



AMERICAN PEANUT SHELLERS ASSOCIATION

Handling and Storage of Farmer Stock Peanuts

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Introduction

All segments of the peanut industry have joined to produce wholesome peanuts of the highest quality. Growers, Shellers, food manufacturers and peanut warehousemen have each drawn a code of good practices for their particular segment of the industry and that code is available for distribution to industry members. Current consumer protection laws and numerous federal and state food laws demand that peanuts and all other food items be totally free from evidence of infestation, mold, bacteria and other similar contaminants. It is in the best interest of the peanut industry as a whole for each segment to do its utmost to perform in the best possible manner.

I. BUILDING STANDARDS

Farmer Stock Warehouse Construction

1. Make sure all closure strips are installed correctly so that screws secure the strips.
2. Assemble putty tape on all laps.
3. White reflective roof and sidewall surfaces reduce heat inside the warehouses. This reduces deterioration of product and insect contamination.
4. Seal around shrouds on fans to prevent short-circuiting of air.
5. Use cushion deadhead boxes on spouting. Install platforms to allow for clearing.
6. Use belt conveyor in top of warehouse, with tripper, to load warehouse.

7. Put a concrete slab apron at entrance doors to work on with loader, extending outward a minimum of 10 feet from each door.
8. Make all doors, hoods, fans, etc., accessible for sealing to fumigate.
9. Locate catwalk and belt in top of warehouse low enough to prevent overloading warehouse.
10. Incorporate cleaners and/or dirt screens to clean peanuts going into warehouse.
11. All wiring should be in conduit and on outside of building. No wiring should be between the wall and the stored peanuts.
12. Roof pitch of 12/12 will improve ventilation. Caution should be taken against over filling. A 12/12-roof pitch will allow for the elimination of a **doghouse**. A 9/12-roof pitch requires a doghouse in order to adequately fill.

Elevator Spouting

A 45-degree slope is necessary to allow for adequate flow of farmer stock peanuts, especially peanuts containing foreign material or high moisture, or if the spouting is rusty. However, a 45-degree slope over a long distance can result in too much velocity, causing damage to the peanuts. Deadheads should be installed every 50 feet to slow down the flow of peanuts.

There are situations where damage can be lessened by reducing the slope to 38 to 40 degrees. To prevent clogging, caution must be exercised to prevent rusty spouting and handling of peanuts with high moisture or foreign material. Peanuts with low moisture and low foreign material can be damaged in spouts with 45-degree slope.

- Deadheads should always be installed when the angle of spouting is greater than 45 degrees, even for short distances. Deadheads should also be installed at the end of elevator spouts to slow velocity before exiting the spout.
- Deadheads should be accessible to personnel for cleaning. Platforms should be installed if necessary for safe access. Deadheads should be designed to allow for opening and cleaning.

Elevator Gate Openings

The width of the gate opening feeding the elevator should be 2 inches less than the width of the elevator cup. The elevator cup should extend one inch beyond the edge of the gate opening on each side. This will reduce spillage into the boot of the elevator where severe damage to the peanuts can occur.

Double Roof Warehouse Construction

CONCEPT

The addition of a second roof on a mechanically ventilated farmer stock warehouse provides a solution to a leaking roof as well as the advantage of stabilizing temperature variations within the warehouse. The costs associated with retrofitting a warehouse with a second roof can many times be less than replacing deteriorated roof sheets.

By spacing a second sheet of metal approximately two (2) inches above the existing sheet, and venting equally at the top and at the bottom to allow for a constant flow of air near ambient temperature, an insulating effect is created (*Figure 1*). The type purlin used should be such that upward airflow will not be restricted between the roof sheets. A vapor barrier is created by the air between the roof sheets, and a 15-20 degree temperature reduction within the warehouse is not unusual.

Venting so that outlet space at the top is at least equal to inlet space at the bottom is essential. A residential-type continuous ridge vent should be used on warehouses without doghouses (*Figure 2*). A warehouse with a doghouse should use a transition flash at the top to allow for adequate airflow (*Figure 3A*). For a warehouse with a double wall doghouse, the transition should be the outer wall (*Figure 3B*).

ADVANTAGES

A number of advantages are created with the installation of a double roof:

1. Condensation is reduced or eliminated due to the insulating effect.
2. Insect pressure is reduced due to lower inside temperatures during times of warm weather.
3. Leaks can be eliminated more effectively than with roof coatings and at less cost than replacing old roof sheets.

Note Additional information may be obtained from the USDA National Peanut Research Laboratory in Dawson, Georgia.

FIGURE 1

Sheeting Detail

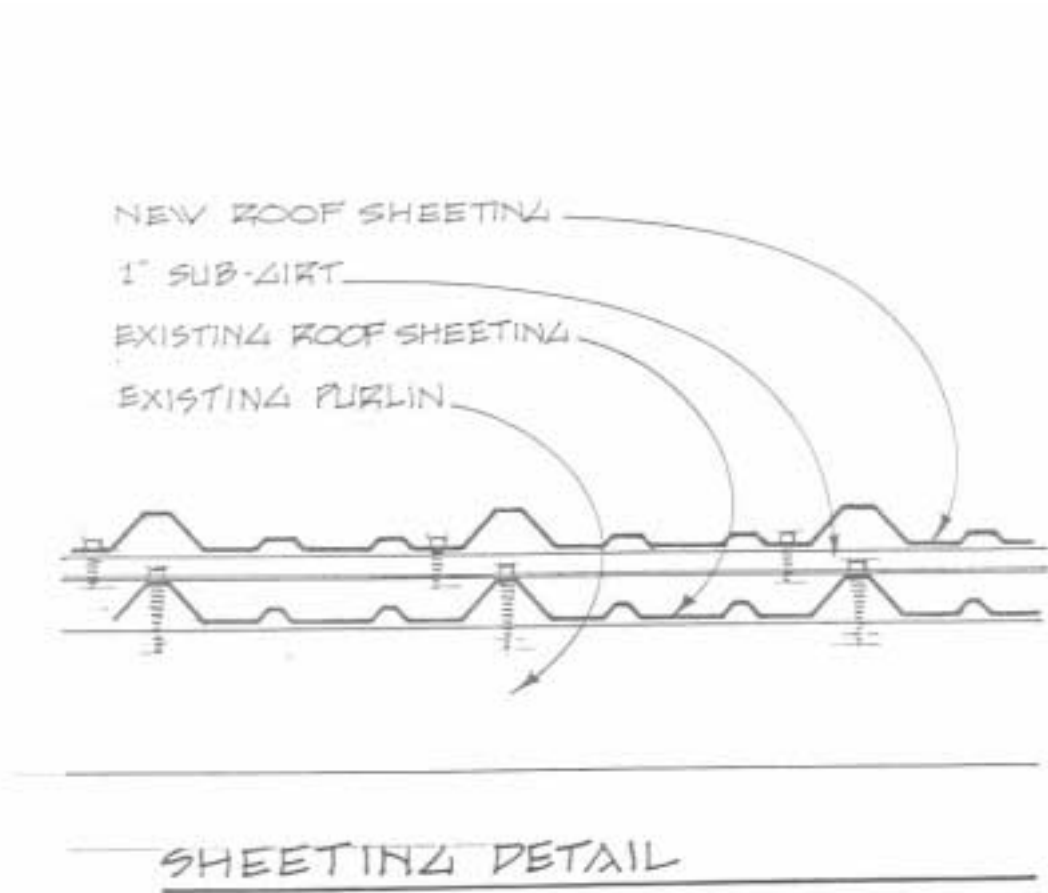


FIGURE 2

Continuous Ridge Vent

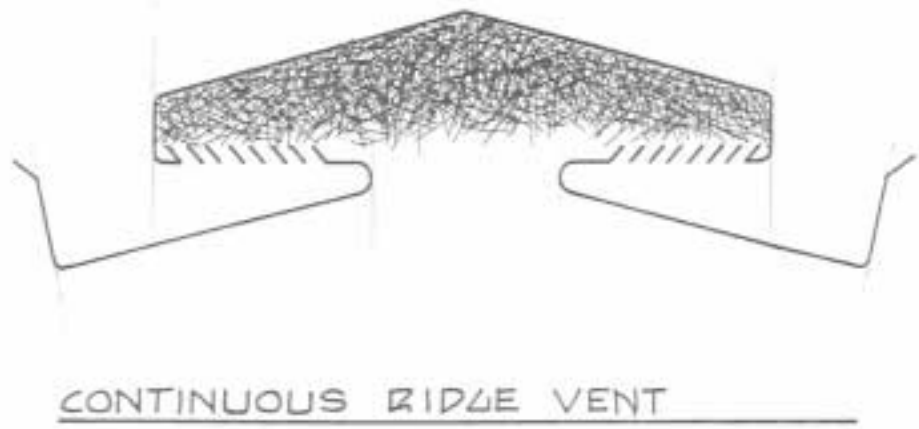


FIGURE 3 A

Roof / Doghouse Transition

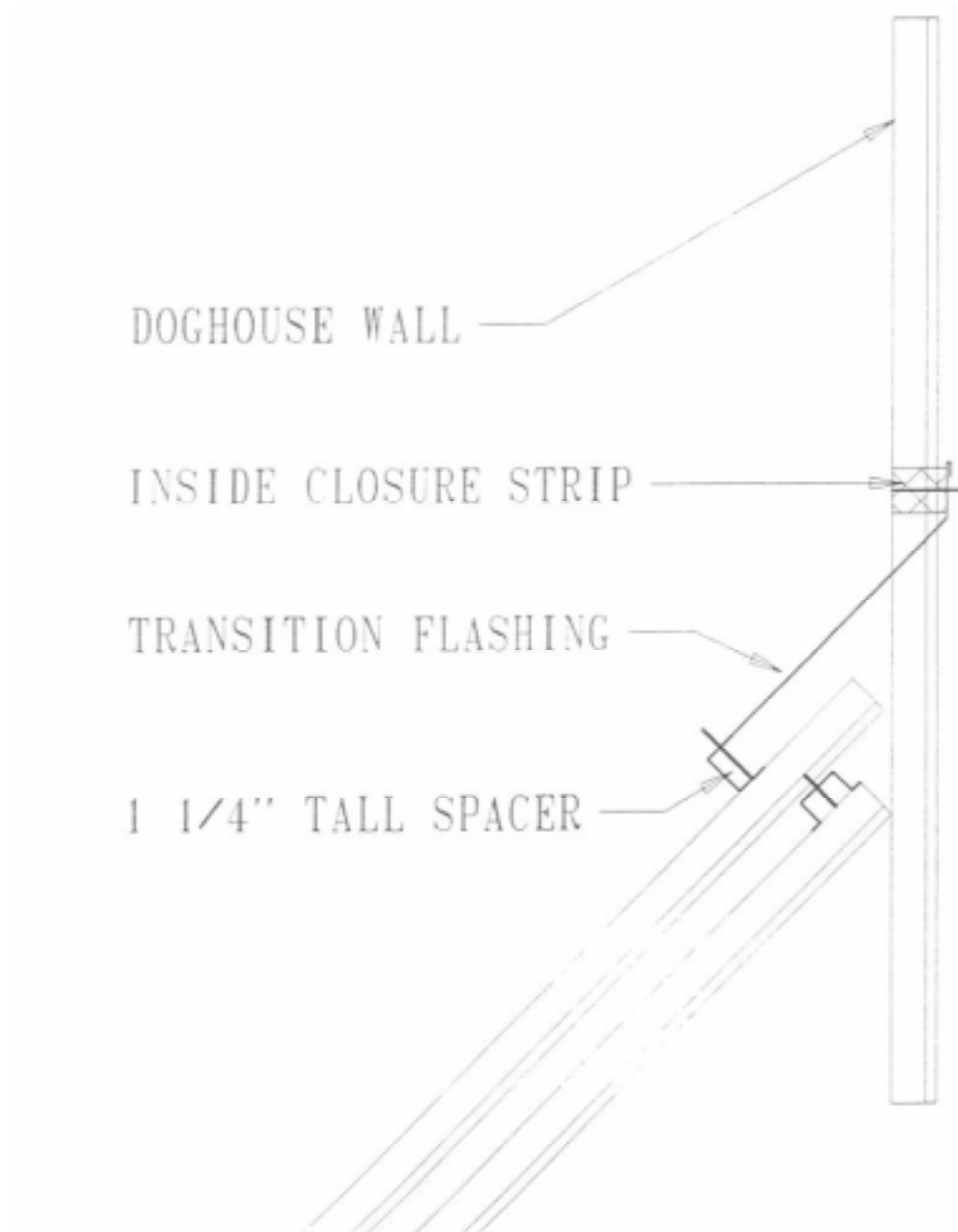
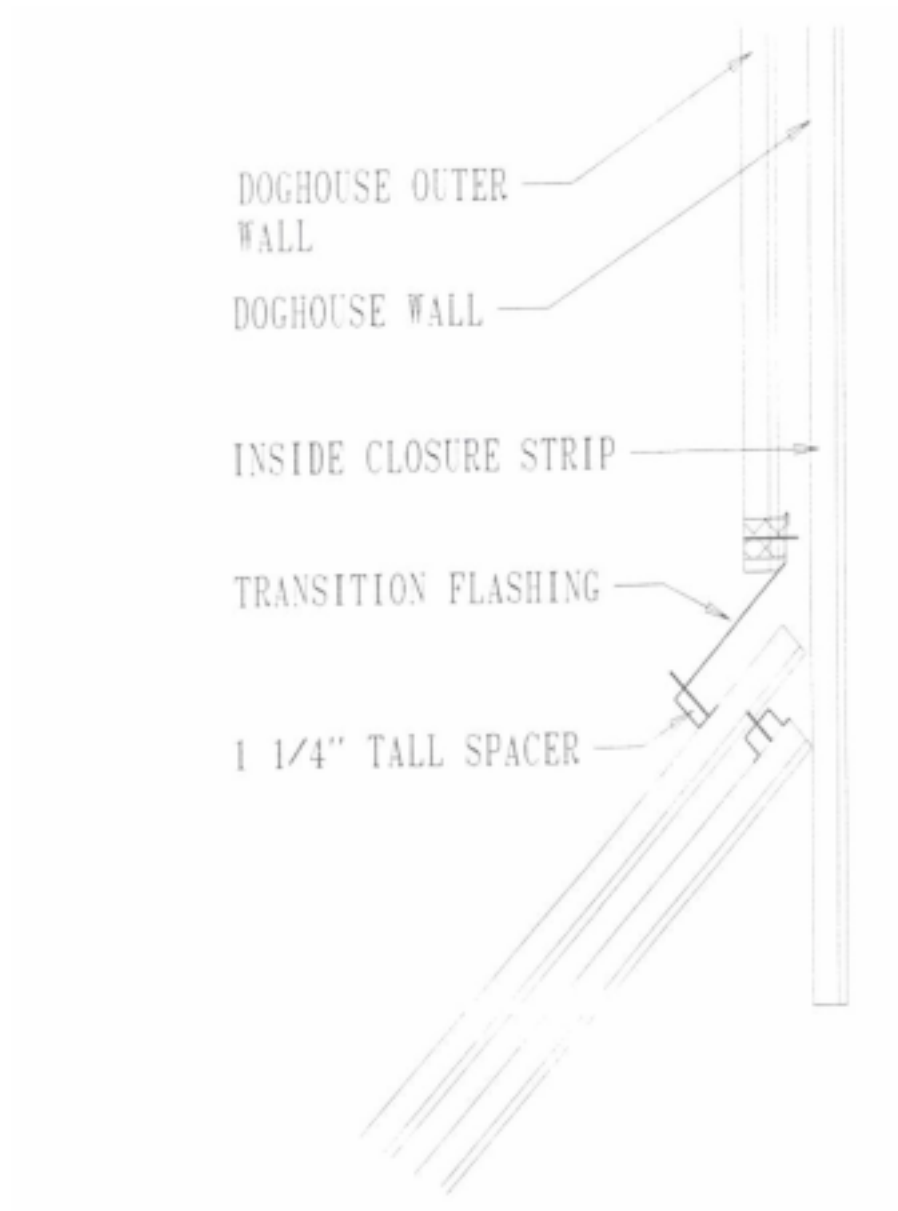


FIGURE 3 B

Roof / Doghouse Transition – Double Wall



opposite gable. Some inlets (totaling 10-20% of inlet area) should be installed under the eaves at the inlet gable for good airflow across the peanut surface.

From a practical standpoint, the ventilation fans should run continuously while peanuts are in the warehouse, except when spraying for insects (*Vapona*, etc.) or when fumigating. However, if proper temperature and humidity sensors are used to determine dew point conditions, they should take preference in controlling fan operation after excess heat and moisture have been removed.

Generally, warehouses should be filled to within 1 foot of the roof at the eaves, maximum. Under no circumstances should the peanuts cover any inlet vents at this level as this will diminish the performance of the ventilation system.

All openings in the warehouse (seams, holes, etc.) not specifically used as inlets should be sealed, especially where they will short-circuit the air to the fans. From a ventilation standpoint, this is not necessary at the inlet end of the warehouse. Any openings may, however, present problems with insects and water entering or when fumigating the warehouse.

All inlets should be covered with ½" hardware cloth to prevent the entry of large insects and birds. Lower mesh size may restrict airflow.

Hooded vents will normally be used instead of louvers because of less air restriction, ease of sealing during fumigation, better water exclusion, and lower maintenance.

Belt slippage on ventilation fans is a common and serious problem, often resulting in a 50% to 75% reduction in airflow. This situation frequently occurs with minimal visual or audible indication of slippage, and requires the routine use of a tachometer to verify actual fan speed.

Whenever selecting a new fan drive or replacement belt it is best to avoid type "A" belts, using either type "B" or "BX" instead.

Replacing existing gravity louvers with hoods is suggested. If the louvers are utilized, care should be exercised to ensure sufficient free area is achieved. Once the needed free area for the opening is calculated, it should be determined that the louvered vent to be used provides the required amount of free area in square feet. Refer to manufacturer specifications for the amount of free area provided by a particular louvered vent. The method for calculating required vent inlet space follows later in this report.

In some cases, 45-degree hoods will be used to cover fan exhaust areas. 90-degree hoods can be used to reduce the possibility of rain blowing into the warehouse, but fan CFM's must be increased to compensate for restricted airflow. 90-degree hoods should always be used to cover vent inlet areas to exclude water droplets from entering.

Generally, the entire ridge and all ridge vents should be sealed if the warehouse is mechanically ventilated. While the ridge vents at the inlet end of the warehouse may be used as inlets, they must be sealed whenever the warehouse is fumigated.

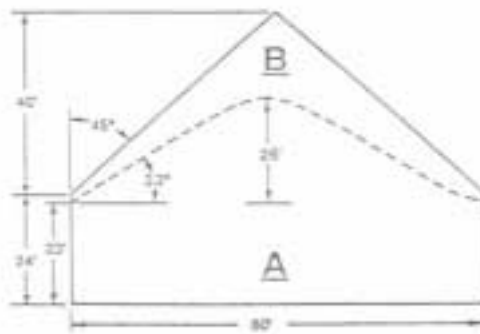
Natural Ventilation

Naturally ventilated warehouses can be effective. However, insect controls through timer-released insecticide applications are less effective. Fumigation is also more difficult in naturally ventilated warehouses.

Generally, on a naturally ventilated warehouse, the inlet area at the eaves should be one (1) square foot per linear foot of warehouse, one half on each side. The exit area in the ridge should equal the inlet area.

Calculating Mechanical Ventilation Requirements

Overspace, area B (the volume of the area above the peanuts to be ventilated) = (Volume of entire building, areas A + B) minus (Volume of pile of peanuts, Area A)



Area A + B = Length (223) x Width (80) x Sidewall (24)	= 428,160
Plus	+
Length (223) x Width (80) x Roof Height (40)	= 356,800
<hr style="border: 1px solid black;"/>	
2	
TOTAL VOLUME OF WAREHOUSE	= 784,960
Area A = Length (223) x Width (80) x Sidewall - 1 ft. (23)	= 410,320
Plus	+
Length (223) x Width (80) Height of Pile (25.78)	= 229,958
<hr style="border: 1px solid black;"/>	
2	
TOTAL VOLUME OF PILE	= 640,278

LOUVERED
VENTS ARE
LESS
EFFICIENT
THAN HOODED
VENTS WITH
½" MESH
SCREEN

- Overspace, Area B = A + B (784,960) – A(640,278) = 144,682 Cubic Feet
- Air needs to exchange every two minutes (144,682 / 2 = 72,341 CFM needed)
- Inlet Opening Required = CFM required (72,341)/ Desired Air Speed (800) = 90.43 square feet.

If louvered inlets are used, refer to the manufacturer to obtain the free area provided by the vents to ensure there is adequate inlet space. As stated previously, louvered vents are less efficient than hooded vents with ½” mesh screen.

Calculations for fan capacity should be based on ¼” static pressure. **Refer to Chart B for typical CFM created by various fans.**

Calculating Approximate CFM of Existing Fans

1. (Diameter of Fan Pulley) / Diameter of Motor Pulley) = Ratio
2. (RPM of Motor) / (Ratio) = RPM of fan
3. Using fan size and RPM of fan, locate correct CFM on Chart B, using ¼” static pressure (**See Chart B, page 12**).

Warehouse Ventilation

Aerating Farmer Stock Peanut Warehouses

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Introduction

Aeration is the practice of forcing air through an agricultural product to control its temperature and moisture. Aeration has been used extensively in storing small grains typically stored in circular bins with perforated floors. Cottonseed are typically stored in flat storage, similar to farmer stock peanuts, and usually aerated. Air is distributed through flat storage using evenly spaced tunnels in the floor or temporary perforated ducts laid on top of the floor (Wilcut et al., 2004).

Aerating farmer stock peanuts began in the mid-1990’s in West Texas with the goal of reducing shrink during storage due to excessive moisture loss. The warehouse was aerated by pulling air down through the peanuts at a rate of 10

cfm/ton when the ambient relative humidity was between 60 and 80% (Blankenship et al., 2000). Moisture loss was less in two out of three years compared to the historical average in the southwest (Butts and Smith, 1995).

During the late 1990's, some handlers began aerating farmers stock peanuts in the Southeast with the goal of removing the excess heat and moisture during loading. This was an effort to minimize the occurrence of aflatoxin contamination during storage as a result of rapidly filling the warehouse. The first warehouse was aerated at a rate of 10 cfm/ton by forcing air into formed tunnels in the floor up through the peanuts. Fans were typically run from 0800 h to 1700h daily unless persistent fog, heavy dew, or rain was present. Aeration occurred during the loading process and for approximately 30 d after loading had been completed. The fans were then turned off and sealed to prevent the headspace ventilation fans from pulling air in through the aeration system. Headspace fans were operated according to conventional practice (Butts, C. L., unpubl. data 1998). The following year, aeration systems were designed and installed in several warehouses. However, the cost of cutting, forming and installing tunnels to introduce air into existing warehouses caused the number of tunnels to be reduced from three to one and the aeration rate reduced to 5 cfm/ton. The American Peanut Shellers Association sponsored research during the 2001 and 2002 crop years to examine aeration of farmer stock peanuts. Those publications are pending acceptance.

Aeration System Design

Aeration system specifications include airflow rates based on the amount of peanuts that can be stored in the warehouse, and the specifications of air distribution systems. The air distribution systems include the fans, motors, duct system, and inlet/outlet area. Aeration rates are based on the designed capacity of the warehouse. If the warehouse is partitioned, each bin should be aerated separately according to their individual storage capacity. Warehouse capacity can be calculated as shown in Chapter 2 or online (Butts, 2002).

Airflow Rates

Aeration systems for farmer stock peanuts should provide between 3 and 10 cfm/ton of peanuts. Research has shown that an aeration rate of 3 cfm/ton in conjunction with headspace ventilation is adequate to remove heat and excess moisture during loading and throughout the storage period. An aeration rate of 10 cfm/ton without the headspace ventilation adequately cooled the peanut mass and maintained quality throughout the storage period. All aeration systems were controlled based on ambient and peanut temperatures to provide cooling and prevent overdrying. Therefore, aeration systems for farmer stock peanuts should provide at least 3 cfm/ton. If no headspace ventilation is used, then peanuts should be aerated using 10 cfm/ton. Total aeration requirements can be calculated using equation (1) shown below.

$$Q = T * \frac{cfm}{ton} \quad (1)$$

Q is the total airflow (cfm). T is the capacity (tons) of the warehouse or bin to be aerated and $\frac{cfm}{ton}$ is the airflow rate per ton required. Airflow should be determined for the total amount of peanuts to be stored in the warehouse, and each bin aerated separately.

Direction of airflow will primarily be determined by the use of a headspace ventilation system in conjunction with the aeration system. If a headspace ventilation system will be used at the same time as the aeration system, then the aeration system should force the air from the floor up through the peanuts. This will work with the ventilation system and the ventilation system will help prevent condensation of moisture that is forced up out of the peanuts by the aeration system. If there is no headspace ventilation system, or it will not be operated simultaneously with the aeration system, the aeration system should pull air in the top of the warehouse, down through the peanuts, and out through the fan. Pulling air down through the peanuts will minimize condensation on the roof due to warm moist air from the peanuts impinging on the cold roof surface.

Inlet/Outlet Area

There should be enough screened inlet/outlet area in the gables and the eaves of the warehouse to

keep the air velocity less than 1000 fpm. This should be based on all of the air moved by the aeration and headspace ventilation systems combined. As mentioned in Chapter 2 of this handbook, water droplets can be lifted and carried into the warehouse if the air velocity is 1000 fpm or faster. Therefore, a conservative design velocity is 800 fpm

Duct System Design

The purpose of the duct system is to deliver air uniformly throughout the mass of peanuts. A full perforated floor system would satisfy this requirement, but is not practical in a typical farmer stock warehouse. Warehouses should be loaded by periodically moving the overhead tripper system so that peanuts are placed in the warehouse in layers the full length of the warehouse or bin. Therefore, the duct system should be installed parallel to the ridge of the warehouse. One duct should be installed down the center of the warehouse regardless of the aeration management scheme. If the design airflow rate is more than 5 cfm/ton, then at least two, preferably three, tunnels should be installed in the warehouse. Assuming that three tunnels are installed, place one tunnel down the center, and then place the other two on either side, approximately halfway between the center and the sidewall (Figure 1).

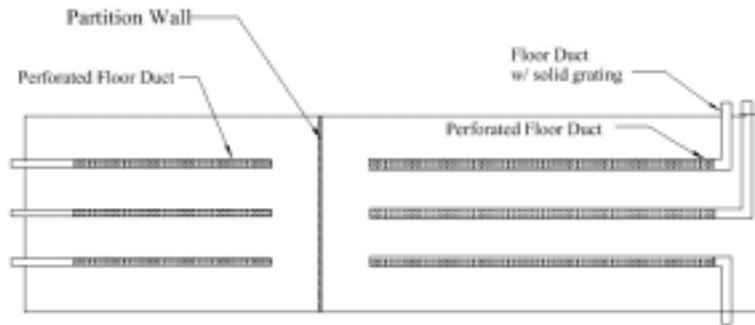


Figure 1. Typical farmer stock peanut warehouse with aeration floor plan.

There are two elements to duct design: cross-sectional area and duct open area. Maximum velocity in the duct should be 2000 fpm. Maintaining this velocity will minimize fan horsepower requirements.

Duct open area is the area of the duct through which air flows into the peanut mass. The average velocity of the air entering the peanuts should be 30 fpm to minimize pressure loss and to ensure uniform air distribution. The velocity (v) can be calculated by dividing the desired airflow rate (Q) by the cross-sectional area (A) as shown in Equation 2 below.

$$v = \frac{Q}{A} \quad (2)$$

Example:

A new warehouse will be built to store runner type peanuts with length, width, eave height, and roof pitch shown below. An overspace ventilation system will be installed and operated according to recommendations in chapter 2. An aeration system is desired to provide initial cool down of the peanuts and run up to 30 days into the storage period. The fan will then be turned off and sealed.

Warehouse Specifications:	Length	=	220 ft
	Width	=	80 ft
	Eave Height	=	24 ft
	Roof Pitch	=	9:12

According to the on-line calculator, the warehouse capacity (T) is 6160 tons. The overhead fan should provide cfm at $\frac{1}{4}$ in. H_2O static pressure. Since the aeration system will be operated in conjunction with the headspace ventilation system, the design aeration rate is 3 cfm/ton and the total cfm is calculated using equation (1).

$$Q = T * \frac{cfm}{ton} = 6160 tons * 3 \frac{cfm}{ton}$$

$$= 18480 cfm$$

Since the aeration fan will be operated simultaneously with the overspace ventilation system, the fan(s) should be installed so that air will be forced into the duct system and up through the peanuts. The duct system will also be a single tunnel down the middle of the warehouse. Rearranging equation (2) and solving for the area, the cross-sectional area of the duct is determined by dividing the airflow in the duct by the maximum allowable velocity (2000 fpm).

If a single fan is used to force air the entire 220-ft length of the warehouse, the duct must have a cross-section of 9.2 ft². A rectangular duct formed into the floor that is 48 inches wide must be 28 inches deep.

If air is supplied by two fans, 9240 cfm from each end, the duct size could then be 48 x 14 in. Using two fans offers the following advantages.

1. Air must travel only 100 feet instead of 200 feet.
2. Duct size is smaller.
3. Can begin aerating as soon as the first layer covers the first section of duct work instead of having to cover the entire length of the warehouse.
4. Smaller fans can be used.

Some disadvantages include the fact that the total electrical load using two fans may be more than using a larger single fan and there are two fans to service instead of one. For the purposes of this example, two fans will be used.

The open area of each duct must be determined. The perforated area of each duct should begin 10 ft from the end wall. Each duct should end 5 ft from the center of the warehouse leaving a 10-ft gap between the ends of the ducts in the center. Therefore, the length of the perforated section of the duct is:

$$L_{perforated} = \frac{L_{warehouse}}{2} - d_{endwall} - d_{center}$$

$$= \frac{220}{2} - 10 - 5$$

$$= 95 ft$$

Using equation 2, the open area needed to achieve a velocity of air entering the peanuts, the total area should be:

$$\begin{aligned}
 A_{perforated} &= \frac{Q_{fan}}{v} \\
 &= \frac{9240 \text{ cfm}}{30 \text{ fpm}} \\
 &= 308 \text{ ft}^2
 \end{aligned}$$

The percent open area of the duct grating is calculated by dividing the perforated area ($A_{perforated}$) by the total area of the duct exposed to the peanuts.

$$\begin{aligned}
 \% \text{ O.A.} &= \frac{A_{perforated}}{A_{duct}} * 100\% \\
 &= \frac{308 \text{ ft}^2}{95 \text{ ft} * 4 \text{ ft}} * 100\% \\
 &= 81 \%
 \end{aligned}$$

The perforated metal for the top surface of the in-floor duct should have a perforation pattern with 81% open area. This type of metal can be found, but may not offer the structural strength needed. To decrease the % perforation to 40%, the width of the tunnel would have to be doubled from 4 to 8 ft, which is not practical. If a 4-ft half-round duct were used, 52% open area perforation could be used which is more widely available. If less open area, i.e. 40%, is used the fan would have to be selected to account for the increased pressure loss.

The final calculation is the static pressure that the fan must overcome to supply the proper airflow. The pressure loss comes from the depth of peanuts, the foreign material in the peanuts, and the friction loss in the duct system. ASAE Standard, **D272.3-Resistance to Airflow of Grains, Seeds, Other Agricultural Products and Perforated Sheets** (ASAE, 2002), is the basis for determining the pressure loss through the peanut mass. The primary variable used in the calculation is the average air velocity through the peanuts and the peanut depth. The average velocity is calculated by dividing the airflow rate by the effective floor area. In this case, one the duct down the middle of warehouse delivering air to one-half of the length of the warehouse, would deliver about 9240 cfm. Assuming that air would spread out approximately 10 ft to either side of the duct, the effective floor area is calculated as

$$\begin{aligned}
 A_{floor} &= L * W = 110 * 20 \\
 &= 2200 \text{ ft}^2
 \end{aligned}$$

The velocity or cfm/ft² is calculated by:

$$\begin{aligned} cfm/ft^2 &= \frac{Q_{fan}}{A_{floor}} = \frac{9240}{2200} \\ &= 4.2 \end{aligned}$$

Based on the curves for clean peanuts, the pressure loss per foot of depth ($\Delta p/ft$) is 0.002 in H_2O/ft . The maximum depth of peanuts in the center of the warehouse is approximately 50 ft. The total pressure loss through *clean* peanuts is:

$$\begin{aligned} \Delta p_{clean} &= \Delta p / ft * depth \\ &= 0.002 * 50 = 0.1 \text{ in } H_2O \end{aligned}$$

The LSK and fine-textured foreign material will tend to concentrate in along the centerline of the warehouse and fill in the air space between the peanuts, and causing increased pressure loss. Typically, the foreign material will double or triple the pressure drop through the peanuts. Therefore, the total pressure loss through the peanuts will be about 0.3 in. H_2O . The friction loss in the transition from the fan and into the tunnel, along the tunnel, and through the perforated metal can be calculated. However, as a rule of thumb, the pressure drop in the air delivery system is about the same as through the peanuts. Therefore, the total pressure drop should be about 0.75 in. H_2O .

Table 1. Aeration system specifications for example farmer stock warehouse

Number of Fans	2
Airflow (each fan)	9240 cfm @ 0.75 in H_2O
Duct Layout	2 ducts, one from each end of the building down the center
Duct dimensions	48" half round, perforated area 95 feet long, 10 ft between ends of ducts at the center of the building
Perforated area	52% O.A. beginning 10 ft from the end wall

Fan Operation

The purpose of the farmer stock warehouse aeration system is to control the peanut temperature and remove excess moisture. Excessive fan operation can dry peanuts to below the desired minimum of 7% causing excessive shrink. Therefore, fan operation is critical especially after the initial cool down and equilibration period.

Aeration fans should not be operated until the entire duct system supplied by the fan is covered. Turning the fan on before the duct is covered will cause the air to be forced out of the uncovered portion of the duct and not through the peanuts. Therefore, it is essential that proper loading practices that load the warehouse in layers are followed. Moving the tripper frequently will cover the tunnel quicker and will maintain a uniform depth of peanuts over the duct as the warehouse is loaded. Once the duct is covered, then fan operation can begin.

To achieve an equilibrium moisture content of 7%, peanuts must be stored at approximately 60% relative humidity. At 75% relative humidity, peanuts will equilibrate to about 9% moisture content (Young et al., 1982). Therefore, to prevent over drying, fans should not be run when the relative humidity of the cooling air is below 60%. If drying still needs to occur for the majority of the peanuts in the warehouse, cooling air with slightly lower, e.g. 50%, relative humidity could be used for short periods of time. Running the fans when the relative humidity is greater than 75% increases the risk of rewetting peanuts, potential mold growth, and aflatoxin contamination. If the aeration system is forcing air up through the peanuts, it will also increase the risk of condensation on the roof.

The second reason for aeration is to cool the peanuts. Therefore, run fans when the air temperature is cooler than the peanut temperature. These conditions would typically occur early in the evening, during the night, and early morning. However, during a portion of these times, the relative humidity may be unacceptable.

Automated aeration control systems are available and highly recommended because they are more reliable than manual operation.

Once the warehouse is loaded, then fan operation will continue until the peanut temperature has cooled sufficiently. This will usually occur within about 30 days. However, the cooler the peanuts the more stable the moisture and quality characteristics become. Once cooled, the peanut mass will maintain its temperature and will warm very slowly if the aeration system is not run. Again, temperature and humidity sensors in the warehouse will be very useful in managing the aeration systems.

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Elevator Speed

Improper elevator speed results in tremendous financial losses to the peanut industry. The creation of loose-shelled kernels not only greatly reduces the value of farmer stock peanuts, but the threat of insect infestation is greatly increased.

WAREHOUSE VENTILATION

Elevator handling of farmer stock peanuts to minimize mechanical damage should be considered when designing the elevator. Usual concern is only with the speed of the elevator belt. However, this is only one factor to consider minimizing mechanical damage.

Damage occurs when the centrifugal force of the peanuts exiting the elevator exceeds the force necessary to damage the peanut. The factors involved in calculating the centrifugal force are:

1. Weight of the Peanut Pod
2. Belt Speed
3. Head Pulley Diameter
4. Size of the Buckets

The ratio of horsepower to CFM varies greatly within fan types and sizes. From the following charts, a comparison of 42" and 48" commercial, medium and high volume fans reveals CFM per horsepower rates from 3,750 CFM to 10,300 CFM. This is especially important because of the much higher electricity cost to operate the less efficient fan. Generally, low and medium volume fans deliver more airflow per horsepower than high volume fans and can lower energy costs by as much as several hundred dollars per warehouse per month.

Chart B
Extra-High- VOLUME FANS COMPLETE WITH MOTOR AND DRIVE

Blade Dia.	1/8" SP	1/4" SP	3/8" SP	1/2" SP	5/8" SP	3/4" SP	Fan RPM	HP 1725 RPM
36"	13,200	11,250	8,250	3,900	2,350	-----	600	1 1/2
	14,800	13,300	10,700	8,200	4,100	2,600	660	2
	17,400	16,300	14,650	12,500	10,200	6,000	760	3
	20,600	19,800	18,800	17,400	15,200	13,600	890	5
42"	17,900	16,200	13,000	10,000	8,100	6,600	565	2
	20,700	19,600	17,600	14,400	11,800	9,900	645	3
	24,900	24,100	23,000	21,400	18,900	16,100	765	5
	28,700	28,100	27,300	26,300	24,800	22,800	875	7 1/2
48"	25,100	23,400	21,400	15,000	9,800	5,000	535	3
	29,800	28,400	27,000	25,200	21,800	15,000	625	5
	34,500	33,500	32,300	31,100	29,700	27,700	720	7 1/2
	38,400	37,500	36,800	35,400	34,200	32,900	795	10
54"	33,500	31,400	28,400	21,500	14,400	10,300	495	5
	38,400	36,900	34,500	32,100	26,400	19,100	565	7 1/2
	43,100	41,400	39,600	37,500	34,900	29,000	620	10
	49,600	48,300	46,300	44,100	43,300	40,600	710	15
60"	46,400	44,100	41,400	37,500	30,500	19,600	505	7 1/2
	51,100	48,500	46,300	43,400	39,000	32,800	550	10
	59,200	57,400	56,000	53,400	50,900	48,200	635	15
	63,100	61,600	60,000	58,200	56,100	53,700	675	20

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Chart B-1
 VERTICAL MOUNT EXHAUST FAN PERFORMANCE
 (5-WING BLADES LIGHT TO MEDIUM DUTY)

Blade Dia.	Free Air	1/8" SP	1/4" SP	3/8" SP	Fan RPM	HP	Max BHP*
24"	5120	4195	2160	-----	650	1/4	0.32
	5595	4775	2830	1650	710	1/3	0.44
	6580	5910	4970	3100	835	1/2	0.66
	7445	6870	6200	4800	945	3/4	0.93
30"	6895	4950	-----	-----	470	1/4	0.27
	7335	5605	2320	-----	500	1/3	0.35
	8585	7305	4750	-----	585	1/2	0.52
	9830	8805	7120	4130	670	3/4	0.80
	10565	9615	8205	5945	720	1	0.96
36"	10160	7590	-----	-----	415	1/3	0.38
	11875	9915	5045	-----	485	1/2	0.62
	13220	11490	8565	4215	540	3/4	0.88
	14815	13300	11415	6600	605	1	1.20
	16160	14805	13215	10400	660	1 1/2	1.53
42"	14515	11040	-----	-----	380	1/2	0.57
	16425	13670	6545	-----	430	3/4	0.79
	17570	15045	8350	4855	460	1	1.04
	20435	18345	15480	8530	535	1 1/2	1.51
48"	17060	10790	-----	-----	315	1/2	0.49
	20040	15900	6450	-----	370	3/4	0.83
	21665	18120	8860	3465	400	1	1.16
	24375	21345	15700	7640	450	1 1/2	1.50
	25455	22575	17615	9275	470	2	1.67

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Chart B-2
 VERTICAL MOUNT EXHAUST FAN PERFORMANCE
 (6-WING BLADES LIGHT DUTY)

Blade Dia.	Free Air	1/8" SP	1/4" SP	3/8" SP	Fan RPM	HP	Hub Bore
24"	5400	4500	2350	-----	675	1/4	1"
	6000	5200	3250	2150	740	1/3	1
	6900	6250	5350	3200	845	1/2	1
	7850	7350	6650	5700	970	3/4	1
30"	7100	4650	-----	-----	445	1/4	1
	7550	6150	2450	-----	485	1/3	1
	8950	7650	4600	-----	560	1/2	1
	10200	9200	7400	4300	640	3/4	1
	11000	10200	9000	6100	690	1	1
36"	9650	5800	-----	-----	380	1/3	1
	11050	7200	4450	-----	440	1/2	1
	12650	9400	6750	3950	500	3/4	1
	13650	11900	8100	5750	545	1	1
	15700	13900	10400	8400	625	1 1/2	1
42"	13600	8200	-----	-----	350	1/2	1
	15600	10600	6800	-----	400	3/4	1
	16800	13400	8500	4800	430	1	1
	19300	16500	11700	8600	495	1 1/2	1
	21200	19100	14300	11200	545	2	1
48"	18400	11500	6300	-----	335	3/4	1
	19800	13600	8300	4400	365	1	1
	22700	18200	12000	8200	415	1 1/2	1
	25100	21300	15000	11200	455	2	1
	28700	25500	20300	15600	525	3	1
54"	23100	13200	8100	-----	305	1	1 3/16
	26400	19300	11700	8200	350	1 1/2	1 3/16
	29100	22300	14100	10800	385	2	1 3/16
	33100	28800	20900	15100	440	3	1 3/16
	39200	35800	31000	22700	525	5	1 3/16
60"	30000	20200	11800	-----	300	1 1/2	1 3/16
	33400	25400	16600	11400	330	2	1 3/16
	37000	31600	22000	15000	380	3	1 3/16
	45200	40000	31200	25200	450	5	1 3/16

Chart B-3
 VERTICAL MOUNT EXHAUST FAN PERFORMANCE
 (6-WING BLADES MEDIUM VOLUME INDUSTRIAL DUTY)

Blade Dia.	Free Air	1/8" SP	1/4" SP	3/8" SP	1/2" SP	Fan RPM	HP	Max BHP
24"	5780	4770	1450	-----	-----	726	1/3	0.37
	6625	5740	3915	1445	-----	832	1/2	0.55
	7565	6845	5835	2450	1565	950	3/4	0.83
	8340	7710	6965	6550	2200	1047	1	1.1
	9445	8915	8210	7430	6015	1186	1 1/2	1.6
30"	9825	8600	4875	1725	-----	617	3/4	0.82
	10795	9680	7650	3270	1130	678	1	1.1
	12320	11410	10090	7525	3565	774	1 1/2	1.6
	13580	12785	11775	10005	5700	853	2	2.2
36"	10955	9490	6370	3625	-----	490	3/4	0.86
	12405	11270	8660	6290	-----	555	1	1.1
	14420	13570	12085	9300	7410	645	1 1/2	1.6
	15825	15110	13845	11890	9525	708	2	2.2
42"	18240	17685	16755	15605	13670	816	3	3.3
	15675	13200	7335	-----	-----	408	1	1.1
	17940	15975	12275	6380	-----	467	1 1/2	1.6
	19745	18080	15255	10890	5255	514	2	2.2
	22590	21245	19150	16040	11630	588	3	3.3
48"	26815	25780	24285	22420	19710	698	5	5.5
	21750	19360	16095	9745	-----	392	1 1/2	1.6
	23915	21845	18920	13010	-----	431	2	2.2
	27410	25730	23385	21055	14615	494	3	3.3
54"	32460	31180	29345	27380	24805	585	5	5.5
	24710	21630	15355	-----	-----	329	1 1/2	1.6
	27035	24345	20085	11410	-----	360	2	2.2
	31090	28885	26180	19720	12985	414	3	3.3
	36800	35050	32775	30295	25320	490	5	5.5
60"	42055	40600	38735	36585	34350	560	7 1/2	8.2
	32595	28990	21445	-----	-----	314	2	2.2
	36265	34345	30040	16125	-----	359	3	3.3
	44220	41950	38760	34550	23795	426	5	5.5
	50550	48665	46150	43040	39050	487	7 1/2	8.2
55635	53975	51830	49240	46690	536	10	10.9	

Calculating the Centrifugal Force Exerted by an Elevator

A formula can be used to calculate the damage resulting from changes in any of the above factors. Slay and Hutchinson determined that approximately 60% of the total damage inflicted on farmers stock peanuts by bucket elevators occurred at belt speeds above 200 feet per minute (fpm). They used an elevator with a head pulley diameter of 8 inches and buckets measuring 9 inches by 5.5 inches with approximately a 5.5-inch projection in their study.

The following formula is used to determine the force imparted to the peanuts in their 200-fpm belt speed:

$$S = \frac{W V^2}{3600 g r} \quad \text{Equation \#1}$$

- Where:
- S = centrifugal force acting radially, lb.
 - W = weight of elemental mass, lb.
 - v = tangential velocity, fpm
 - g = acceleration of gravity, 32.2 ft/s
 - r = effective radius, ft.

The effective radius, r, is approximately equal to one-half the diameter of the head pulley plus one-half the depth of the bucket. For a head pulley diameter of 8 inches and the bucket size used by Slay and Hutchinson (9" x 5 & 1/2"), the effective radius would be 6 & 3/4" (0.5625 ft). The weight of a two-seeded pod for runner peanuts is approximately 0.005 lb. Substituting the appropriate values (W=0.005 lb.; V=200 fpm; g=32.2 ft/s; r=0.5625 ft) in equation #1, we obtain the following:

$$S = \frac{0.005 (200)^2}{3600(32.2)(0.5625)}$$

$$S = 0.003067$$

$$S = 0.003$$

Calculating the Safe Speed of an Elevator

Rearranging equation (1) and solving for the velocity, V, results in an expression for the velocity in terms of the centrifugal force, S, and effective radius, r. Substituting (S=0.003), and solving the first equation for the velocity in terms of the effective radius, we get:

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$$V = \frac{\sqrt{3600 (32.2) (r) (0.003)}}{0.005}$$

$$V = 263.727 \sqrt{r}$$

$$V = 264 \sqrt{r}$$

$$V = 264 \sqrt{.5625}$$

$$V = (2.64) (.75)$$

$$V = 198 \text{ fpm}$$

Using equation (2) and assuming an average of 6 in. for the bucket projection, the following rpm's were determined for various head pulley diameters that resulted in the same centrifugal force imparted by the 8" pulley used in the study by Slay and Hutchinson. (*See Chart C, below*)

CHART C

Head Pulley Diameter	Effective Radius r, feet	Velocity fpm	Head Pulley rpm
8	0.58	203	97
10	0.67	217	83
12	0.75	230	73
14	0.83	240	66
16	0.92	253	66
18	1.00	264	61
20	1.08	275	52
22	1.17	285	50
24	1.25	296	47
26	1.33	304	45
28	1.42	314	43
30	1.50	322	41
32	1.58	333	40
34	1.67	341	38
36	1.75	349	37

Note the above belt velocity (fpm) and head pulley speed (rpm) are not absolute values since the peanut weight and the effective radius (r) have been eliminated. All speeds have been rounded to the nearest whole number. These velocities should be used only as guidelines. If belt speeds are within approximately 10%, the damage to the peanuts due to excessive speeds will be minimized.

The formula to calculate the centrifugal force was obtained from *Agricultural Process Engineering* by S. M. Henderson and R. L. Perry while the 200 fpm elevator speed was obtained from *Handling Peanuts with Bucket Elevators – Rates of Conveying and Mechanical Damage* by Whit O. Slay and Reed S. Hutchinson.

By using the formula above, if centrifugal force is too high, the elevator needs to be adjusted to lower the centrifugal force. Example: Increased diameter of head pulley decreases speed of belt.

Elevator Speeds Exceeding 200 FPM

Elevator Speeds can be greater than 200 fpm's, as long as the centrifugal fore exerted on the peanuts does not exceed .003. This section illustrates that elevator speeds can greatly exceed 200 fpm's without causing damage.

In the first calculation, $S = 0.003067$ in a scenario with an elevator belt speed of 200 fpm, peanuts with a pod weight of .005 lb., a head pulley of 8 inches, and bucket size of 9" wide x 5 1/2" deep. S of 0.003067 should not be exceeded to keep damage to a minimum. The formula can be used to calculate S when any factor changes.

In a setup where the head pulley diameter is changed to 30 inches, bucket size remains the same, and belt speed remains at 200 fpm, S can be calculated as follows:

$$r = (30'' \text{ head pulley} \times .5) + (5.5'' \text{ bucket depth} \times .5)$$

$$r = 17.75'' (1.479 \text{ ft.})$$

$$S = \frac{.005 (200)}{3600 (32.2) (1.479)}$$

$$S = \frac{200}{171,446}$$

$$S = .0011665$$

S is well below the critical point of .003067 where damage begins. How much can the belt speed be increased?

To solve for V , belt speed, the formula is rearranged with the new r of 1.479.

$$V = \frac{\sqrt{(3600) (32.2) (.003067)}}{.005} \sqrt{(1.479)}$$

$$V = (266.66) (1.216)$$

$$V = 324 \text{ fpm}$$

The elevator speed can be set at 324 fpm before S exceeds the critical point of .003067.

Calculating the Speed of an Existing Elevator

To obtain elevator belt speed, the following will be needed:

1. Head Pulley Diameter
2. RPM of Motor
3. Ratio of Reduction Box
4. Sprocket or Sheave Size on Head Pulley
5. Sprocket or Sheave Size on Motor

Example:

- 24" head pulley x 3.1416 (pi) = 75.40" (6.28 ft.)
- 1750 motor RPM / 9.2 reduction box ratio = 190 output RPM
- 60 teeth on head pulley / 17 teeth on motor = 3.53 ratio
- 190 / 3.53 = 53.82 head pulley RPM
- 53.82 RPM x 6.28 ft. = 338 fpm

III. WAREHOUSE MAINTENANCE

General Cleanup

Prior to the storage season, the warehouseman should:

1. Thoroughly clean each building or bin included in the warehouse and surrounding outside areas.
 2. Clean trash and oil remains or spillage of peanuts, grain, feed, or other prior contents. Pay particular attention to areas underneath loading platforms and underneath each building raised off the ground.
 3. Clean out elevators, conveyors, elevator or conveyor wells, and any other location where old peanuts and refuse have collected.
 4. Sweep down the walls, windowsills, rafters, beams, ledges, and other parts of the building where old peanuts, grain, dust, dirt, webs, and other debris can lodge.
 5. Clean out loose accumulations from cracks in wooden floors. If available, use a vacuum cleaner in this operation to prevent spreading filth and contaminants.
 6. All refuse collected in these operations should be removed from the premises and destroyed.
-

7. The six steps above should be carried on continuously as part of the regular housekeeping routine. Particular care should be exercised during and immediately following each delivery of peanuts from the warehouse and as often as practical during peanut receiving operations.
8. All elevator pits and conveyors should be checked following their use to see that all peanuts and related material are cleaned out. Mold will form after the remaining peanuts are subjected to moisture in any form.
9. Catwalks should continuously be kept clean and free of debris, trash, etc.
10. Keep all grass, weeds, trash and other items cleared to a distance of at least six feet away from the outside walls of the warehouse.
11. A responsible employee conducting a regular inspection program should verify the foregoing conditions.

Insect and Rodent Control

All warehousemen who do not employ licensed or professional control services should utilize their Area Association's approved ***Insect and Rodent Control Programs***. These programs have been sanctioned by proper governmental agencies and should be followed closely.

Contamination Prevention

Products that affect the storage life, quality or flavor of peanuts should not be stored in the same room or compartment with peanuts. For example, fertilizer, gasoline or lubricating oils, and certain fruits and vegetables are objectionable.

Extreme caution should be taken with the use and handling of rodenticides to prevent contamination of the product. Pellets or any type of rodenticide that can be transported by rodents should be avoided.

Glass is a very serious contaminant of peanuts. Use of glass containers should be avoided and all light bulbs should be shatterproof.

Transportation or warehouse loading equipment should not be used for other commodities. If it is necessary to use for other commodities, equipment should be thoroughly cleaned and inspected before using for peanuts.

Good housekeeping practices should be in place to prevent contamination. Use of tobacco products should be avoided. Measures should be in place to prevent entry by birds.

Mold Prevention

1. The peanut drying practices enumerated in the voluntary *Code of Good Peanut Drying Practices* should be followed.
2. All moisture collecting in elevator pits should be removed immediately following rains or seepage. All peanut buying points should be equipped with sump pumps or other type pumps to remove water from elevator pits.
3. Should loads of farmer stock become wet from rainfall prior to unloading, they should be examined and re-dried if necessary prior to dumping. All wet peanuts and trash should be removed from the premises and destroyed. Such peanuts should not be placed with other peanuts either on trucks or in warehouses.
4. All conveyor buckets and belts should be checked, cleaned and dried following rain. They should be checked often for old peanuts, foreign material, etc., including during the off-season when such equipment is not being used. Immediately prior to load-out, elevator buckets and elevator pits should be re-checked to make certain they are completely free of moisture, old peanuts, refuse and trash.
5. Peanuts in storage should be routinely checked for evidence of mold. If mold is evident, the reason for mold formation should be immediately determined and corrected. Moldy peanuts must be removed from edible use.
6. Warehousemen should check regularly for leaks in roofs, walls and around doors and ventilators. Such an inspection should also be made while rain is falling on the building.
7. All down spouts into buildings should be periodically checked to see that their points of spout entry are securely closed and sealed to prevent entry of moisture during and following rain.

8. Ventilation systems should be adequate. (See building Standards, Ventilation.)
9. Moisture in any form other than surface spray applications for insect control should not be applied to peanuts in storage.
10. Special attention should be given to proper ventilation of tank type storage structures. Regular checks for condensation are extremely important.
11. Handling equipment should be checked regularly to see that it is properly adjusted to prevent the shelling, cracking or damaging of peanut hulls that will permit mold invasion of the kernels.

Loading Out Precautions

1. Loading out of peanuts from the warehouse should cease during periods of precipitation.
2. Peanuts spilling in areas of loading operation should be immediately cleaned up and disposed of by placing on truck or back in warehouse before such peanuts are damaged or begin to collect moisture. If this is not done, such peanuts should be completely removed from the premises and destroyed.
3. Peanuts in transit other than cars or vans should be protected from weather by use of weatherproof tarpaulin in good repair.
4. All trucks and rail cars should be carefully inspected for undesirable odors or material residues that might affect flavor and quality of peanuts. They should be checked for weatherproofness and should be swept clean prior to use. Vehicles that are objectionable from these standpoints should be rejected.
5. Temporary storage facilities at outside buying points should be adequate to protect peanuts against:
 - a. Inclement weather
 - b. Insects, rodents, birds and bird droppings

6. Peanuts in drying trailers waiting dumping or transport should be protected from inclement weather by shed, roof, tarp, or other cover.
7. When unloading or emptying the warehouse of peanuts, particular attention should be paid to moldy, wet, or hot spots that may have previously gone unnoticed. These peanuts should be separated from the balance of the good farmer stock and destroyed.
8. When loading peanuts out of a warehouse, buying point operators should avoid overloading trucks, causing spillage.

Summary

The warehouse must be constructed and maintained to prevent water leakage and moisture build-up but to allow adequate ventilation and air circulation through the peanuts.

- A good housekeeping program must be prepared, written, posted and followed at all times.
- An insect and rodent control program must be utilized.
- Prevention and removal of mold must be practiced by:
 - a. Proper peanut drying techniques
 - b. Regular building and equipment inspections
 - c. Proper insect spray applications
 - d. Effective ventilation techniques
 - e. Regular peanut quality inspections

- A safe unloading program must be followed in minimize damage and handling.
- Peanuts must never be exposed to either birds or bird droppings.

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