actual individual room lengths chosen for one building plus any additional building length for flush tanks and or storage.

Interior walls between different rooms within a MO-Flex Farrowing Building do not add to the total length of a building. The interior walls are to be 2" x 4" stud frame walls.

Structural Considerations for a MO-Flex Farrowing Building

Design loads used for the building structure follow Standard ANSI/ASCE 7-93, Minimum Design Loads for Buildings and Other Structures. The live load for the roof structure was 20 psf (pounds per square foot). Wind loads for the structure were based on an 80 mph wind speed. Appropriate dead loads were included. Structural design details given in this plan meet required load conditions for Missouri. NOTE: If changes are made to structural design of the building, the changes shall be certified by an engineer to insure the proposed changes will provide adequate strength to meet required loads at the location the building is constructed.

The structural design details included in this plan should not be used in areas where either the design roof live load (i.e.. snow load) or the design wind speed is exceeded. Areas where either the roof live load or the wind speed are exceeded require different structural design details than ones included in this plan. An engineer will be required to redesign and certify the necessary structural changes so that the new design will meet the load conditions of the new area.

Structural Lumber Specifications

Lumber quality of all structural components is to be Number 2 Southern Pine or better. Treated lumber is to be 0.6 PCF CCA treated. Structural components include 2x6 post members, bottom plate, 2x8 bottom girt, 2x10 top girt, and purlins, either 2x4 or 2x6. Structural members for this MO-Flex Farrowing Building exposed to moisture include bottom plate and need to be CCA treated. The remaining sidewall structural members, which include 2x6 post members, 2x8 bottom girt, and 2x10 top girt, do not need to be CCA treated except for partitions at the sidewalls that may have curtains. If a lesser quality of lumber is used, the structural design details may be inadequate and then would require an engineer to redesign the structure for poorer quality lumber.

Ceiling Construction

Construction of the insulated ceiling may be accomplished by several different techniques. Owners and builders should determine with what and how a ceiling is actually constructed. The finished ceiling construction should have an R-value of 30 and have the proper interior surface characteristics. Two acceptable methods are given below.

One method of ceiling construction is to attach 29 ga. corrugated aluminum directly to the bottom chord of the trusses after a vapor barrier is installed. If a metal ceiling construction is used, the truss manufacturer should be notified when purchasing trusses because the ceiling may provide the necessary bottom chord bracing.

Another method of constructing the ceiling is to use a flexible plastic sheet material for the ceiling. The flexible plastic sheet can provide the desired surface characteristics and hold insulation adequately but will not provide bottom chord bracing. Additional framing may be required to provide the necessary bottom chord bracing.

Truss Selection

Trusses for the MO-Flex Swine Buildings have the following specifications:

Roof Slope:	4/12
Loading Criteria:	For insulated ceiling (20#-4#-0#-5#) Top chord live load - 20 psf Top chord dead load - 4 psf Bottom chord live load - 0 psf Bottom chord dead load - 5 psf
Support Width:	41' (Exterior posts are 41'-6" apart [exterior face to exterior face])
Top Chord Overhang:	18" to help protect fans in sidewalls
Truss Spacing:	4' o.c.
Purlins:	For insulated ceiling, 2x4's at 24" o.c. attached flat on top
Bottom Chord Bracing	Follow BWT-76 from Truss Plate Institute. Indicate construction method of ceiling (if used).

Trusses should be purchased from a truss supplier. Truss design should be certified by an engineer to meet the required loading.

Truss Erection

Truss erection and temporary bracing are important considerations during the design process of a truss. However, this component is the most difficult to manage from the building designer's point of view because of differences between construction crews and locations. Even though erection is the most difficult to manage, truss engineering firms are greatly concerned because of the potential loss of human life and property losses due to a construction accident during truss erection. Information on proper truss erection is available from "Bracing Wood Trusses" (BWT-76) and Handling and Erecting Wood Trusses (HET-80). Both pieces are available from the Truss Plate Institute. "Commentary and Recommendations for Handling, Installing and Bracing Metal Plate Connected Wood Trusses" (HIB-91) is another document from the Truss Plate Institute and provides diagrams and specifications for getting trusses safely installed.

General Concrete Specification

Concrete is used in the MO-Flex Farrowing Buildings for footings, exterior stub walls, flooring for manure handling systems, interior stub walls and/or concrete siphon flush tanks. Concrete specifications are as follows:

- Minimum 3,500 psi compressive strength (about a 6 bag mix),
- Air-entrained,
- Maximum aggregate size of 1 inch,
- Maximum slump of 4 inches.

This level of concrete quality is required to obtain the desired finishing and durability characteristics.

Reinforcing Steel Requirements

Reinforcing steel should be included in all structural concrete for MO-Flex Farrowing Swine Buildings. Structural concrete includes slab on grade construction, footings, exterior structural walls and/or concrete siphon flush tanks. Reinforcing steel is required not only for structural strength but also for temperature and shrinkage reinforcement.

Footings: Footings require two #4 bars running the entire length and located about 8" apart in the lower third of the footing. When footings go around corners, each corner should have #4 dowels to maintain the steel around each corner.

Slabs on Grade: Concrete floors 4" thick require #4 bars at 18" o.c. in both directions and located at the vertical center of the slab.

Exterior Structural Walls: Steel requirements for 8" exterior concrete walls include both vertical and horizontal steel reinforcing. Vertical steel should be #4 bars, 16" on center throughout the length of the exterior walls. Horizontal steel should be #4 bars, 10" on center (maximum) throughout the height of the exterior walls. For 4' high exterior walls, five (5) rows of #4 bars should be used (See sheet F4). For 5' high exterior walls, seven (7) rows of #4 bars should be used (See sheets P3 and/or H3).

Concrete Siphon Flush Tanks: If MO Siphon Flush Tanks are to be built, reinforcing steel requirements are detailed in drawings on sheets F7 and F9. Steel requirements for the siphon flush tank provide structural strength. If the steel requirements are not followed, a tank failure is possible.

Above steel reinforcing requirements are given as general recommendations. Drawings that accompany this plan should be examined to find locational details for reinforcing steel requirements of any particular concrete structural components.

Concrete Finishes

Structural Walls and Siphon Tank: All vertical structural walls, including concrete siphon tank components, should be vibrated during placement of the concrete. Vibrating is required to minimize honeycombing; insure that concrete entirely fills forms and also adheres to all connection and steel reinforcing.

Slabs on Grade: Concrete slabs on grade should be finished to a smooth float finish. The finish should be smooth enough so that manure removal is not inhibited. Also, the finish should be such that no aggregate or holes are left at the top surface to allow manure to easily begin corrosion of the concrete surface.

Alleys or Walkways: Alleys or walkways where human or animal traffic exist should have a non-skid surface. Concrete surfaces for alleys or walkways should first have a smooth float finish and then be completed with light to medium broom finish. The float finish is first required to give a durable surface, and the broom finish is to provide a non-skid surface for traffic.

Insulation Requirements

Insulation levels are shown on the drawings. Insulated components include: building perimeter, exposed concrete walls, frame end walls, and ceiling or roof. Reduced insulation levels from those shown on the drawings will increase heat loss from the building shell and result in higher heating costs.

Vapor Retarder Requirement

A vapor retarder should be placed behind the inside surface material of all insulated building components. An acceptable vapor retarder is 6-mil plastic. The plastic should be continuous and should be either sealed or overlapped at least 6" at joints. Other materials which meet vapor retarder performance of 6 mil plastic may be substituted.

Interior Surfaces

Interior surfaces can be constructed from a variety of materials. Interior surfaces should be non-porous. Surfaces need to withstand repeated high pressure washings using detergents and disinfectants. Typical surfaces include corrugated galvanized metal, corrugated aluminum and glassboard.

Exterior End Walls

Exterior end walls should be constructed as 2x6 stud frame walls using standard framing techniques. The sill plate should be CCA treated and attached to the concrete wall with ½" x 8" anchor bolts at a maximum of 36" on center. Insulation should be placed between the 2x6 studs to provide an R-value of about 19. A vapor retarder should be placed on the inside of the wall just under the interior wall surface. Exterior siding is placed on the outside of the walls.

Interior Partition Walls

Interior partition walls separate any rooms within a building. Several possible methods of constructing interior partition walls exist. One method to construct interior partition walls is presented below as 2x4 stud frame construction. However, any construction paractice or methodology that will give the same performance characteristics as the example stud frame construction is acceptable.

A standard 2x4 stud frame construction could be used for all interior partition walls. Bottom sill plate should be CCA treated and lag bolted to the floor. Top sill plate should be framed between bottom chords of adjacent trusses. The framing between trusses for the top plate of partition walls should not interfere with the proper function of the trusses. The 2x4 studs could be placed on either 16" or 24" centers. The selection of surface material will dictate stud spacing. Interior surfaces should be placed on both sides of the 2x4 studs. If pigs will have access to an interior partition wall, the pig contact area should be covered by a smooth, durable, joint free, pig resistant surface. A wall surface is more pig resistant if all joints at pig level are eliminated. Interior partition walls do not need to be insulated.

Post Frame Bracket Installation

The post frame bracket attaches the three 2x6's forming the post to the exterior concrete stem wall. The bracket connection provides a rigid joint at the bottom of the post. No knee braces are required for the design loads because the steel bracket connection provides the necessary lateral wind resistance. The bracket must be installed as shown on the drawings. To aid in construction, a template can be constructed and used to help with placing the four anchor bolts (4 - ½" x 8" anchor bolts) required for each post bracket. The four anchor bolts for each bracket must be properly placed in the exterior concrete stem walls when the concrete walls are constructed. When done properly, the bracket connection will provide a rigid connection between the concrete stem wall and the post frame structure.

The use of the post frame bracket removes the need for knee braces between the trusses and the posts or for interior shear walls. If the post frame bracket is not installed, knee braces or shear walls must be designed into the building to provide lateral wind stability.

Ventilation Specifications for a MO-Flex Farrowing Building

Fan recommendations for the various farrowing room sizes are given in Appendix E or Appendix F, depending upon whether pit ventilation is selected. Pit ventilation exhaust pipe designs are provided in Appendix G. A pit ventilation fan will need to be selected based on the pipes used in the system and how a manifold system is designed and built for a particular installation. These pit ventilation details are construction and equipment specific which makes it beyond the scope of the general ventilation recommendations incorporated in this plan.

Inlet system must match the fan capacity installed for a particular installation. Review the drawings of this plan for general inlet placement information.

Supplemental heating will be required for this plan. Heat can be added in either the common hallway, individual rooms or split between both. Specific heater sizes will depend upon the specific installation. Heater capacity can be estimated as 3,000 to 4,000 BTU/hr per farrowing crate capacity. For example, a 24 crate farrowing room will need between 72,000 and 96,000 BTU/hr heater capacity that is provided in either the room, common hallway or split between the two.

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A. Missouri Siphon Flush Tanks

Flushing is the preferred means of removing manure from MO-Flex Swine Buildings, and siphon flush tanks have attained preference as a water release device due to their simplicity and durability. A few commercially built siphons are available, and if properly sized and installed, work quite well. In Missouri, we have had considerable success with a "home-made" siphon design. Drawings are included in this plan to build MO Siphon Tanks as an integral part of the building structure. However, other water release devices can be used with MO-Flex Swine Buildings.

MO Siphon Tank Components

Although detailed knowledge of siphon operation is not necessary for construction of a siphon, a basic understanding of how a siphon works can help in judging its application and feasibility for a particular individual. The "Missouri" siphon tank consists of the following basic components as noted below and shown in figure 1.

1. Tank
2. Bell with Vent Hole
3. Discharge Pipe
4. Trigger Tube
5. Trap

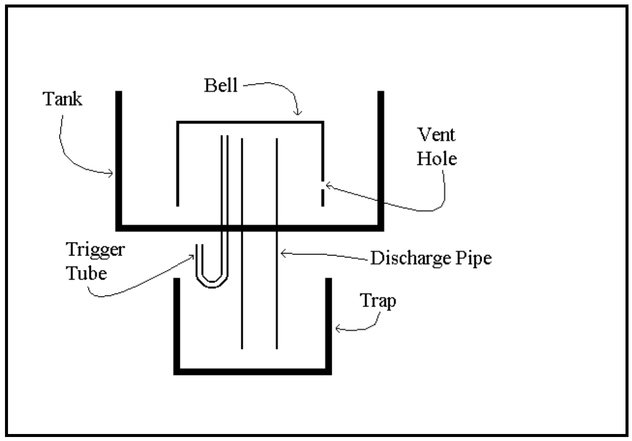

Figure 1. Siphon Tank Components

Siphon Tank Operation

The operational sequence of the Missouri Siphon Flush Tank is described in the following section. The simplicity of this siphon tank is realized by understanding the operation. No moving parts exist with the operation of the tank.

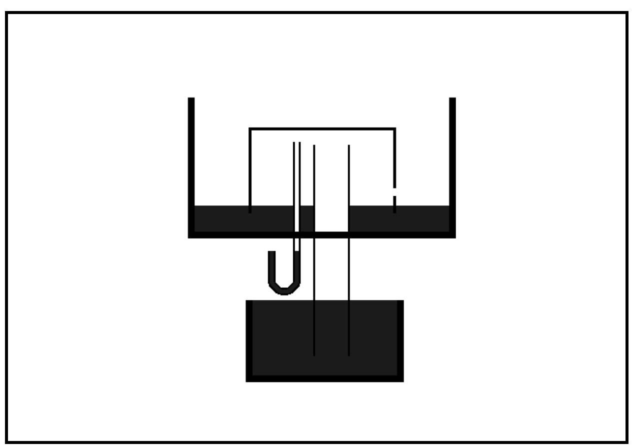

Figure 2. Beginning of Fill

The sequence of operation of the siphon tank begins with the tank filling with water as shown in figure 2. At the beginning of fill, subsequent to a prior flush, water occupies the shaded portions of the system. As the tank continues to fill, water covers the vent hole in the bell and a specific volume of air is trapped under the bell and in the discharge pipe. After the vent hole is covered, the water level under the bell rises at a slower rate than the water level in the tank. Also, the water levels in the discharge pipe and trigger tube are "pushed downward" by air pressure as water rises inside the bell.

Figure 3 shows the water levels in the various components of the siphon tank during the filling process. The water level in the tank will continue to rise faster than the water level under the bell. Also, the water levels will continue to drop in the trigger tube and discharge pipe until the tank is full.

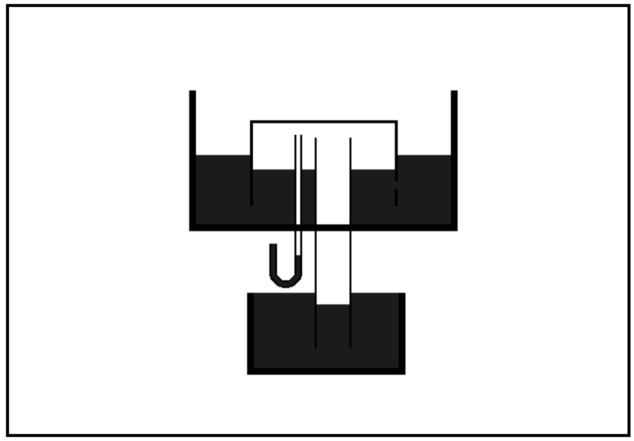

Figure 3. During the Fill

At the end of the fill cycle, water levels are as shown in the figure 4. At the end of fill, air is "pushed" around the bottom of the "U" in the trigger tube. This blows the remaining water out of the "up" leg of the trigger tube and allows the air to escape from under the bell. When air is purged from the system, water fills the area under the bell and the discharge pipe, and flow begins.

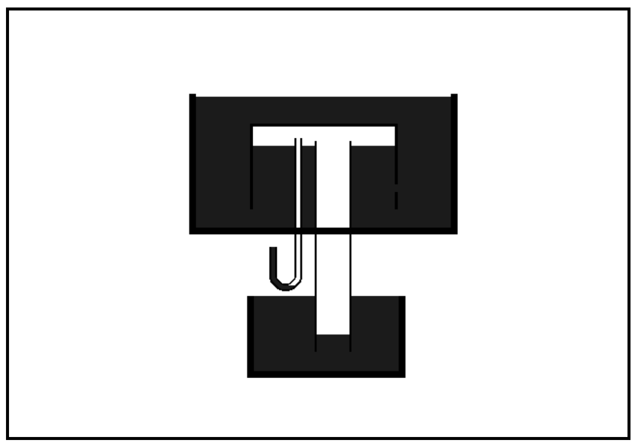

Figure 4. End of Fill

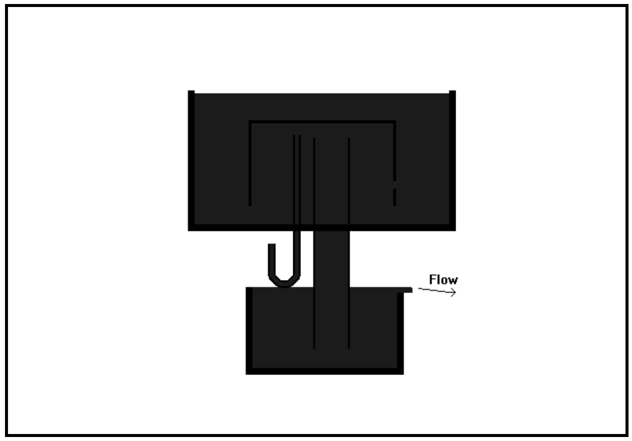

Figure 5. Beginning of Flow

At the beginning and during flow water occupies the area under the bell as shown in figure 5. After flow is established, the water level in the tank continues to drop until air enters the system underneath the bottom edge of the bell, and the siphon "breaks." Since the vent hole is exposed at this point, air is admitted into the bell until atmospheric pressure exists and conditions are correct for the next fill cycle as shown in figure 1. If properly installed, the trigger tube will refill with water during the tank discharge cycle as shown in figure 5.

By examining figures 1 through 5, one can ascertain that rather precise dimensions and construction/installation techniques are necessary in order to insure that the Missouri Siphon Flush Tank operates properly. Some of the parameters which are critical to siphon design and operations include:

1. Tank area in plan view and tank depth
2. Bell area in plan view and number of bells
3. Discharge pipe diameter and number of pipes
4. Trigger tube diameter
5. Depth of tank
6. Vent hole diameter and placement
7. Distance discharge pipe extends into tank
8. Distance discharge pipe extends into bell
9. Height of bell above bottom of tank
10. Length of "open" leg of trigger tube.

Siphon flush tanks MUST be built strictly according to plans to insure proper operation.

<u>Siphon Tank Start-up Procedure</u>

This start-up procedure insures that the tank will flush at the desired level by accounting for construction tolerances.

1. Make the "up" leg of the trigger tube 2" longer than indicated on the plan.
2. Fill trigger tube and sump. Then fill tank with fresh water to desired level and shut off water.
3. Drill ¼" holes in ¼" increments down from the top edge of the "up" leg of the trigger tube until tank flushes. For safety, <u>use a cordless drill</u> due to the wet environment.
4. Cutoff trigger tube pipe at last hole drilled when tank flushed.
5. Use fresh water during the start-up procedure.

B. Flush Gutter Water Trap

A water trap is required to isolate the air spaces and ventilation systems between adjacent rooms served by a common flush gutter. Different water trap designs are possible. A recommended flush gutter water trap is shown below.

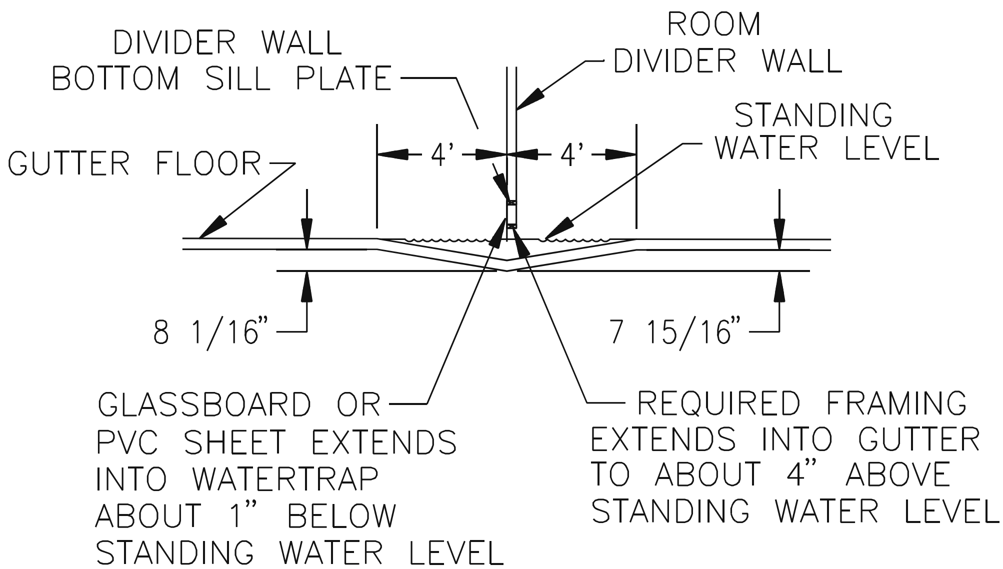

Figure 6. Scaled Sketch of Flush Gutter Water Trap

The above water trap isolates ventilation systems in adjacent rooms while allowing the flush water to pass under the interior partition wall (divider wall) from room to room. The isolation is accomplished by the glassboard extending about 1" into the standing water.

The glassboard is located on the "uphill" side of the divider wall and protects the wall from flush water splashing against the wall. The wall sill plate and the framing that extends the wall into the gutter channel should be constructed using CCA treated lumber. The gutter floor slope is continuous from one side of the trap to the other. Up to three of the above water traps can be placed in one continuous gutter.

If more than three traps are required, the flush volume should be increased to insure an adequate flush flow is maintained throughout the length of the gutter. The flush volume can easily be increased when using the MO Siphon Flush Tank by lengthening the flush tank length by 1' over the length of the tank recommended on the flush tank drawings (Sheets F5, F8 or F9).

C. Anaerobic Lagoon Systems

Anaerobic lagoon systems are a popular manure storage and treatment option for Missouri. Anaerobic lagoons are earthen structures that must be designed and built to meet Missouri Department of Natural Resources regulations. An anaerobic lagoon system is needed for use with flush and pit recharge manure handling and removal systems. A hairpin gutter manure system can also be used with an anaerobic lagoon.

PVC pipe is recommended to connect manure handling systems from building(s) to the anaerobic lagoon. A submerged inlet, shown in Figure 6, allows effluent to flow into an anaerobic lagoon without the potential of cold air entering a building through the drain line. A submerged inlet can help reduce odor potential from manure effluent draining from a building. A surface inlet, shown in Figure 7, can be used instead of a submerged inlet.

A recycle pump system will be required for both a flush and a pit recharge manure system. The recycle pump used for a recycle system should be a submersible, sewage ejector type of pump. A sewage ejector pump has larger impeller tolerances which allow the pump to operate longer between services. A wet well, shown in Figure 8, is located in the anaerobic lagoon bank to supply the recycle water. A wet well installation allows for easier maintenance of the recycle pump. To service the pump, one can simply lift the pump from the wet well instead of having to either drag the pump out of the lagoon or raft out onto the lagoon.

The build-up of salt crystals (struvite) is a common problem when using recycle systems. An acid cleaning system should be considered to help maintain any recycle system. Muriatic acid solution (a 10% hydrochloric acid) can be circulated through a recycle system to dissolve the struvite. If a wet well is used, the acid cleaning system can be relatively easily incorporated into the recycle system. An acid cleaning system generally consists of an acid storage tank and a small acid recycle pump. The acid recycle pump can be plumbed into the union of the recycle pipe that connects to the building(s), and a return line can be laid on the ground to return the acid back to the storage tank. The circulating acid will dissolve any salt build-up in the recycle line(s). If an acid recycle system is desired, the small stud frame building could store the acid recycle system.

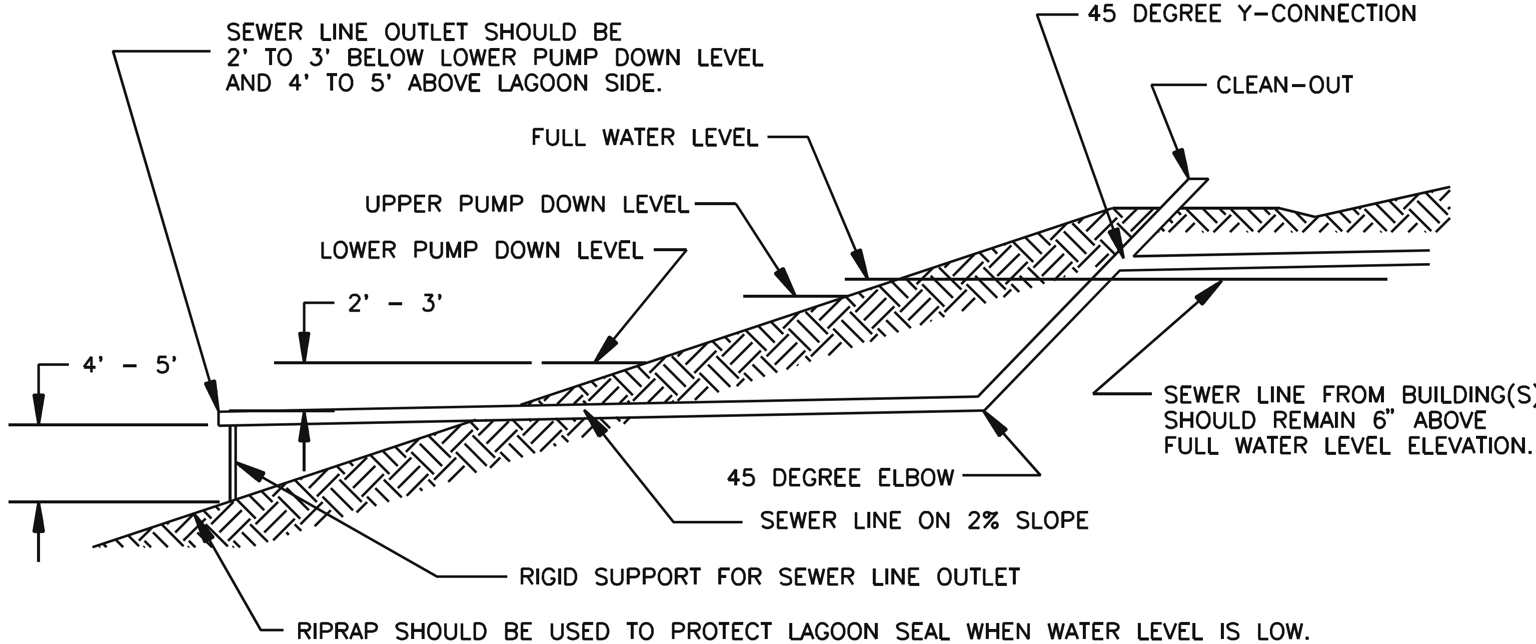

Figure 6. Scaled Sketch of Submerged Inlet into Anaerobic Lagoon.

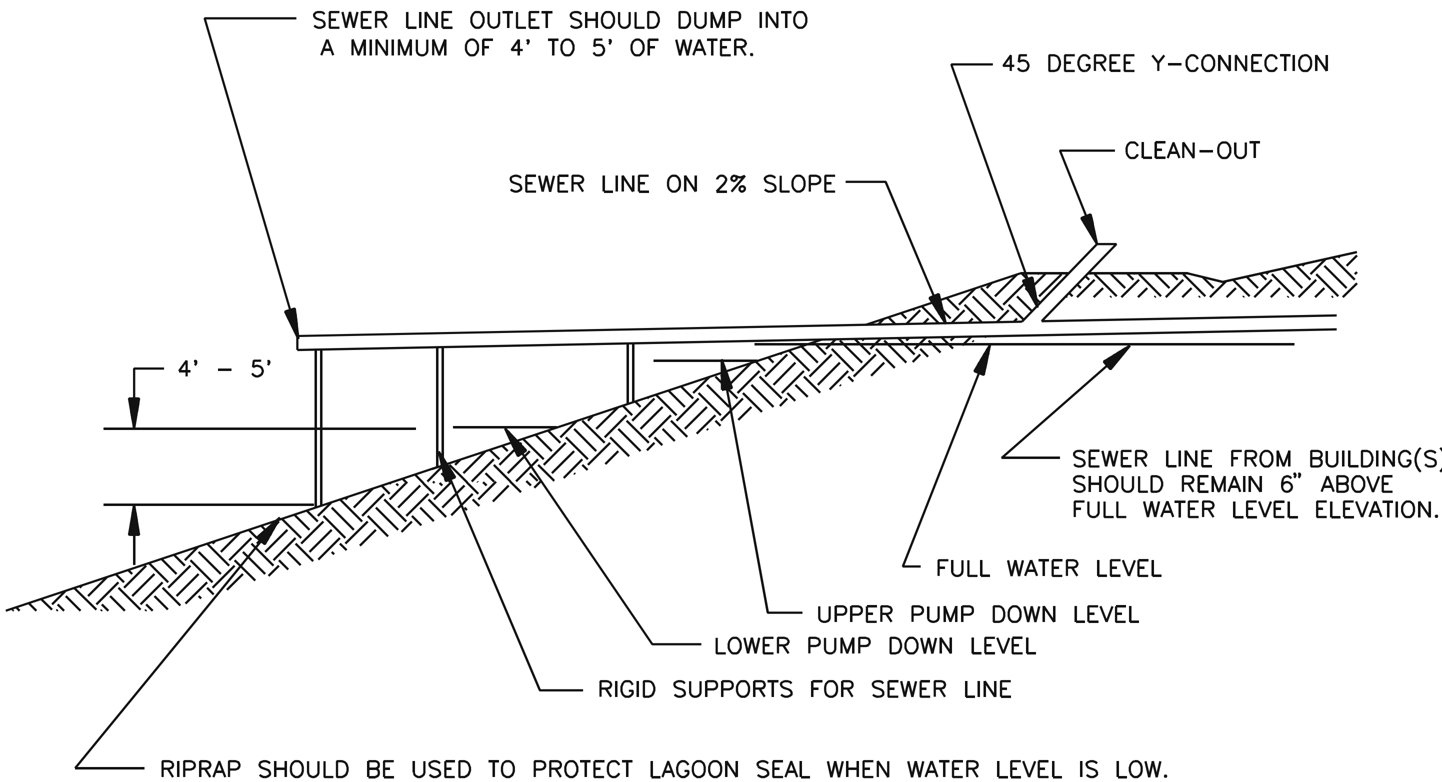

Figure 7. Scaled Sketch of Surface Inlet into Anaerobic Lagoon.

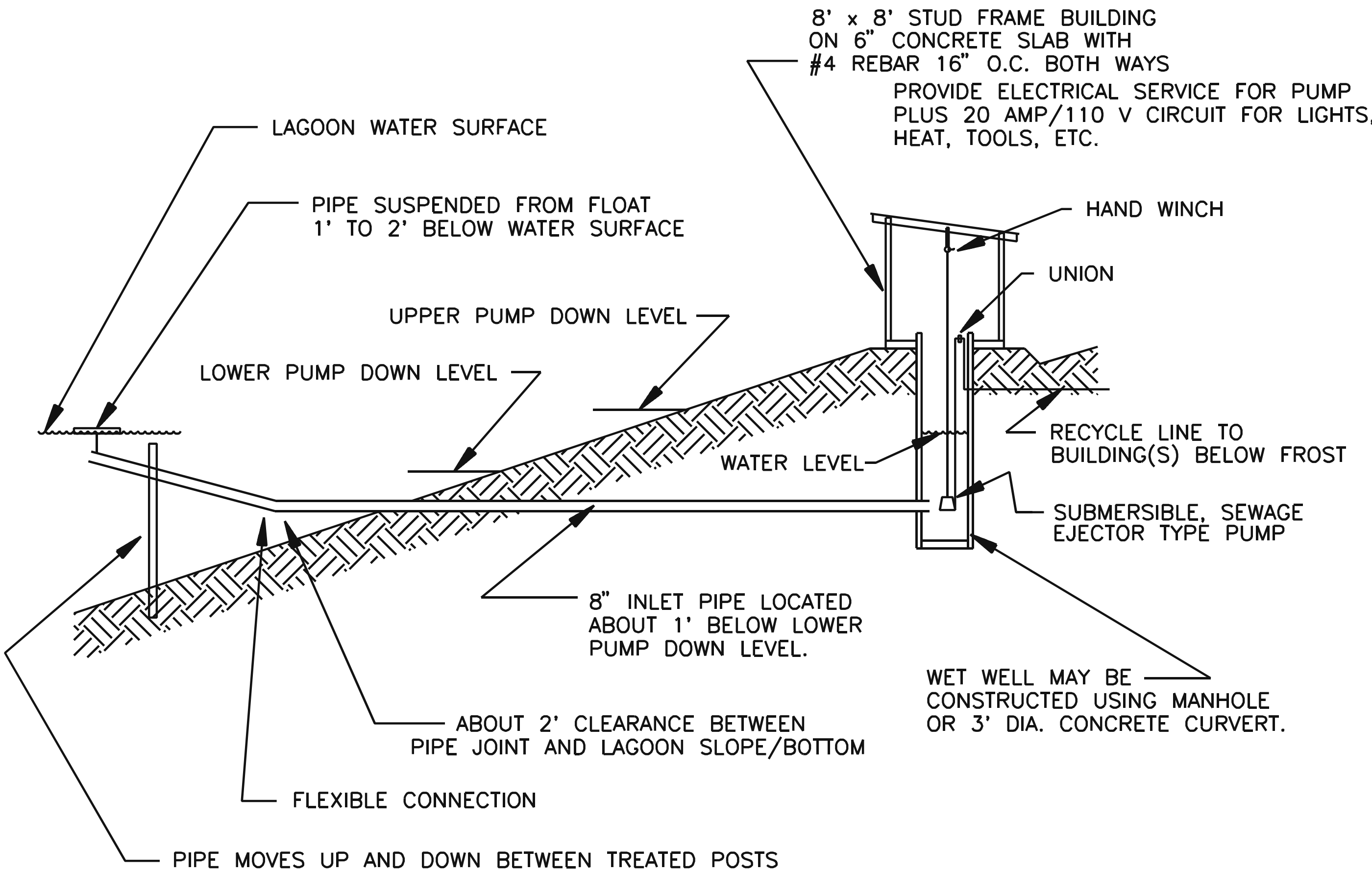

Figure 8. Scaled Sketch of Wet Well Installation for Lagoon Recycle Pump.

D. Concrete Manure Storages

The gravity drain gutter system allows for a liquid manure system. If the gravity drain gutter option is selected, an outside manure storage structure will be needed. Several types of structures are possible to serve as a liquid manure storage facility. Concrete manure storage facilities are probably the most common type of swine manure storage structure.

This MO-Flex Farrowing Building Plan does not have a manure storage plan included with the building plan. Information for designing and constructing concrete manure storages is available Concrete Manure Storages Handbook (MWPS-36). This handbook provides design criteria, reinforcing selection and construction details for liquid manure storages. However, local requirements and conditions may require specific design changes. A liquid manure storage should be certified by an engineer to insure that the structure will meet the required loads and comply with an environmental regulations.

E. Fan Sizes With No Pit Ventilation

Fan Requirements for a 12 Crate Farrowing Room			
No Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	8" variable speed	240	600
2	16" variable speed	800/1200	2400
3	24" single speed		5500

Fan Requirements for a 15 Crate Farrowing Room			
No Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	8" variable speed	300	600
2	18" variable speed	1150/1750	3500
3	24" single speed		5500

Fan Requirements for a 18 Crate Farrowing Room			
No Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	10" variable speed	360	1000
2	18" variable speed	1150/1750	3500
3	36" single speed		9000

Fan Requirements for a 21 Crate Farrowing Room			
No Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	10" variable speed	420	1000
2	20" variable speed	1300/2000	4000
3	36" single speed		9000

Fan Requirements for a 24 Crate Farrowing Room			
No Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	10" variable speed	480	1000
2	18" variable speed	1150/1750	3500
3	24" single speed		5500
4	24" single speed		5500

Fan Requirements for a 27 Crate Farrowing Room			
No Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	12" variable speed	540	1300
2	18" variable speed	1150/1750	3500
3	24" single speed		5500
4	36" single speed		9000

Fan Requirements for a 30 Crate Farrowing Room			
No Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	12" variable speed	600	1300
2	20" variable speed	1300/2000	4000
3	24" single speed		5500
4	36" single speed		9000

F. Fan Sizes Using Pit Ventilation

Fan Requirements for a 12 Crate Farrowing Room			
Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	Pit System		240
2	12" variable speed	650	1300
3	18" single speed		3500
4	24" single speed		4000

Fan Requirements for a 15 Crate Farrowing Room			
Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	Pit System		300
2	14" variable speed	900	1800
3	18" single speed		3500
4	24" single speed		5500

Fan Requirements for a 18 Crate Farrowing Room			
Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	Pit System		360
2	14" variable speed	900	1800
3	24" single speed		5500
4	24" single speed		5500

Fan Requirements for a 21 Crate Farrowing Room			
Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	Pit System		420
2	16" variable speed	1200	2400
3	24" single speed		5500
4	24" single speed		5500

Fan Requirements for a 24 Crate Farrowing Room			
Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	Pit System		480
2	16" variable speed	1200	2400
3	24" single speed		5500
4	36" single speed		9000

Fan Requirements for a 27 Crate Farrowing Room			
Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	Pit System		540
2	18" variable speed	1750	3500
3	24" single speed		5500
4	36" single speed		9000

Fan Requirements for a 30 Crate Farrowing Room			
Pit Ventilation			
Stage	Typical Fan Diameter and Type	Minimum Operating Rate (cfm)	Maximum Operating Rate (cfm)
1	Pit System		600
2	18" variable speed	1750	3500
3	36" single speed		9000
4	36" single speed		9000

G. Pit Ventilation Pipe Designs for Pit Ventilation

Fan Rating: 60 cfm @ 0.10" S.P. **Pipe Size:** 6" **Pipe Length:** 15' **Hole Size[1]:** 1" @ 4 & 8 o'clock				
Location from fan[2]	Distance from fan[3]		Location from fan[2]	Distance from fan[3]
1	1' 2½"		4	8' 5"
2	3' 7½"		5	10' 9½"
3	6' 0"		6	13' 2½"

1. For a given location. Hole size gives the size of the 2 holes drilled at the 4 and 8 o'clock positions.
2. Locations from fan are the positions down the length of the pipe from the fan or the end of the gutter that has the fan.
3. Distance from fan or end of gutter with fan to the center of the holes.

Fan Rating: 80 cfm @ 0.10" S.P. **Pipe Size:** 6" **Pipe Length:** 20' **Hole Size[1]:** 1" @ 4 & 8 o'clock				
Location from fan[2]	Distance from fan[3]		Location from fan[2]	Distance from fan[3]
1	1' 2"		6	12' 10"
2	3' 6"		7	15' 2"
3	5' 10"		8	17' 6"
4	8' 2"		9	19' 10"
5	10' 6"			

1. For a given location. Hole size gives the size of the 2 holes drilled at the 4 and 8 o'clock positions.
2. Locations from fan are the positions down the length of the pipe from the fan or the end of the gutter that has the fan.
3. Distance from fan or end of gutter with fan to the center of the holes.

Fan Rating: 100 cfm @ 0.10" S.P. **Pipe Size:** 6" **Pipe Length:** 25' **Hole Size[1]:** 1" @ 4 & 8 o'clock				
Location from fan[2]	Distance from fan[3]		Location from fan[2]	Distance from fan[3]
1	1' 1½"		7	14' 7"
2	3' 4½"		8	16' 9½"
3	5' 7½"		9	19' 0"
4	7' 10½"		10	21' 3"
5	10' 1½"		11	23' 5½"
6	12' 4"			

1. For a given location. Hole size gives the size of the 2 holes drilled at the 4 and 8 o'clock positions.
2. Locations from fan are the positions down the length of the pipe from the fan or the end of the gutter that has the fan.
3. Distance from fan or end of gutter with fan to the center of the holes.

Fan Rating: 120 cfm @ 0.10" S.P. **Pipe Size:** 6" **Pipe Length:** 30' **Hole Size**[1]**:** 1" @ 4 & 8 o'clock				
Location from fan[2]	Distance from fan[3]		Location from fan[2]	Distance from fan[3]
1	1' 1"		8	15' 10½"
2	3' 3"		9	17' 11½"
3	5' 4½"		10	20' ½"
4	7' 6"		11	22' 1½"
5	9' 7"		12	24' 2½"
6	11' 8½"		13	26' 3"
7	13' 9½"		14	28' 4"

[1.]For a given location. Hole size gives the size of the 2 holes drilled at the 4 and 8 o'clock positions.
[2.]Locations from fan are the positions down the length of the pipe from the fan or the end of the gutter that has the fan.
[3.]Distance from fan or end of gutter with fan to the center of the holes.

Fan Rating: 140 cfm @ 0.10" S.P. **Pipe Size:** 6" **Pipe Length:** 35' **Hole Size[1]:** 1" @ 4 & 8 o'clock			
Location from fan[2]	Distance from fan[3]	Location from fan[2]	Distance from fan[3]
1	1' 0"	10	18' 6"
2	3' ½"	11	20' 4½"
3	5' ½"	12	22' 3"
4	7' 0"	13	24' 2"
5	8' 11½"	14	26' ½"
6	10' 10½"	15	27' 11"
7	12' 9½"	16	29' 9½"
8	14' 8½"	17	31' 8"
9	16' 7½"	18	33' 6½"

1. For a given location. Hole size gives the size of the 2 holes drilled at the 4 and 8 o'clock positions.
2. Locations from fan are the positions down the length of the pipe from the fan or the end of the gutter that has the fan.
3. Distance from fan or end of gutter with fan to the center of the holes.

Fan Rating: 160 cfm @ 0.10" S.P. **Pipe Size:** 8" **Pipe Length:** 40' **Hole Size[1]:** 1" @ 4 & 8 o'clock				
Location from fan[2]	Distance from fan[3]		Location from fan[2]	Distance from fan[3]
1	1' 2"		10	21' 8½"
2	3' 5½"		11	23' 11½"
3	5' 9"		12	26' 3"
4	8' ½"		13	28' 6"
5	10' 4"		14	30' 9"
6	12' 7"		15	33' ½"
7	14' 10½"		16	35' 3½"
8	17' 2"		17	37' 7"
9	19' 5"		18	39' 10"

1. For a given location. Hole size gives the size of the 2 holes drilled at the 4 and 8 o'clock positions.
2. Locations from fan are the positions down the length of the pipe from the fan or the end of the gutter that has the fan.
3. Distance from fan or end of gutter with fan to the center of the holes.

Fan Rating: 180 cfm @ 0.10" S.P.
Pipe Size: 8" **Pipe Length:** 45'
Hole Size[1]: 1" @ 4 & 8 o'clock

Location from fan[2]	Distance from fan[3]	Location from fan[2]	Distance from fan[3]
1	1' 1½"	11	23' 4"
2	3' 4½"	12	25' 6½"
3	5' 7½"	13	27' 9"
4	7' 10½"	14	29' 11½"
5	10' 1"	15	32' 2"
6	12' 4"	16	34' 4"
7	14' 6½"	17	36' 6½"
8	16' 9"	18	38' 9"
9	18' 11½"	19	40' 11½"
10	21' 2"	20	43' 1½"

1. For a given location. Hole size gives the size of the 2 holes drilled at the 4 and 8 o'clock positions.
2. Locations from fan are the positions down the length of the pipe from the fan or the end of the gutter that has the fan.
3. Distance from fan or end of gutter with fan to the center of the holes.

Fan Rating: 200 cfm @ 0.10" S.P. **Pipe Size:** 8" **Pipe Length:** 50' **Hole Size**[1]**:** 1" @ 4 & 8 o'clock				
Location from fan[2]	Distance from fan[3]		Location from fan[2]	Distance from fan[3]
1	1' 1"		13	26' 10½"
2	3' 3½"		14	29' 0"
3	5' 6"		15	31' 1½"
4	7' 8"		16	33' 3"
5	9' 10"		17	35' 4"
6	12' 0"		18	37' 5½"
7	14' 1½"		19	39' 7"
8	16' 3"		20	41' 8"
9	18' 5"		21	43' 9½"
10	20' 6½"		22	45' 11"
11	22' 8"		23	48' 0"
12	24' 9"			

1. For a given location. Hole size gives the size of the 2 holes drilled at the 4 and 8 o'clock positions.
2. Locations from fan are the positions down the length of the pipe from the fan or the end of the gutter that has the fan.
3. Distance from fan or end of gutter with fan to the center of the holes.