The *Journal of Cotton Science 22:47–59 (2018)*
http://journal.cotton.org, © The Cotton Foundation 2018

ENGINEERING AND GINNING

Cottonseed Air-Handling and Storage Requirements

Harrison Ashley, Joe Thomas, Greg Holt*, Thomas Valco

ABSTRACT

Along with lint, cottonseed is another product of the cotton plant that accounts for 15 to 25% of the crop value. Due to the nature of cottonseed, proper handling, storage, and aeration are critical for maintaining seed quality and minimizing spoilage. Over the last few decades, the mass of cottonseed per bale of lint (500 lb [227 kg]) has declined from a national average of 823 lb (373 kg) to an average value of 696 lb (316 kg). This chapter updates handling, storage, and aeration data based on the smaller mass of seed per bale being encountered in today's cotton gins and provides the most current information available.

The information presented in this chapter sources earlier cotton ginner handbooks (Smith and Rayburn, 1977; Wilcutt and Mayfield, 1994) and includes up-to-date information for cottonseed handling, aeration, and storage.

For every 500-lb (227-kg) bale of lint, approximately 700 lb (317.5 kg) of cottonseed is produced. The national average weight of cottonseed per bale of lint has been trending downward over the last few decades (Hughs and Holt, 2015). Typical products generated from cottonseed include linters, hulls, oil, and meal. The breakdown of each of these products, on a mass basis, can vary but generally runs at 10% linters, 25% hulls, 16% oil, 46% meal, and 3% miscellaneous foreign matter (Dowd, 2015). In the past, a greater portion of cottonseed was sent to the mills for crushing; however, today only 35% of the crop is crushed for the products listed above with the remaining 65% being fed to dairy cattle. Because cottonseed accounts for 15 to 25% of the value of the crop, it is important to properly handle, aerate, and store the seed to avoid spoilage. This chapter is divided into the following areas: characteristics of cottonseed, cottonseed storage, cottonseed aeration, and cottonseed conveyance. The idea is that storage needs to be available before the seed can be conveyed and aeration is needed to minimize seed spoilage.

H. Ashley, National Cotton Ginners Association, 7193 Goodlett Farms Parkway, Memphis, TN 38016; J. Thomas, Lummus Corporation, 225 Bourne Blvd., Savannah, GA 31408; G. Holt*, USDA-ARS Cotton Production and Processing Research Unit, 1604 E. FM 1294, Lubbock, TX 79403; T. Valco, USDA-ARS (Retired), 141 Experiment Station Rd., Stoneville, MS 38776.
*Corresponding author: greg.holt@ars.usda.gov

CHARACTERISTICS OF COTTONSEED

The bulk density of gin-run cottonseed averages approximately 25 lb/ft^3 (400.5 kg/m^3) and requires approximately 80 ft^3 of storage space per ton (2.5 m^3/mt). Cottonseed is hygroscopic and therefore absorbs moisture from or gives up moisture to the surrounding air. Storage temperatures below 60 °F (16 °C) and 10% moisture content wet basis provide best storage conditions. Whole, fuzzy cottonseed has some unique characteristics that makes it difficult to handle with common grain handling facilities. Unlike grain, cottonseed has a variable angle of repose. The angle of repose is the steepest angle at which a sloping surface of loose material is stable. The angle of repose when an unrestricted pile of cottonseed is formed is about 45°. However, after the seeds have settled, they will bridge—an indication that the angle of repose is greater than 90°. Cottonseed can be handled by belts, screw conveyors, or pneumatics. Pneumatics is often the most effective way to load seed into storage facilities.

COTTONSEED STORAGE

Long-term Storage. The type of seed storage facility will dictate how seed will be handled for long-term storage. In more arid production areas, seed can be safely stored in open piles or piles that are covered without any aeration. However, in more humid areas, some aeration is needed to remove heat from the ginning process and any excess moisture present in the seed, minimizing storage losses and quality deterioration. Seed is usually highest in moisture at the beginning of the harvest season and can be as high as 18%. As the season progresses, seed moisture content typically ranges from 10 to 15% but can be as low as 6%. With proper aeration, seed having moisture content below 19% can be successfully stored. In situations where seed moisture is high, as in rain soaked cotton, seed should be stored separate from dry seed. Most ginners send their high moisture seed to the oil mill for immediate processing and/or into separated storage with high aeration capacity.

Building Design and Considerations. Three types of buildings are commonly used to store cottonseed at gins: clear-span metal buildings, Quonset huts, and Muskogee buildings. The metal building (or flat storage building) is the most popular for new construction. Some flat storage buildings exceed 100 ft (30.5 m) in width, but 60 to 80 ft (18.3-24.4 m) widths are more common. Quonset huts rely on formed panels for structural integrity and have no steel framework to support the outside skin. When constructed as a true Quonset hut, the floor space is not efficiently used. Four- to eight-foot sidewalls of adequate strength are sometimes used to increase the storage volume and minimize wall damage from loading equipment. Muskogee houses generally have roof slopes of 45° and a high ridge line to maximize storage volume while minimizing the force, or pressure of seed “flowing” against the walls. The roof slope and height also require a greater steel superstructure. Muskogee houses are normally used for volumes greater than 6,000 tons (5,443 mt). Seed depths of 40 to 80 ft (12.2-24.4 m) and lower air flow rates are found in most Muskogee houses.

Most cottonseed storage facilities have moisture proof concrete or asphalt floors. Floor loads from seed alone will be approximately 700 lb/ft^2 (3417kg/m^2) for a 20 ft (6 m) seed depth. Floors should have sufficient reinforcement to support a loaded truck in areas where loading will take place.

Several side and end wall failures have occurred in cottonseed storage facilities using rectangular storage buildings. Walls of existing buildings converted to cottonseed storage should be analyzed and strengthened as needed before filling with seed. Lining the interior walls with plywood (at least 0.75-in [19-mm] thick), oriented strand board (OSB) or similar materials helps prevent damage to the outside building walls, facilitates clean out, increases wall strength, and reduces settling pressure on otherwise exposed framework. The top of this inside wall should be sealed to prevent seed and lint from accumulating between the walls.

Buildings used to store cottonseed must be designed to withstand lateral forces. Lateral wall forces for storage of cottonseed can be estimated by the following formula (Willcutt and Mayfield, 1994):

WP = KA x D x H

Where: WP = horizontal wall pressure lb/ft^2 (kg /m^2),
KA = active pressure coefficient (0.17 to 0.20 when an angle of repose of 45° is used),
D = density = mass/volume = 28 lb/ft3 (448.5 kg/m3), and
H = height or seed depth ft (m).

When the preceding formula is used, the lateral pressure at the base of a 20-ft (6.1-m) seed depth would be 112 lb/ft^2 (546.8 kg/ m^2). Because of boundary effects of the floor, maximum force and wall failure usually occur at 10 to 20% of wall height above the floor (Willcutt et al., 1996). Walls should be designed to include a safety factor and to accommodate front-end loader pressure against them. When existing buildings are converted for cottonseed storage, the walls should be analyzed and strengthened as needed before filling with seed.

Calculation of Storage Capacity. The capacity of a seed storage house can be calculated by determining the useable storage volume and seed density. Because seed density varies by seed depth, an average value can be used based on the cottonseed properties in Table 1. For example: the capacity of a storage building that is 120 ft by 60 ft (36.6 m by 18.3 m) with a wall height of 18 ft (5.5 m) and a 10 ft (3.1 m) gable height can be determined by calculating the floor and gable volumes.

1. Floor Volume = L x W x H = 120 ft x 60 ft x 18 ft = 129,600 ft^3. (36.6 m x 18.3 m x 5.5 m = 3,669 m^3).
2. Gable Volume = L x W x H/2 = 120 ft x 60 ft x 10 ft/2 = 36,000 ft^3 (36.6 m x 18.3 m x 3.1 m = 1,019 m^3).
3. Total = 129,600 + 36,000 = 165,600 ft^3 (3,669 + 1,019 = 4,688 m^3). Because the house cannot be completely full, the usable volume is approximately 160,000 ft^3. (4,531 m^3).
4. Total seed volume would be approximately 2,000 tons (1,814 mt) =160,000 ft^3 ÷ 80 ft^3/ton (recommended aeration value from Characteristics of Cottonseed section above). (4,531 m^3 ÷ 2.5 m^3/ mt).

This example can be used for different house dimensions and designs. (Note: differences in metric and English unit calculations are due to rounding errors.)

Table 1. Basic properties of bulk cottonseed and cottonseed products

Product	Density (lb/ft^3)	Density (kg/m^3)	Volume (ft^3/ton)	Volume (m^3/mt)
Whole seed				
Loose on Conveyor	20	320	100	3.12
< 24 ft (7.3 m) deep	25	400	80	2.50
24-50 ft (7.3-15.2 m) deep	27	432	75	2.34
> 50 ft (15.2 m) (((15.2m)deep	30	481	70	2.18
Machine delinted	35	561	57	1.78
Acid delinted	34-37	545-593	54	1.69
Meal (extracted)	38	609	53	1.65
Hulls	12	192	67	2.09
Oil	57	913	35	1.09

COTTONSEED AERATION

Aeration Considerations and Design. In humid areas, long-term cottonseed storage facilities must be equipped with an aeration system. Most aeration systems are designed so that the air flows downward through the cottonseed to prevent tunneling and to help minimize moisture accumulation in the top layers of seed (Smith, 1975). If the airflow is not downward, the top layer will become moist when warm, moist air moves upward into the cooler top layers of seed. Downward airflow also counteracts any natural convectional air movement. The temperature and odor of the exhaust air from the fan can give an indication of cottonseed condition.

A safe airflow rate for aerating cottonseed in storage is 10 ft^3/min/ton (0.312 m^3/min/ mt). At this rate, cottonseed with as much as 15% moisture can be safely stored. Drier seed and well managed storage facilities do not require such a high airflow rate, requiring 3 to 5 ft^3/min/ton (0.08 to 0.14 m^3/min/mt).

For storage buildings, static pressure losses and fan horsepower requirements from cottonseed depths ranging from 10 to 30 ft (3.1-9.1 m) are given in Table 2 for airflow rates of 5, 7.5, and 10 ft^3/min/ton (0.15, 0.23, and 0.31 m^3/min/mt). For large Muskogee houses (Smith and Rayburn, 1977), cottonseed depth usually limits the amount of air that can be economically moved. For example (Fig. 1), when cottonseed is 80-ft (24.4-m) deep and the airflow rate is 2 ft^3/min/ton (0.062 m^3/min/mt), the static pressure is 21 in (507 mm) of water.

Usually no additional aeration is necessary once the seed has cooled to the desired temperature. The safe temperature for long term storage is about 60 °F (15.5 °C). Even so, seed temperatures should be monitored throughout the storage period, because hot spots occasionally develop. Usually a few hours of additional aeration will remove the heat from the trouble spot. Many seed storage facilities are equipped with temperature monitoring systems. Seed temperature should be monitored by inserting thermocouple probes attached to steel rods or electrical conduit into the seed.

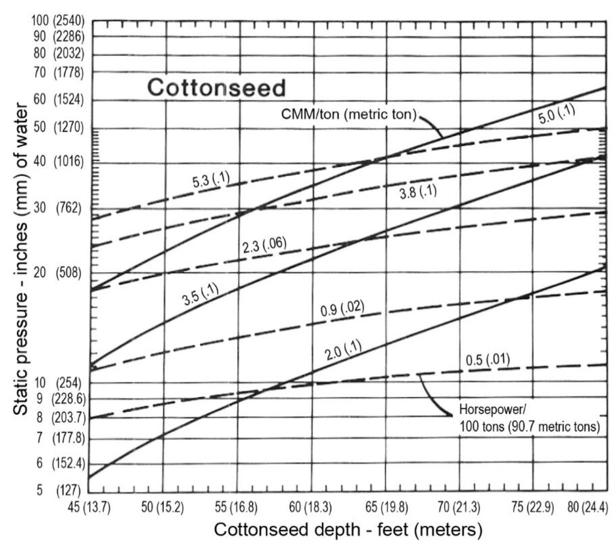

Figure 1. Fan horsepower and static pressure requirements for aerating cottonseed in Muskogee type storage buildings in cubic meters per minute per metric ton (cmm/ton).

Design of Aeration Systems. Aeration systems have four principal parts that must be properly designed: (1) aeration ducts to move air out of the cottonseed, (2) supply pipes to transport the air, (3) fans to supply the required volume of air at a specific static pressure, and (4) motors to drive the fans.

Table 2. Resistance of cottonseed to airflow, measured as static pressure loss, in a storage building

Depth of cottonseed (ft)	Airflow rate (ft^3/min/ton)	Static pressure losses (inches H_2O)	Horsepower required (per 100 tons)	Depth of cottonseed (m)	Airflow rate (m^3/min/mt)	Static pressure losses (mm H_2O)	Kilowatts required (per 100 mt)
10	5	1	0.1	3.04	0.16	25.39	0.08
	7.5	1.1	0.2		0.23	27.93	0.16
	10	1.6	0.4		0.31	40.62	0.33
12	5	1	0.1	3.65	0.16	25.39	0.08
	7.5	1.6	0.35		0.23	40.62	0.29
	10	2.3	0.65		0.31	58.40	0.53
14	5	1.3	0.16	4.26	0.16	33.01	0.13
	7.5	2.1	0.6		0.23	53.32	0.49
	10	3.1	1.2		0.31	78.71	0.99
16	5	1.7	0.22	4.87	0.16	43.16	0.18
	7.5	2.8	0.6		0.23	71.09	0.49
	10	4	1.2		0.31	101.56	0.99
18	5	2.2	0.29	5.48	0.16	55.86	0.24
	7.5	3.5	0.75		0.23	88.87	0.62
	10	5	1.5		0.31	126.95	1.23
20	5	2.7	0.37	6.08	0.16	68.55	0.30
	7.5	4.5	0.9		0.23	114.26	0.74
	10	6.3	1.7		0.31	159.96	1.40
22	5	3.3	0.46	6.69	0.16	83.79	0.38
	7.5	5.3	1.1		0.23	134.57	0.90
	10	7.7	1.9		0.31	195.50	1.56
24	5	4.1	0.55	7.30	0.16	104.10	0.45
	7.5	6.4	1.4		0.23	162.50	1.15
	10	9.5	2.5		0.31	241.21	2.05
26	5	4.7	0.66	7.90	0.16	119.33	0.54
	7.5	7.6	1.6		0.23	192.96	1.32
	10	11.4	2.9		0.31	289.45	2.38
28	5	5.5	0.78	7.90	0.16	139.65	0.64
	7.5	9.9	1.7		0.23	251.36	1.40
	10	13.5	3.4		0.31	342.77	2.79
30	5	6.3	0.9	9.12	0.16	159.96	0.74
	7.5	10.1	2		0.23	256.44	1.64
	10	15.5	3.9		0.31	393.55	3.21

Aeration Ducts. Two important design criteria for a cottonseed aeration duct are (1) to provide adequate duct surface area to produce even airflow down through the cottonseed piles and (2) to provide adequate cross-sectional area so that all the stored seed can be properly aerated. Aeration ducts can be any shape, but their open surface area or air inlets should be at least 10% of the total duct surface area. Basically, take the total surface area of the ductwork and 10% should be inlets to allow sufficient airflow through the ductwork for proper aeration. Within a duct, pressure losses can be held to a minimum by limiting the velocity of the air leaving the cottonseed through the duct (face velocity) to 10 ft/min (3.1 m/min).

For cottonseed depths up to 25 ft (7.6 m), the air velocity within a duct should range from 1,500 to 2,000 ft/min (457-610 m/min). For duct lengths less than 10 ft (3.1 m), velocities up to 2,500 ft/min (762 m/min) are acceptable. Ducts on the floor of a seed house should be spaced to keep the airflow path to all ducts as equal as possible. Thus, duct spacing should not exceed 1.5 times the depth of the cottonseed.

Ducts can be installed along the length or width of a storage facility. Ducts across the width are preferred because they provide better airflow distribution and allow aeration to start as soon as the first duct is covered with seed. Also, widthwise ducts allow the airflow to be concentrated in selected areas to remove hot spots that sometimes develop. Many new seed house designs have aeration ducts constructed flush with the floor to allow for easy equipment movement and unloading.

Supply Pipes. Pipes should be designed to transport air from the ducts to the fan at air velocities ranging from 3,000 to 4000 ft/min (914-1,219 m/min). Pipe size can be determined from Table 3 or by the following equations: area (ft^2 or m^2) = air volume (cubic feet/meter per min) / velocity (feet/meter per min). After calculating area, diameter (in/mm) = $[(\text{area} \times 4) \div 3.14159]^{0.5}$

Fans and Motors. Before a fan and motor are selected, the static pressure and the required volume of air to aerate the number of tons of seed must be known. Static pressure depends on the depth of seed (Table 2 and Fig. 1). Once the volume and static pressure are known, a fan and motor can be selected from manufacturers' catalogs. In some seed houses, individual fans are utilized for each aeration duct, eliminating the need for manifold pipes. This simplifies the design and operation of the aeration system.

Table 3. Air-carrying capacities, ft^3/min (m^3/min), for round supply pipes and manifolds

Pipe dia (in)	Cross-sectional area (ft^2)	1500 ft/min	2000 ft/min	3000 ft/min	Pipe dia (mm)	Cross-sectional area (m^2)	457 m/min	610 m/min	914 m/min
6	0.20	295	393	589	152.4	0.018	8.3	11.1	16.7
7	0.27	401	535	802	177.8	0.025	11.4	15.1	22.7
8	0.35	524	698	1047	203.2	0.032	14.8	19.8	29.7
9	0.44	663	884	1325	228.6	0.041	18.8	25.0	37.5
10	0.55	818	1091	1636	254	0.051	23.2	30.9	46.3
11	0.66	990	1320	1980	279.4	0.061	28.0	37.4	56.1
12	0.79	1178	1571	2356	304.8	0.073	33.4	44.5	66.7
13	0.92	1383	1844	2765	330.2	0.086	39.2	52.2	78.3
14	1.07	1604	2138	3207	355.6	0.099	45.4	60.5	90.8
15	1.23	1841	2454	3682	381	0.114	52.1	69.5	104.2
16	1.40	2094	2793	4189	406.4	0.130	59.3	79.1	118.6
17	1.58	2364	3152	4729	431.8	0.146	67.0	89.3	133.9
18	1.77	2651	3534	5301	457.2	0.164	75.1	100.1	150.1
19	1.97	2953	3938	5907	482.6	0.183	83.6	111.5	167.3
20	2.18	3272	4363	6545	508	0.203	92.7	123.6	185.3
21	2.41	3608	4811	7216	533.4	0.223	102.2	136.2	204.3
22	2.64	3960	5280	7919	558.8	0.245	112.1	149.5	224.3
23	2.89	4328	5770	8656	584.2	0.268	122.6	163.4	245.1
24	3.14	4712	6283	9425	609.6	0.292	133.4	177.9	266.9
25	3.41	5113	6818	10227	635	0.317	144.8	193.1	289.6
26	3.69	5531	7374	11061	660.4	0.343	156.6	208.8	313.2
27	3.98	5964	7952	11928	685.8	0.369	168.9	225.2	337.8
28	4.28	6414	8552	12828	711.2	0.397	181.6	242.2	363.3
29	4.59	6880	9174	13761	736.6	0.426	194.8	259.8	389.7
30	4.91	7363	9817	14726	762	0.456	208.5	278.0	417.0
31	5.24	7862	10483	15724	787.4	0.487	222.6	296.8	445.3
32	5.59	8378	11170	16755	812.8	0.519	237.2	316.3	474.5
33	5.94	8909	11879	17819	838.2	0.552	252.3	336.4	504.6
34	6.30	9457	12610	18915	863.6	0.586	267.8	357.1	535.6
35	6.68	10022	13363	20044	889	0.621	283.8	378.4	567.6
36	7.07	10603	14137	21206	914.4	0.657	300.2	400.3	600.5

Aeration Examples. The following are examples of two typical cottonseed aeration systems.

Example 1. A ginner wishes to store 1,200 tons (1,089 mt) of cottonseed on the gin yard. A small pipe seed handling system will be used to put the cottonseed into storage, and the seed will be unloaded with a front-end loader. The design of the aeration system given the building dimensions and calculation of seed storage should be as follows:

1. Building Details
   a. Dimensions of storage structure: 60 ft (18.3 m) wide, 100 ft (30.5 m) long, 16 ft (4.9) wall height, and a gable height of 18 ft (5.5 m) to accommodate the front-end loader.
   b. Building length: 120 ft (36.6 m), enough to provide access for unloading without requiring a bulkhead door, but this additional length will not be part of the aeration system.
2. Calculation of Seed Storage
   a. Assuming the cottonseed will be stored to the full wall height then cottonseed depth = 16 ft (4.9m). Using the building dimensions in 1a above, the volume storage potential is: 60 x 100 x 16 = 96,000 ft^3. Dividing the storage volume by the recommended aeration from the Cottonseed Characteristics section, 80 ft^3/ton = 1,200 tons of seed storage (18.3 x 30.5 x 4.9 = 2734.9 m^3 ÷ 2.5 m^3/mt = 1,089 mt). (Note: differences in metric and English unit calculations are due to rounding errors.)
3. Aeration System
   a. System capacity: 1,200 tons (1,089 mt) of cottonseed.
   b. Airflow rate (from Aeration Considerations and Design section– safe airflow rate): 10 ft^3/min/ton (0.312 m^3/min/mt).
   c. Total air volume needed: 1,200 tons at 10 ft^3/min/ton = 12,000 ft^3/min (1,089 mt at 0.312 m^3/min/mt = 339.8 m^3/min).
   d. Duct layout as shown in Fig. 2 with five ducts spaced 20 ft (6.1 m) apart, 50 ft (15.2 m) long (maximum duct spacing: 1.5 x 16 ft (4.8 m) = 24 ft [7.2 m]).
   e. Duct size: each duct carries 1/5 of the total volume of air needed or 2,400 ft^3/min (67.9 m^3/min). For a maximum air velocity of 2,000 ft/min (610 m/min), the duct cross-sectional area should be 1.2 ft^2 (0.1 m^2). This could be attained by using a 15-in (38-cm) round duct (Table 3). To make sure the duct open surface area does not exceed a face velocity greater than 10 ft/min (3.1 m/min), take Pitot tube measurements and calculate air volume to ensure the safe airflow rate is not exceeded.
   f. Supply pipes: 18 in (45.7cm). Each duct carries 1/5 of the total volume of air or 2,400 ft^3/min/duct (67.9 m^3/min/duct). From Table 3 we can see that an 18-in (45.7-cm) diameter supply pipe will carry up to 2,651 ft^3/min (75 m^3/min), which is close enough for this example, at a velocity of 1,500 ft/min (457 m/min).
   g. Manifold pipes: 20 in (50.8 cm). The manifold pipe carries air for two supply pipes or 4,800 ft^3/min (136 m^3/min). From Table 3, we can see that a 21-in (53.3-cm) diameter supply pipe will carry up to 4,811 ft^3/min (136.2 m^3/min) at 2,000 ft/min (610 m/min).
   h. Fan and motor: Using Table 2 for a cottonseed depth of 16 ft (4.8 m) and an airflow rate of 10 ft^3/min/ton (0.31 m^3/min/mt), the static pressure to be overcome by the fan is 4.0 in of water (101.6 mm of water) and a 1.2 hp/100 tons (1.2 hp x 1,200 tons of cottonseed ÷ by 100 tons) equals 14.4 hp, rounding up, a 15 hp (11.2 kW) fan motor would be the best selection.

Note: This system is designed to handle additional air volumes so slide valves can be used to force more or less air into different ducts. For instance, when high moisture seed is stored in a certain area, additional air can be directed to that duct to prevent overheating.

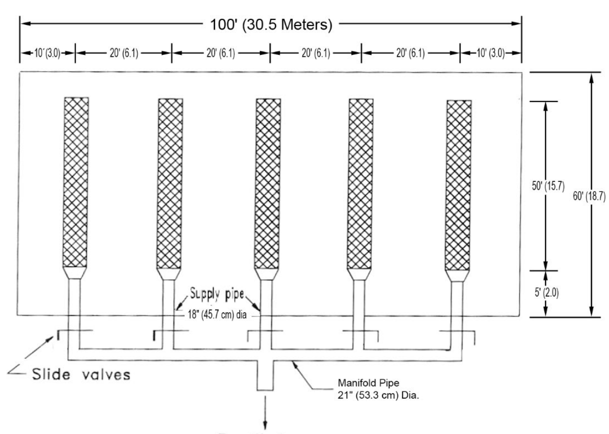

Figure 2. Aeration duct layout for 1,200 ton (1,089 mt) cottonseed storage building.

Example 2. A ginner wishes to store 2,000 tons (2,032 mt) of cottonseed on the yard. Seed will be loaded into the storage house with a small pipe handling system and will be unloaded with a front-end loader. The design of the aeration system given the building dimensions and calculation of seed storage should be as follows.

1. Building details
    a. Dimensions of storage structure: 60 ft (18.3 m) wide, 160 ft (49 m) long; wall height of 18 ft (5.5 m).
    b. Building length: 160 ft (49 m) with a bulkhead door that can be removed when unloading.
2. Calculation of seed storage
    a. Average cottonseed depth: 17 ft (5.2 m). Using the building dimensions in 1a above but substituting the average depth of cottonseed stored, the volume of cottonseed storage needing aeration is: 60 x 160 x 17 = 163,200 ft^3 (4,621 m^3). Dividing the storage volume by the recommended aeration of 80 ft^3/ton (2.5 m^3/mt) = 2,040 tons (1,851 mt) of seed stored. (Note: differences in metric and English unit calculations are due to rounding errors.)
3. Aeration system
    a. System capacity: 2,040 tons (1,851 mt) of cottonseed.
    b. Airflow rate: 5 ft^3/min/ton (0.16 m^3/min/mt).
    c. Total air volume required: 2,040 tons at 5 ft^3/min/ton = 10,200 ft^3/min (1,851 mt at 0.16 m^3/min/mt = 296 m^3/min).
    d. Duct layout: Shown in Fig. 3.

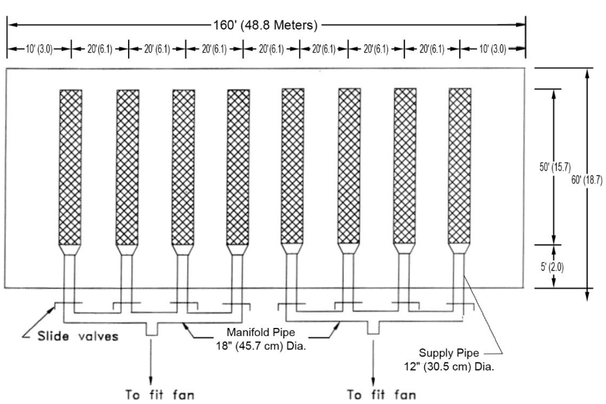

Figure 3. Aeration duct layout for 2,000 ton (1,814 mt) cottonseed storage building.

    e. Duct size: Because there are eight aeration ducts, each duct carries 1/8 of the total air volume, 1/8 of 10,200 ft^3/min = 1,275 ft^3/min (1/8 of 296 m^3/min = 37 m^3/min). For a desired maximum air velocity of 1,500 ft/min (457 m/min), the duct cross-sectional area should be 0.85ft^2 (0.08 m^2), obtained by dividing 1,275 ft^3/min by the desired maximum air velocity of 1,500 ft/min (37 m^3/min divided by 457 m/min = 0.08 m^2). Referencing Table 3 under the 1,500 ft/min (457 m/min) column, the desired conveyance could be attained by using either a 12- or 13-in (305- or 330-mm) round duct. To make sure the duct open surface area does not exceed a face velocity greater than 10 ft/min (3.1 m/min), take Pitot tube measurements and calculate air volume to ensure the safe airflow rate is not exceeded.
    f. Supply pipes: Based on the calculations above, the duct size should be either a 12- or 13-in (305- or 330-mm) diameter pipe. From Table 3, for a velocity of 1,500 ft/min (457 m/min), if a 12-in (305-mm) pipe is used, the volume in each supply line will be 1,178 ft^3/min. If a 13-in (330-mm) pipe is used, the volume in each supply line will be 1,383 ft^3/min. Both are within a reasonable range of 1,275 ft^3/min (37 m^3/min).
    g. Manifold pipes: From Fig. 3, 18 in (457 mm). Given the total required air volume of 10,200 ft^3/min (296 m^3/min), each of the four manifold pipes must handle 2,500 ft^3/min (70.8 m^3/min). Table 3 shows that a 15-in (381-mm) pipe can handle a volume of 2,454 ft^3/min (69.5 m^3/min) at a velocity of 2,000 ft/min (610 m/min) and that a 16-in (406.4-mm) pipe can handle a volume of 2,793 ft^3/min (79.2 m^3/min) at the same velocity. Either pipe size would work.
    h. Fans and motors: At a cottonseed depth of 17 ft (5.2 m) and an airflow rate of 5 ft^3/min/ton (0.2 m^3/min/mt), using Table 2 and interpolating between 16 and 18 ft (4.9 and 5.5 m) depths, the static pressure to be overcome is 2 in of water (50.8 mm of water). From a manufacturers catalog, select two centrifugal fans that can each deliver at least 5,100 ft^3/min (144.4 m^3/min) at 2 in (50.8 mm) of static pressure.

Note: This system is designed at a lower air volume, however slide valves can be used to force more or less air into different ducts for increased aeration.

Managing Aeration Systems. Aeration systems are designed to cool the cottonseed and prevent hot spots and moisture buildup from occurring. Aeration to remove heat created by the ginning process usually should be started as soon as the first lots of cottonseed are in storage. Even though little cooling can occur during storage, experience has shown that seed quality can be maintained if the fans continuously run until the facility is filled to capacity. If the seed house has a manifold aeration system, air volumes in areas of high temperature and moisture should be increased.

NOTE: If cottonseed is to be shipped immediately from the gin, the heat from the ginning process should be allowed to dissipate before loading. Condensation and resulting degradation of the cottonseed might occur if blown directly into containers or van trailers before it has a chance to cool. The use of an overhead storage system is an effective method to allow ginning heat to dissipate.

Being hygroscopic, cottonseed will absorb moisture from or give up moisture to its surrounding air. After the cottonseed has been cooled from the heat generated in the ginning process and because of the hygroscopic nature of cottonseed, aeration fans should not be operated during high humidity periods or during rain or fog. Ideally, cottonseed in storage should be cooled to 50 to 60 °F (10 to 15.5 °C) by selecting cool, dry days to run the fans.

Usually no additional aeration is necessary once the seed has been cooled to the desired temperature. Even so, seed temperatures should be monitored throughout the storage period because hot spots occasionally can develop. If the seed storage is not equipped with a temperature monitoring systems, as many of them are, temperature monitoring can be accomplished by placing a thermometer in the exhausting aeration airflow and/or by inserting thermocouple probes into the seed pile.

COTTONSEED CONVEYANCE

Air-Handling Systems for Cottonseed. The high-pressure, lobed-blower seed handling systems commonly used in gins handle cottonseed effectively, are economical to operate, and are relatively trouble free. They have adequate capacity for moving seed as fast as the cotton is ginned. They may also be used for carrying seed to and from storage facilities on the gin yard (Smith 1975). Systems having a pressure of 1 to 6 psi (6.9-41.4 kpa) can convey cottonseed up to 1,500 ft (457 m) of piping. Because no two systems are alike in length and in the number of risers and elbows, the limitations of pressure and volume must be considered carefully in the design of any particular system.

A typical rotary dropper system is shown in Fig. 4. A screw conveyor is used to feed the dropper (vacuum lock) that introduces the seed into the positive pressure air pipe. A valve (Fig. 4F) enables the seed to be diverted to a truck, bin, or to long-term storage. Fig. 5 shows a typical seed plug system with a positive pressure air pipe. The main difference between a rotary dropper system (Fig. 4) and a seed plug system (Fig. 5) is the mechanism used to feed the cottonseed into the airline and prevent air leakage into the feeding auger. The dropper system uses a rotary vacuum (Fig. 4C) to prevent air leakage while feeding seed into a positive pressure system, whereas the seed plug (Fig. 5C) uses an auger full of cottonseed to prevent air leakage. The rotary vacuum lock depends on the rotary valve alone, whereas the seed plug depends primarily on an auger loaded with cottonseed to act as the air seal for the feeding system.

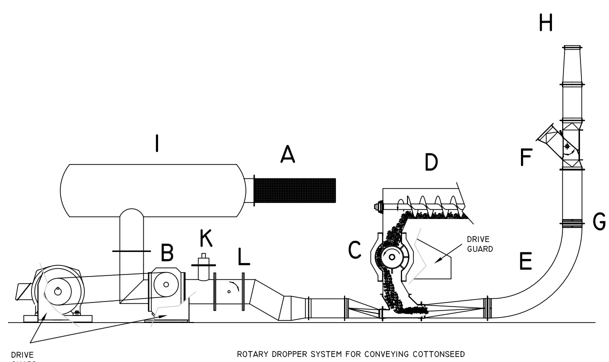

Figure 4. Rotary dropper system for conveying cottonseed. *A*, Steel mesh air filter, or screen box; *B*, Rotary positive-pressure blower; *C*, Rotary dropper, or vacuum-wheel feeder, with eight or more shallow pockets; *D*, Gin stand steel screw conveyor 9- to 24-in (22.9-61 cm) diameter depending on plant capacity; *E*, Long-sweep large-radius elbow; *F*, Valve for diverting seed to bin or storage; *G*, Pipe flange and gasket; *H*, Discharge connection (shown as reducer to accelerate seed when loading vans or box cars. Can be inverted for wider coverage); *I*, Inlet silencer or muffler; *K*, Blower discharge pressure relief valve, typically 4 to 6 psi (27.6-41.4 kpa); *L*, Optional swing-type check valve to prevent material from back-flowing into blower when there is an up-stream blockage.

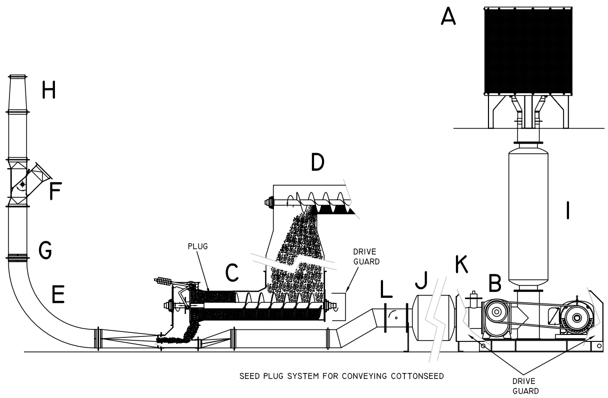

Figure 5. Seed plug system for conveying cottonseed. *A*, Steel mesh air filter, or screen box; *B*, Rotary positive-pressure blower; *C*, Screw type seed plug, 12 and 14-in (30.5- and 35.6-cm) diameter screw depending on plant capacity; *D*, Gin stand steel screw conveyor, 9 to 24-in (22.9-61-cm) diameter depending on plant capacity; *E*, Long-sweep large-radius elbow; *F*, Valve for diverting seed to bin or storage; *G*, Pipe flange and gasket; *H*, Discharge connection (shown as reducer to accelerate seed when loading vans or box cars. Can be inverted for wider coverage); *I*, Inlet silencer or muffler; *J*, Outlet silencer or muffler, typical with larger blower systems; *K*, Blower discharge pressure relief valve, typically 4 to 6 psi (27.6-41.4 kpa); *L*, Optional swing-type check valve to prevent material from back-flowing into blower when there is an up-stream blockage.

Blowers. The positive pressure in a cottonseed conveying system is generated by a two-lobe rotary air pump (Figs. 4B and 5B) known as a positive-pressure blower (Fig. 6) that commonly is used in small-pipe systems operating with an air-pressure range of 1 to 5 lb/in^2 (6.9-34.5 kpa) These blowers can overcome minor chokages by a temporary increase in air pressure. Relief valves are a recommended complement to the pressure blower because they are sized and set for additional pressure to overcome minor chokages, yet limit the maximum pressure to protect the electric motor. Air-pressure requirements, suggested equipment, operating parameters, and performance data for rotary blowers to convey seed are shown in Table 4. A screened intake or air filter is imperative on cottonseed-handling blowers to protect the lobes and casing from excessive wear. In some instances, inline swing check valves have been installed immediately after the blower or discharge silencer. Should the blower motor stall due to system chokage, the check valve will stop any cottonseed from backing up into the blower as cottonseed attempts to reverse direction due to captured system pressure. Typical rotary blower-lobe clearances are less than 0.020 in (0.51 mm). Any intrusion by material can have catastrophic effects.

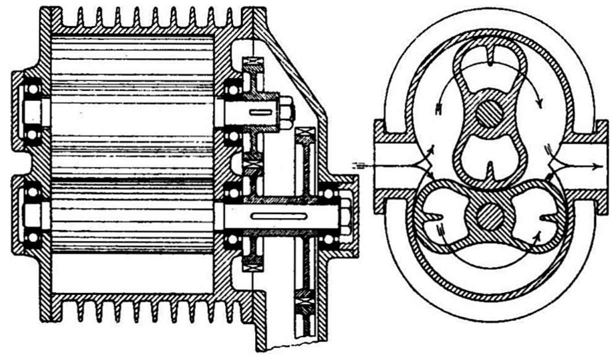

Figure 6. Cross section of a typical positive pressure two-lobe rotary air pump used for conveying cottonseed. Rotation can be reversed if desired.

Piping. Flanged pipes with gaskets at the joints are normally used to transport cottonseed. Table 5 gives the seed-handling capacity of various-sized pipes. Most pipes are made of carbon steel or aluminum, but galvanized pipe or galvanized tubing can be used in areas exposed to the weather. PVC piping causes static electricity problems and should not be used. On the blower intake and discharge, silencers are used to muffle the sound of the blower, which can be in excess of 80 dB. Pressure drop through each silencer is in the range of 0.25 psi (1.73 kpa), which is an acceptable loss for the noise reduction obtained by using the silencer.

The air resistance, due to friction that the pump must overcome, can be estimated by referring to Table 6. Each short elbow and valve should be considered equivalent to approximately 12 pipe diameters of straight pipe. Material losses are a function of the material-to-air ratio, type of material to be conveyed, conveying velocity, and distance to be conveyed. It is not unusual for material losses to account for 20% of the total seed system air loss. Losses due to acceleration and vertical lift can account for an additional 5%.

When conveying cottonseed, air velocities for short runs, 100 ft (30.5 m) or less, of seed pipe should be in the 4,200 to 5,200 ft/min (1,280-1,585 m/min) range with 5,000 ft/min (1,524 m/min) the common target. Additionally, screw or belt conveying could be used as an alternative to convey cottonseed for short runs. For long runs of pipe, more than 100 ft (30.5 m) that are straight (i.e., they have few turns that could cause seed damage), velocities can reach 6,000 ft/min (1,828 m/min). Velocities higher than 6,000 ft/min (1,828 m/min) should be avoided as seed damage can occur due to the seed impacting elbows and transitions in the ductwork. Air volumes from 3 to 5 ft^3 per lb (0.19-0.31 m^3 per kg) of cottonseed are desirable in seed handling systems. No seed should pass through the blower.

Table 4. Air pressure requirement and performance data for rotary blowers.

Bales per hr	lb seed/min @ 700 lb/bale (318 kg/bale)	ft^3/lb (m^3/kg) @ q	Pipe dia in (cm)	Inlet[z] cfm (q) (cmm)	cfm (q) (cmm)	Vel fpm (m/s)	psi (kpa)	bhp (kw)
10	116 (53)	5.8 (0.36)	5 (12.7)	775 (21.9)	682 (19.3)	5000 (25.4)	2 (13.8)	8(6)
		5.8 (0.36)	5 (12.7)	868 (24.6)	682 (19.3)	5000 (25.4)	4 (27.6)	19(14)
		5.8 (0.36)	5 (12.7)	960 (27.20	682 (19.3)	5000 (25.4)	6 (41.4)	26(19)
20	234 (106)	4.2 (0.26)	6 (15.2)	1116 (31.6)	982 (27.8)	5000 (25.4)	2 (13.8)	12(9)
		4.2 (0.26)	6 (15.2)	1249 (35.4)	982 (27.8)	5000 (25.4)	4 (27.6)	26(19)
		4.2 (0.26)	6 (15.2)	1383 (39.2)	982 (27.8)	5000 (25.4)	6 (41.4)	42(31)
30	350 (159)	5.0 (0.31)	8 (20.3)	1982 (56.1)	1745 (49.4)	5000 (25.4)	2 (13.8)	22(16)
		5.0 (0.31)	8 (20.3)	2220 (62.9)	1745 (49.4)	5000 (25.4)	4 (27.6)	50(37)
		5.0 (0.31)	8 (20.3)	2457 (69.6)	1745 (49.4)	5000 (25.4)	6 (41.4)	80(60)
40	467 (212)	3.7 (0.23)	8 (20.3)	1982 (56.1)	1745 (49.4)	5000 (25.4)	2 (13.8)	22(16)
		3.7 (0.23)	8 (20.3)	2220 (62.9)	1745 (49.4)	5000 (25.4)	4 (27.6)	50(37)
		3.7 (0.23)	8 (20.3)	2457 (69.6)	1745 (49.4)	5000 (25.4)	6 (41.4)	80(60)
50	584 (265)	4.7 (0.29)	10 (25.4)	3098 (87.7)	2727 (77.2)	5000 (25.4)	2 (13.8)	50(37)
		4.7 (0.29)	10 (25.4)	3469 (98.2)	2727 (77.2)	5000 (25.4)	4 (27.6)	80(60)
		4.7 (0.29)	10 (25.4)	3840 (108.7)	2727 (77.2)	5000 (25.4)	6 (41.4)	140(104)
60	700 (318)	3.9 (0.24)	10 (25.4)	3098 (87.7)	2727 (77.2)	5000 (25.4)	2 (13.8)	50(37)
		3.9 (0.24)	10 (25.4)	3469 (98.2)	2727 (77.2)	5000 (25.4)	4 (27.6)	80(60)
		3.9 (0.24)	10 (25.4)	3840 (108.7)	2727 (77.2)	5000 (25.4)	6 (41.4)	140(104)
70	816 (370)	4.0 (0.25)	11 (27.9)	3748 (107.2)	3299 (93.4)	5000 (25.4)	2 (13.8)	37(28)
		4.0 (0.25)	11 (27.9)	4197 (118.8)	3299 (93.4)	5000 (25.4)	4 (27.6)	105(78)
		4.0 (0.25)	11 (27.9)	4645 (131.5)	3299 (93.4)	5000 (25.4)	6 (41.4)	160(119)
80	934 (423)	3.5 (0.22)	11 (27.9)	3748 (107.2)	3299 (93.4)	5000 (25.4)	2 (13.8)	37(28)
		3.5 (0.22)	11 (27.9)	4197 (118.8)	3299 (93.4)	5000 (25.4)	4 (27.6)	105(78)
		3.5 (0.22)	11 (27.9)	4645 (131.5)	3299 (93.4)	5000 (25.4)	6 (41.4)	160(119)
80+-100	934 - 1167 934 (423)	Use two blowers, two separate 10-in (25.4-cm) pipeline systems						
	(424-530)	5.8-4.7 (0.36-0.29)	two 10 (25.4)	3098 (87.7)	2727 (77.2)	5000 (25.4)	2 (13.8)	50(37)EA
		5.8-4.7 (0.36-0.29)	two 10 (25.4)	3469 (98.2)	2727 (77.2)	5000 (25.4)	4 (27.6)	80(60) EA
		5.8 - 4.7 (0.36-0.29)	two 10 (25.4)	3840 (108.7)	2727 (77.2)	5000 (25.4)	6 (41.4)	140(104)EA

[z] $Q_I = [(14.7 + psiA)(Q_A)]/14.7$ where Q_I = inlet air volume; psiA = estimated system resistance in psi; Q_A = actual air volume at psiA.

Derivation of Boyle's and Charles' laws, Fan Engineering 5th Edition, pg. 12

Table 5. Cottonseed handling capacities of pipes

Pipe diameter in (cm)	Volume of air[z] ft^3/min (m^3/min)	Capacity (assuming 700 lb (317 kg) seed/bale)		
		lbs/min[y] (kg/min)	tons/hr (metric tons/hr)	bales/hr[x]
4 (10.2)	436 (12.4)	87-145 (40-66)	2.6-4.4 (2.4-4.0)	7.5-12.5
5 (12.7)	682 (19.3)	136-227 (62-103)	4.1-6.8 (3.7-6.2)	11.7-19.5
6 (15.2)	982 (27.8)	196-327 (89-148)	5.9-9.8 (5.3-8.9)	16.8-28.0
8 (20.3)	1746 (49.4)	349-582 (158-264)	10.5-17.5 (9.5-15.8)	29.9-49.9
10 (25.4)	2727 (77.2)	545-909 (247-412)	16.4-27.3 (14.8-24.7)	46.7-77.9
11 (27.9)	3300 (93.4)	660-1100 (299-499)	19.8-33.0 (18.0-29.9)	56.6-94.3

[z] Based on a velocity of 5000 ft/min at 0 psi

[y] Based on 700 lb (317 kg) of seed per bale

[x] Based on 500 lb (227 kg) of lint per bale

Table 6. Components of pipe conveying system, ΔPs

Component	ΔPs (wc)[z] (mm wc)
4 inch (10.2 cm) pipe, loss per 100 ft (30.5 m)	5.60 (142)
5 inch (12.7 cm) pipe, loss per 100 ft (30.5 m)	4.20 (107)
6 inch (15.2 cm) pipe, loss per 100 ft (30.5 m)	3.50 (89)
8 inch (20.3 cm) pipe, loss per 100 ft (30.5 m)	2.40 (61)
10 inch (25.4 cm) pipe, loss per 100 ft (30.5 m)	1.90 (48)
11 inch (27.9 cm) pipe, loss per 100 ft (30.5 m)	1.80 (46)
4 inch (10.2 cm) 90 degree elbow	0.22 (6)
5 inch (12.7 cm) 90 degree elbow	0.21 (5)
6 inch (15.2 cm) 90 degree elbow	0.21 (5)
8 inch (20.3 cm) 90 degree elbow	0.19 (5)
10 inch (25.4 cm) 90 degree elbow	0.19 (5)
11 inch (27.9 cm) 90 degree elbow	0.20 (5)
venturi discharge	3.00 (76)
cyclone collector and sacker	4.00 (101)
silencer/muffler	8.00 (203)

[z] wc is acronym for “water column” measured in inches or millimeters

1 psi ≈ 27.7” water column (wc) = 6.9 kpa = (0.07 kg/cm2) ≈ 700 mm wc

1 kpa = 4.021” wc = 0.145 psi

Risers in lines should be inclined, not vertical. The angled pipe will prevent 90° bends, allowing larger angles at elbows and saving piping length. Downward pipe slopes should be avoided because they cause chokages.

Seed-handling elbows should be 18 gauge (1.2 mm) or heavier and must be the long-sweep type to give satisfactory service without chokage. An 18-in (45.7-cm) minimum elbow radius is recommended for pipes 4, 5, and 6 in (10.2, 12.7, and 15.2 cm) in diameter. A 24-in (61-cm) elbow radius should be used for 8-in (20.3-cm) pipes and a 30-in (76.2-cm) elbow radius for 10-in (25.4-cm) pipes.

Feeding Seed into Pressure Pipes. Cottonseed is normally fed into a small-pipe system by a dropper or rotary lock (sometimes called a vacuum wheel) that mechanically drops the seed into the positive-pressure air line on the discharge side of the blower; Fig. 4 shows a typical seed rotary lock installation. The rotary lock should operate at 30 to 60 rpm. Internal seals and pocket divisions are necessary to prevent serious air leakage. More flights on a seed dropper will likely provide a better seal. In some installations, eight-blade droppers without flashing or seed plugs at the end of an auger have been used successfully. Feeder base outlets should be sufficiently tapered to prevent bridging and chokage. Outlets should be set as close to the feeder as possible.

In recent years, high capacity gins have used seed plug conveyors in lieu of the conventional vacuum feeder (Fig. 5). Commercially available cottonseed plugs have either 12-in or 14-in (30.5- or 35.6-cm) plug conveyors. The general guidance is that 12-in (30.5-cm) plugs are recommended for cotton gins with capacities up to 45 bales/hr, the 14-in (35.6-cm) plug is for higher ginning capacities. Roughly one quarter to a third of the effective conveyor flight is removed from the tail end of the conveyor to allow for the seed plug to form. Accumulation of seed in the region void of flighting is what forms the plug. The purpose of the plug is to create an air seal preventing leakage into the atmospheric surroundings of the seed plug hopper. Variable speed drives could be needed to adjust the conveyor rpm’s to enhance the operation of the seed plug by maintaining a constant relationship between the plug densities and processing rate of the gin plant. The nominal fixed conveyor speed for both size plugs is 75 rpm. Power requirements can vary from 7-1/2 to 15 hp (5.5-11.1 kW) depending on the size and number of plugs used. Dual seed plugs are recommended for capacities in excess of 90 bales/hr.

The capacity of seed droppers depends upon their length, flight-wheel diameter, and speed and upon the methods used to seal and feed them. Droppers fed continuously will have more capacity than those fed in pulses from a seed scale. Capacities of cottonseed droppers are given in Table 7.

Valves and Discharges. Valves that are not well fitted for small-pipe systems can give trouble. For lines containing vane-type seed valves, the takeoff angle should not exceed 30°. The deflector vane should be of adequate thickness and should be well fitted into the body of the valve, with the seated end adjusted to prevent blockage by lint or by seed buildup at the valve intake.

The discharge funnel directs the flow of air and seed through the pipe and into the desired container and/or storage location. This flow, however, should not be directed toward a wall or any obstacle that might create hard impacts causing damage to the seed (i.e., cracking or spitting).

Table 7. Capacities of cottonseed droppers

Diameter in (cm)	Length in (cm)	Drive hp	Rotor rpm	cfr (cmr)	Effective cf (cm)/rev	Capacity (assuming 700 lb seed/bale)		
						lb/min (kg/min)	tons/hr (mt/hr)	bales per hr[z]
12 (30.5)	10 (25.4)	1	70	0.52 (.02)	0.13 (.004)	123 (56)	3.7 (3.4)	10
12 (30.5)	18 (45.7)	3	70	0.94 (.03)	0.24 (.007)	227 (103)	6.8 (6.2)	20
16 (40.6)	12 (30.5)	1	55	1.12 (.03)	0.28 (.008)	208 (95)	6.2 (5.6)	20
16 (40.6)	18 (45.7)	2	55	1.67 (.05)	0.42 (.019)	312 (142)	9.4 (8.5)	25
16 (40.6)	24 (61)	3	55	2.23 (.06)	0.56 (.016)	416 (189)	12.5 (11.3)	35
22 (55.9)	12 (30.5)	3	55	2.11 (.06)	0.53 (.015)	394 (179)	11.8 (10.7)	35
22 (55.9)	18 (45.7)	5	55	3.17 (.09)	0.79 (.022)	587 (267)	17.6 (16.0)	50
22 (55.9)	24 (61)	7.5	55	4.22 (.12)	1.06 (.030)	787 (358)	23.6 (21.4)	65
22 (55.9)	36 (91.4)	10	55	6.34 (.18)	1.59 (.045)	1181 (537)	35.4 (32.1)	100[y,x]
34 (86.3)	30 (76.7)	7.5	45	12.61 (.36)	3.15 (.090)	1914 (870)	57.4 (52.0)	165[y,x]

[z] Rounded to nearest multiple of 5

[y] use of seed plug preferred @ capacities in excess of 60 bph

[x] dual seed systems recommended for systems in excess of 90 bph

cfr (cubic ft per rev) (cmr (cubic meters per rev) = area of rotor diameter x length x 0.8

Effective cfr (cmr)/ rev = cfr (cmr) x 0. 5 x 0.5

lb/min (kg/min) = effective cfr (cmr) / rev x rpm of rotor x 18 lb/ft^3 (8.2 kg.m^3) x 0.75

System Design. The following is a system design example for a 30 bale per hour ginning facility:

Example. A 30 bale per hour (BPH) ginning facility wants to upgrade the seed handling system with new seed vacuum dropper, seed blower and motor, inlet and outlet silencers, and new seed pipe. The average amount of seed per bale experienced by the gin is 700 lb (317.5 kg). The length of pipe from seed vacuum dropper discharge to the outlet of new pipe at seed bunker is 300 ft (91.4 m) with six 90° elbows and a 30-ft (9.1-m) vertical lift. To upgrade the seed handling facility, the ginner needs to determine the following items:

1) volume of seed per minute, 2) cottonseed dropper size, 3) air volume required, 4) pipe size for conveying cottonseed at a target velocity, 5) system friction loss, and 6) cottonseed blower requirement. Example is shown in Imperial units to simplify the explanation. Basic formulas necessary for air calculations when conveying seed at a target velocity of 5,000 ft/min (1,524 m/min) in a cotton gin are:

$$Q = VA \quad (1)$$

Where: Q = volume of air in cubic feet per minute (cfm),

V = velocity of air in pipeline in feet per minute (fm) and,

A = cross-sectional area of round seed pipe in square feet (ft^2).

For round pipe, $A=\pi r^2$

Where: π = the constant 3.1416 and

r = the radius of the pipe in inches. (2)

a) Determine volume of seed per minute: Given capacity of 30 BPH and 700 lb of seed per bale, the volume of seed per minute is calculated as follows:

(30 BPH x 700 lb per bale)/60 min = 350 lb/min (3)

b) Determine cottonseed dropper size: Given capacity of seed per minute from Equation 3, 350 lb per min, use Table 7 to determine proper cottonseed dropper. From Table 7, the closest capacity that is greater than 350 lb/min is 394 lb/min. Therefore, a 22-in diameter x 12-in long dropper operating at 55 rpm with a 3-hp drive motor would be the best choice for this example.

c) Determine required air volume (Q): Given a capacity of 30 BPH and 700 lb of seed per bale, the volume of air per minute needed to convey the cottonseed at the recommended upper limit of 5 cfm/lb is calculated to be:

Vol of seed/min (Equation 3) x recommended conveying air volume (5 cfm/lb);

350 lb/min x 5 cfm/lb = 1,750 cfm

d) Determine pipe size(s): Substituting 1,750 cfm and 5,000 fm for Q and V respectively in equation (1), the resulting pipe area A is determined as follows:

Q = VA can be rewritten as, A = Q/V.
Plugging in the values from above for air volume and velocity:
A = 1750 cfm/5000 fm = 0.35 ft2
To convert square feet into square inches use A (ft2) x 144 in2/ ft2 = A (in2).
Therefore, 0.35 ft2 x 144 = 50.40 in2
Now using Equation 2, the radius and diameter of the preferred pipe size can be determined as follows:
A = πr2 can be rewritten as A/π = r2 ; 50.40 in2 /π = r2 ; r = 16.0430.5 = 4.0-in radius or 8.0-in diameter seed pipe.

e) Estimate system friction losses: The system friction losses need to be calculated to ensure the correct rotary blower is selected (Table 4) because the friction loss determines the pressure the blower will work against to convey the cottonseed.

Accumulative losses (water column, wc. Shown below in inches of water[1]) for the system can be estimated from Table 6.

Inlet silencer	8.00 in H2O
Outlet silencer	8.00 in H2O
Blower loss (assumed)	1.50 in H20
Venturi	3.00 in H20
300 ft of 8-in pipe @ 2.40 in/100 ft, (8 x 2.4 = 7.2)	7.20 in H2O
Six 90° 8-in elbows @ 0.19-in ea, (6 x 0.19 = 1.14)	1.14 in H2O
Cyclone collector	4.00 in H2O
Total friction loss	32.84 in H2O
Converting the friction loss from inches water column to psi;	
Loss in psi @ 27.7” wc/psi, (32.84 ÷ 27.7 = 1.2)	1.20 psi
Loss due to material @ 20% (rule of thumb)	0.24 psi
Loss due to vertical lift/accel @ 5% (rule of thumb)	0.06 psi
Total relief setting psi >	1.50 psi

f) Determine rotary blower requirement: Consult Table 4 and the manufacturer’s catalog for rotary blower specifications to meet your system requirements of 1,750 cfm and 1.5 psi. See footnote at bottom of Table 4 for additional reference.

SUMMARY

Cottonseed is a valuable co-product of the cotton gin and as such should be handled and stored in a way that best preserves its quality characteristics. This chapter provides rule-of-thumb guidance and recommendations for handling, conveying, aeration and storage of cottonseed. When applying the examples to one’s own gin, the reader should be aware of the impact of ambient conditions such as temperature and humidity and of the cotton gins elevation in regard to sea level. Also, the temperature and moisture of the seed being stored should be accounted for and monitored routinely.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Tom Wedegaertner of Cotton Incorporated and Mike Dowd of USDA-ARS, Southern Regional Research Center.

DISCLAIMER

Mention of product or trade names does not constitute an endorsement by the USDA-ARS, Lummus Corporation, or National Cotton Council over other comparable products. Products or trade names are listed for reference only. USDA, Lummus Corporation, and National Cotton Council are equal opportunity providers and employers.

REFERENCES

Dowd, M. 2015. Seed. p. 745–781. *In* D.D. Fang and R.G. Percy (eds.). Cotton, 2nd ed. Agronomy Monograph No. 57, Madison, WI.

Hughs, S. and G. Holt. 2015. Ginning. p. 609–664. *In* D.D. Fang and R.G. Percy (eds.). Cotton, 2nd ed. Agronomy Monograph No. 57, Madison, WI.

Smith, L.L. 1975. Aeration of cottonseed in storage. U.S. Department of Agriculture, Marketing Research Report 1020.

Smith, L.L., and S.T. Rayburn, Jr. 1977, Cottonseed Aeration and Storage. p. 72–79 *In* Cotton Ginners Handbook, USDA Agricultural Handbook 503, Washington, D.C.

Willcutt, M.H., and W.D. Mayfield. 1994. Cottonseed Handling and Storage. p. 195-214 *In* Cotton Ginners Handbook, USDA Agricultural Research Service, Washington, D.C.,

Willcutt, M.H., S.D. Filip To, P. Kradangga. 1996. A study in wall pressures in a flat clear-span cottonseed storage house, p. 1625–1630 *In* Proc. Beltwide Cotton Conf., Nashville TN. 9-12 Jan. 1996. Natl. Cotton Counc. Am., Memphis, TN.