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Chapter **15**

GRADING, CLEANING, STORAGE, SHELLING, AND MARKETING OF PEANUTS IN THE UNITED STATES

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AND JAMES W. DICKENS

The entire production, marketing and processing system for peanuts in the United States is influenced by the price support program and the predominately edible use for peanuts produced in the country. Clearly defined official grading procedures for farmers stock peanuts (peanuts delivered from the farm) were developed for price support purposes, but they generally are the basis for price negotiations between the farmer and buyer. On the average, less than 20% of the peanuts produced in the USA are crushed for oil (USDA, 1979). Consequently, the grades for both farmers stock peanuts and shelled peanuts are intended to reflect the suitability of the peanuts for food.

The typical peanut handling, marketing and processing system for peanuts employed in the USA is diagrammed in Figure 1. Each stage of the system is discussed below.

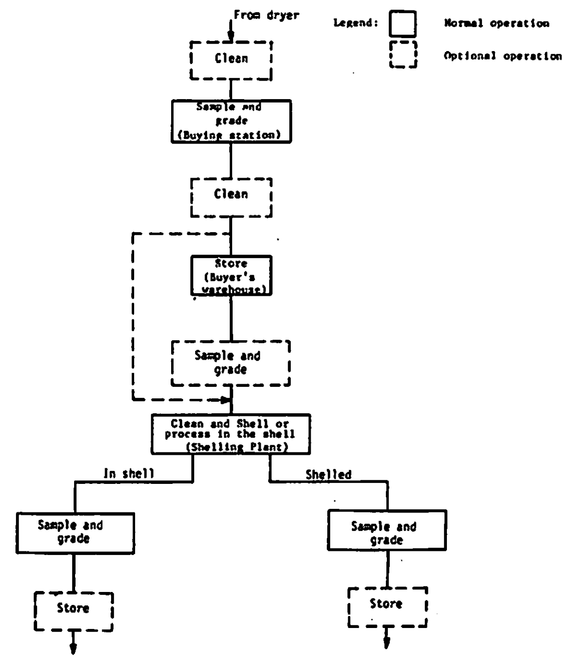


Fig. 1. Typical USA peanut marketing processing operations.

CLEANING FARMERS STOCK PEANUTS

When peanuts are harvested, they contain a wide variety of foreign material (material other than peanuts). The types and quantities of foreign material depends upon the adjustment and operation of the harvesting equipment, soil type and condition, weather conditions, and other factors. Types of foreign material commonly found in farmers stock peanuts at time of marketing and the problems that result from their presence are listed in Table 1. Foreign material and loose shelled kernels (LSK), peanut seed inadvertently shelled by harvesting and handling operations, cause problems in storage and processing (McIntosh and Davidson, 1971a; Dickens and Hutchison, 1976). LSK are often dirty, moldy, mechanically damaged, or insect damaged; and they deteriorate more rapidly during storage than inshell peanuts. Small shriveled pods (raisins) contain high concentrations of moisture and often mold during storage. The undesirable concentration of LSK, raisins, and foreign material beneath the discharge of conveying systems is indicated by Table 2. High concentrations of this material restrict air flow and prevent the high-moisture peanuts from drying during storage.

The incidence of foreign material in farmers stock peanuts may be reduced with a program of prevention and removal. Table 3 lists some suggested methods of prevention and removal for common types of foreign material. The types of equipment used to clean peanuts before storage range from a dirt screen or simple aspiration equipment to procedures that utilize screening, aspiration and specific gravity separation to remove the bulk of the foreign material.

The precleaning facility usually consists of a dump pit, cradle hoist, precleaner, elevators, and a shed or building to enclose the equipment (Figure 2). A flow chart of the typical precleaner operation is shown in Figure 3. The peanuts are unloaded into the dump pit by lifting 1 end of the 4-wheel wagon with the cradle hoist. The peanuts are then elevated from the dump pit to the roll feeder on the precleaner. After passing through the precleaner, the peanuts are then elevated into a holding bin or into a transport vehicle. Since the standard precleaning unit is only about 85% efficient, further cleaning is needed before shelling the peanuts. A comparison of the properties of foreign materials and peanuts indicates that the efficiency of precleaning equipment can be improved (Williams and Butler, 1973; Blankenship and Williams, 1977).

Despite the obvious advantages, most peanuts are not cleaned before storage, because it requires a large investment in equipment and labor, provides another potential source for breakdown and delay during the rapid harvest season, and usually results in a small loss of marketable peanuts. However, peanuts with more than 10% foreign material are usually cleaned before marketing.

Cleaning equipment and methods to remove some of the foreign material that segregate in storage have been developed (Blankenship and Hutchison, 1978; Blankenship et al., 1979). The primary equipment consists of magnetic gates for rear-entry drying wagons to trap dirt, fines and insects that have sifted through the perforated floor of the wagons and a screening, and/or aspiration machine installed between the discharge head of the elevator and the overhead conveyor belt at the warehouse. This equipment is low cost and usually requires essentially no supervision or operating cost except for a little off-season maintenance. Cleaning with sandscreens at ground level and employing additional elevators is also an effective cleaning method. Screening and aspiration equipment removes some insects and part of the foreign material that restricts air movement through the peanuts during storage. Many warehousemen have implemented and installed this equipment at their warehouses.

Table 1. Foreign materials that are commonly found in farmers stock peanuts.

Foreign material(s)	Source(s)	Normal range of incidence based upon gross weight of farmers stock peanuts %	Problems that result from presence of specific foreign materials(s)
Dirt	Soil adhering to peanut pods	1-6	Air pollution, wear of machinery, loss of insecticide, restriction of air movement in storage, dirt contamination of edible grades.
Rocks	Rocky or pebble-type soil	1-4	Damage and wear of machinery, damage to peanut pods and seed, presence of stones in shelled peanuts and peanut products.
Sticks	Peanut plant (vines and taproots), weeds, cotton stalks, other crop residue, tree limbs, etc.	1-8	Restriction of peanut flow, high moisture source, blinding of screen and sheller grates, and presence of pieces of sticks in shelled peanuts and peanut products.
Raisins (Immature shriveled pods)	Peanut plant	1-2	High moisture source, difficult to remove during processing.
Pops, leaves, stems and hulls	Peanut plant	1-2	Reduces drying, handling and storage capacity.
Weed fruit (wild cucumbers, bull nettle berries, maypops, cocklebur s)	Weeds	0-1	High moisture source, difficult to remove.
Nutgrass and rhizomes	Weeds	0-1	Difficult to remove.
Corn cobs, corn, grain, peach seed	Crop residue from field or transport vehicles	0-1	Difficult to remove.
Metal	Machinery	0-1	Destructive to machinery, presence in shelled peanuts and peanut products.
Miscellaneous (glass, firearm shell casings, etc.)	Litter	0-1	Difficult to remove, presence in shelled peanuts and peanut products.

Table 2. Composition of 26 samples taken from each of 6 warehouses. (The samples were taken directly beneath the overhead conveyer used to fill the warehouses.)

Types of material	Range		Average	Standard deviation
	Highest %	Lowest %	%	
Unshelled	93.6	12.7	59.7	21.2
Loose shelled kernels (LSK)	40.7	0.0	12.0	10.8
Raisins (Shriveled unshelled peanuts)	2.1	0.0	0.6	0.6
Sticks	7.4	0.1	0.8	1.6
Dirt	41.9	0.0	16.6	13.5
Light trash	16.5	0.5	3.7	3.1
Rocks	18.1	0.0	3.4	4.3
Misc. seeds	0.2	0.0	0.0	0.0
Misc.	13.7	0.0	1.1	3.4
Total foreign material and LSK	86.7	6.7	39.0	21.0

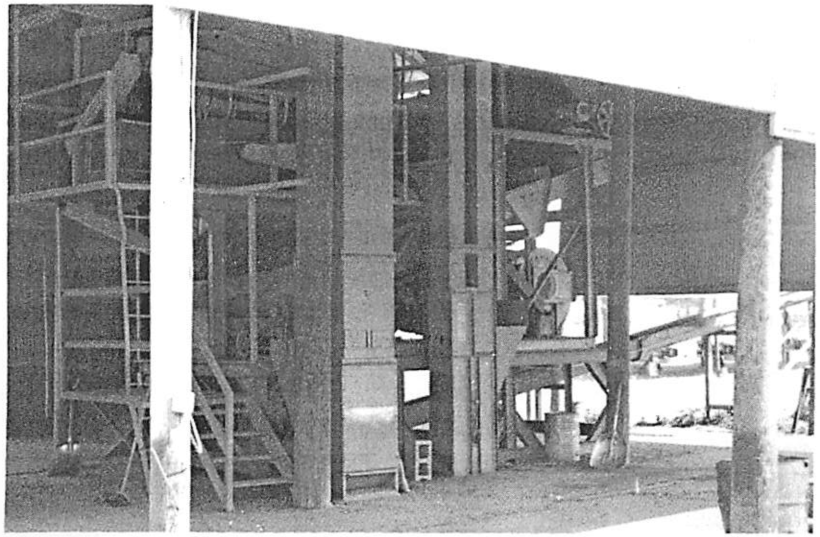


Fig. 2. A typical peanut cleaning facility.

HANDLING AND STORAGE OF FARMERS STOCK PEANUTS

Peanuts are a semiperishable crop and are subject to loss in quality during storage through microbial proliferation, insect and rodent infestation, biochemical changes (flavor change, rancidity, viability loss, etc.), physical changes (shrinkage, weight loss, etc.) and absorption of odors and chemicals. When subjected to suitable storage environments, clean peanuts can be stored for several years (Woodruff, 1973). Like most agricultural products, as moisture and temperature are decreased the rate of deterioration in storage also de-

Table 3. Methods to reduce the incidence of foreign material in peanuts.

Foreign material(s)	Best conventional method(s) of prevention	Best conventional method(s) of removal
Dirt	Harvest when soil is not too wet or dry. Control weeds. Obtain fluffy windrow.	Screening.
Rocks	Avoid planting on rocky or pebble-type soil. Obtain fluffy windrow.	Specific gravity.
Sticks	Remove or bury old crop residue before planting. Control weeds. Set peanut diggers to cut taproots as shallow as possible. Set combine aggressiveness as low as possible to prevent excessive vine, taproot and stick breakage.	Aspiration and screening.
Immature pods	Harvest at optimum maturity. Set combine aggressiveness to leave a maximum number of immature pods on the peanut vine. Set combine aspiration and screening to remove a maximum number of immature pods.	Screening, aspiration and specific gravity.
Pops, leaves, stems and hulls	Harvest at optimum maturity and combine at optimum vine conditions. Set aspiration on combine to remove a maximum amount.	Aspiration.
Weed fruit	Control weeds. Clip vines in weedy fields.	Screening and color sorting.
Nutgrass and rhizomes	Control weeds. Obtain fluffy windrow.	Screening and color sorting.
Corn cobs and crop residue	Remove or bury old crop litter before planting. Clean out transportation vehicles prior to loading vehicle with peanuts.	Screening, aspiration and color sorting.
Metal	Maintain machinery in good condition.	Screening and magnetic separation.
Miscellaneous (glass, firearm shell casings, etc.)	Control litter disposal.	Screening, specific gravity, and color sorting.

creases. However, serious losses in milling quality result when peanut seed are dried below 7% seed moisture content wet basis (w.b.) or if peanut temperature is below 7 C when they are shelled (Beasley and Dickens, 1963; McIntosh and Davidson, 1971b). Thus, the best storage conditions for normal dry bulk storage of unshelled peanuts is about 7.5% seed moisture content w.b. at 10 C. If these storage conditions are maintained, good quality unshelled peanuts can be stored without significant loss in quality for at least 1 storage season (about 10 months).

Some peanut varieties have been noted to have poor storability (Davis, 1961; Young and Holley, 1965). The storability (as indicated by iodine, oxygen bomb and free fatty acid measurements) of each proposed variety is usually

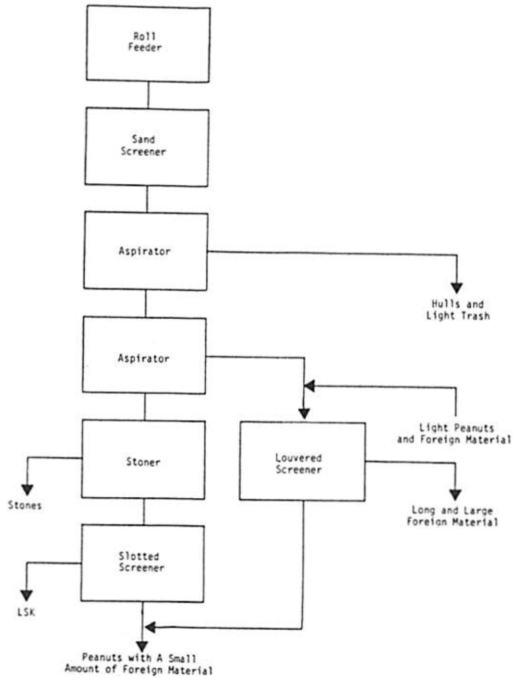


Fig. 3. Cleaning operations of a typical peanut precleaner.

evaluated before it is released for production. Treatment during the growing, harvesting, curing, and handling of the peanuts may affect their storability (Young et al., 1971; Shewfelt and Young, 1977; Siberstein and Rao, 1977; Smith et al., 1980). Conditions that provide a healthy peanut plant and a properly cured sound pod would normally provide good quality peanuts for storage.

A small amount of farmers stock peanuts is transferred directly from the buying point to the shelling point. However, most of the peanuts must be stored until they can be shelled. Storage periods range from a few days to about 10 months. Peanuts are segregated in storage according to grade (Segregation I, II, and III) and type (runner, spanish, virginia, and valencia). Research (Hutchison, 1973; Dickens and Hutchison, 1976) also indicates that further segregation as to quality and variety would minimize loss of quality during storage by allowing the poorest quality peanuts to be shelled first. Additional segregation would also provide more uniform physical and shelling properties that would allow more efficient shelling and processing (Davidson et al., 1976a). However, the cost of maintaining different storage areas must also be considered.

Farmers stock storage warehouses include tanks and bins (Figure 4), concrete silos (Figure 5), and flat-type storage (Figure 6). Most peanuts in the USA are stored in flat-type storage. Wood, brick or insulated warehouses have less problems with condensation than uninsulated warehouses. Concrete silos provide good insulation and are a design that is very adaptable to ventilation and aeration. However, a silo-type storage provides for large drop heights dur-

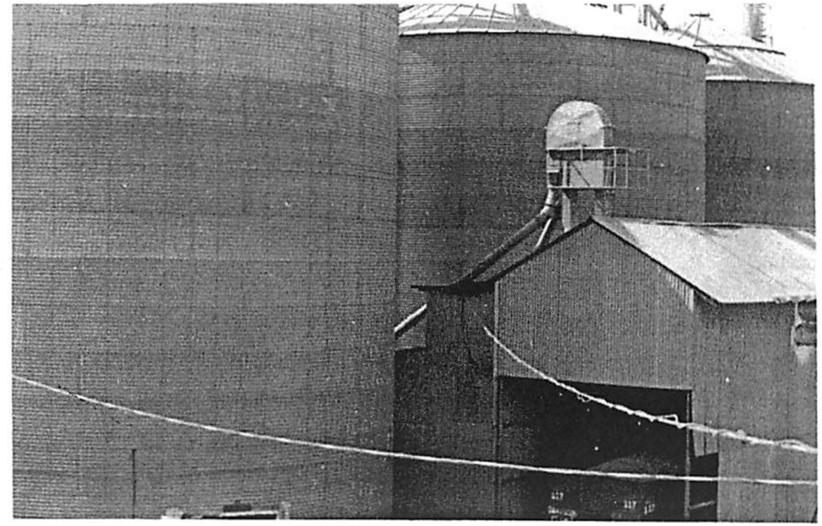


Fig. 4. Bins used to store farmers stock peanuts.

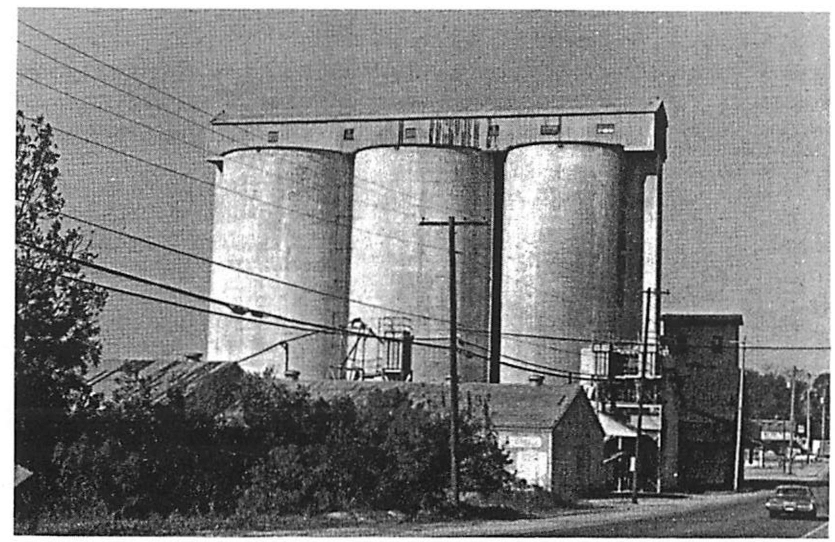
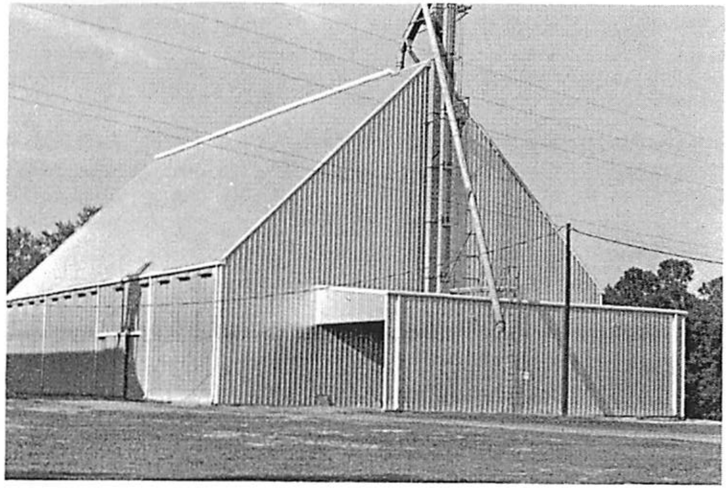


Fig. 5. Concrete silos used to store farmers stock peanuts.

ing filling that result in mechanical damage to the pods and seeds. Significant mechanical damage results when farmers stock peanuts are dropped more than 2.42 m and when shelled peanuts fall more than 0.61 m (Slay, 1976). Mechanical damage is more when peanuts are dropped on surfaces such as concrete and steel and when peanuts are dropped at low ambient temperatures (below 2 C). Another serious problem experienced with silo-type storage is the difficulty in unloading because of "bridging" of the peanuts due to pressure (weight of pea-



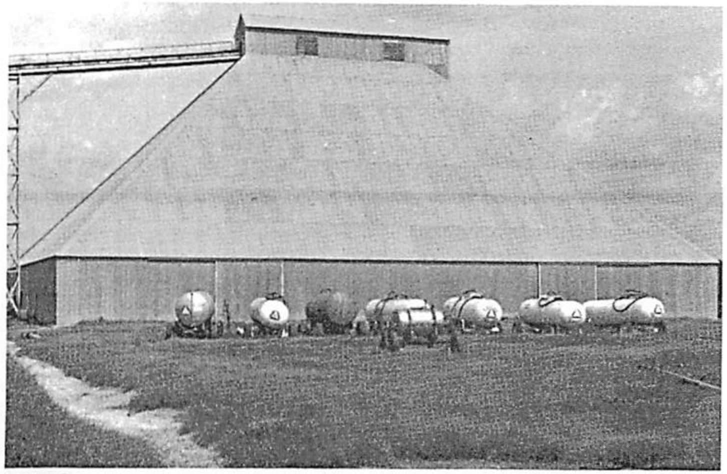


Fig. 6. Typical flat-type storage warehouses used to store farmers stock peanuts (top-conventional type; bottom-muscogee type.)

nuts), physical properties of the peanuts (shape, length, densities, size, etc.), and the presence of foreign material. Bridging is worse if peanuts are not cooled to ambient temperatures before storing. Most of the techniques and methods used to dislodge the peanuts are hazardous and usually result in additional mechanical damage to the peanuts.

The flat-type peanut storages are popular because of their low initial cost and ease of loading and unloading. Except for the older warehouses (20 years or older), the flat-type storage warehouses are uninsulated steel buildings (usually 26.25 m wide) that have eave heights of about 3.66 to 7.32 m and roof slope of at least 33 degrees (angle of repose of farmers stock peanuts). Desirable storage conditions in small warehouses are much more difficult to maintain than

for larger warehouses because smaller warehouses are affected more by outside ambient conditions. Thus, flat-type storage warehouses usually maintain the quality of the peanuts better than tank or small bin storage (Woodward and Blankenship, 1974).

Generally, the structural design of peanut warehouses has been based upon procedures developed for grain (Stahl, 1950). The prime considerations are static peanut pressures; wind, snow and dead loads (conveyor, catwalk, etc.); and allowable stresses of the building materials. Static pressure is estimated by Janssen's formula $L = WR/\mu(1-e^{-K\mu H/R})$ where L= lateral pressure, W= bulk density of the peanuts, R = hydraulic radius of the warehouse, μ = coefficient of friction of peanuts on the walls, K = ratio of lateral to vertical pressure, and H = height of fill. Values of μ for peanuts contacting various types of materials have been reported by Samples (1966). Dynamic pressures (pressure resulting from bins being filled or unloaded) have not been reported but may be estimated to be about 1.5 times the static pressures. ASAE standard 5288.3 (1981) provides information for estimating the snow and wind loads as well as listing the references for obtaining allowable stresses for various construction materials. Plans for small bins and warehouses are usually available through the state agricultural experiment stations in the peanut producing states. Plans for the large warehouses can be usually obtained from the major building manufacturers. Many structural problems (leaks, excessive wall deflection, under or over design, etc.) have been noted that indicate the need for research on the optimum design of peanut warehouses.

Measurements of the bulk density of farmers stock peanuts made at the National Peanut Research Laboratory are given in Table 4. The difference in bulk densities among peanut varieties are related to differences in pod size and shape, seed size, and hull thickness. Varieties having smaller and more normal shaped pods with larger kernels and thinner hulls usually have the higher bulk densities. For a particular variety, the bulk density will vary with the grade in a manner similar to that described by Johnson (1959). The bulk density will increase with an increase in sound mature kernels (SMK) and LSK. Bulk density will decrease slightly with an increase in foreign material. The pressure of the peanuts in a typical warehouse may increase the bulk density by an estimated 10%. Desirable design features for peanut warehouses are summarized in Table 5 (Dickens and Hutchison, 1976). Peanuts are usually loaded into the warehouse by use of a dump pit, a hoist or hydraulic lift, a bucket elevator, and an overhead belt conveyor (Figure 7). Pneumatic loaders and unloaders and enclosed screw conveyors have proved unsatisfactory because of excessive mechanical damage imparted to the peanuts. Dump pits are designed to minimize labor cost and mechanical damage (White and Smith, 1961). The pits are covered and water tight; hold at least 4.5 t (5 tons) of peanuts; have minimum grate dimension of 3.7 m W x 3.0 m L (10 ft L x 12 ft W); and have sides with valley angles of at least 45 degrees for self-cleaning. The clearance under the pit shelter should be about 4.57 m. The runway should be even with the top of the pit and should slope away from the pit to provide proper drainage.

Slay and Hutchison (1973) found that standard bucket elevators impart very little damage when operated properly. Belt speeds and bucket spacings must be properly correlated to obtain optimum conveying rates. The overhead con-

Table 4. Bulk density[1] of farmers stock peanuts.

Variety	Normal range (Kg/m^3)	Average (Kg/m^3)
Florigiant[2]	248-288	272
Florunner[3]	304-344	327
Starr[4]	288-336	316

[1]Values were obtained by measuring the weight and volume of peanuts poured into a 30.48 x 30.48 x 60.95 cm container (loose fill). To obtain bulk density in pounds per cubic foot, multiply the Kg/m^3 values by 0.0624.
[2]Florigiant is the most widely grown variety of the virginia type peanuts.
[3]Florunner is the most widely grown variety of the runner type peanuts.
[4]Starr is the most widely grown variety of the spanish type peanuts.

Table 5. Some desirable design features for farmers stock warehouses.

Component	Desirable characteristics	Function
Site	Clean, elevated, graded, well drained.	To prevent seepage of water into the warehouse.
Building orientation	North and south.	To prevent nonuniform sun exposure and minimize condensation.
Approach and exit to dump pit and unloading doors	Concrete or asphalt paving inclined away from dump pit.	To prevent additional moisture and foreign material from entering the pit.
Foundation and floor	Steel reinforced concrete with vapor barrier underneath floor.	To support the weight of the building, peanuts, and the unloading vehicles and to prevent moisture seepage through the floor.
Exterior walls and roof	Steel adequately designed for integrity and strength with no crevices or cracks and exterior painted with reflective coating.	To withstand peanut pressures, wind, ice and snow loads, while preventing leaks, penetration by rodents, insects, and birds. To reflect solar heat.
Interior	Open floor space with no beams and obstructions. No partitions.	To permit easy removal of peanuts from storage. To prevent the restriction of overspace ventilation.
Loading equipment	Dump pit, elevator, and overhead conveyor.	To provide for rapid but gentle loading of peanuts into warehouses at minimum cost.
Unloading equipment	Under floor conveyor and inclined floor or front end loader.	To provide for rapid but gentle unloading of warehouses at minimum cost.
Precleaning equipment	Standard precleaner and additional elevator at ground level or cleaning equipment on elevator down spouting.	To remove foreign materials that restrict air movement during storage and/or that add additional moisture, and/or take up storage space.
Ventilation system	Overspace ventilation that will provide at least three air changes per minute.	To remove excessive moisture and heat, to minimize condensation and to reduce excessive overspace temperatures.
Aeration system	Under floor ducts to provide at least 0.10 m^3/min of air per m^3 of peanuts.	To provide better control of peanut temperature and moisture and to minimize condensation.
Insect control system	Warehouse designed for fumigation automated surface treatments and/or automated spraying of peanuts as they enter the warehouse.	To provide good insect control with a minimum risk of adding to the moisture problems.

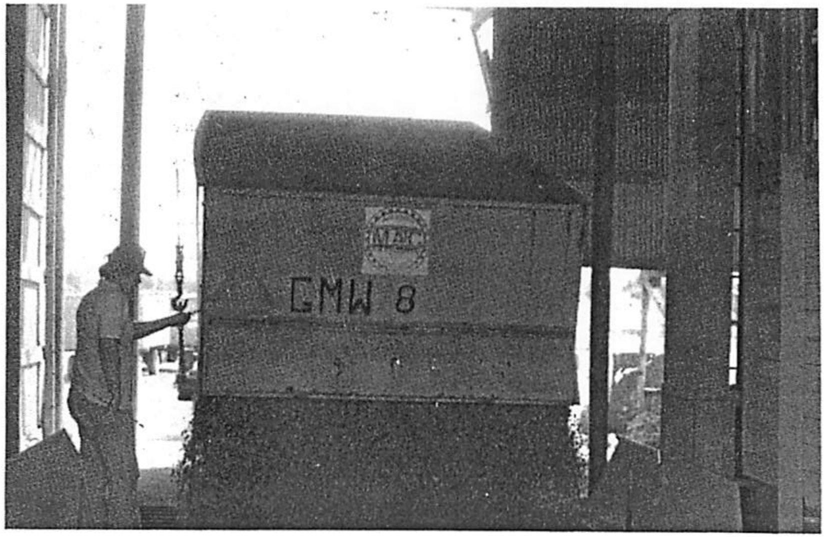


Fig. 7. Farmers stock warehouse showing the receiving and dump pit area.

veyor and bucket elevator should be designed to handle the desired flow rates using a maximum belt speed of 61 m/min. The conveyor should handle slightly more than the elevator to prevent "backlegging." Peanuts should be directed into the center of the second or third cup from the bottom to prevent "dipping" that will result in additional pod and seed damage. Allowances should be made for peanut size and presence of foreign material. Effects of foreign material on handling generally require manual monitoring and operation of the discharge gate to the elevator to provide a consistent and acceptable flowrate.

In the warm climates, peanuts are sometimes sprayed with insecticide as they enter storage. This procedure and other types of insect control used during storage are discussed in Chapter 14. The formulation of the insecticide (malathion) approved for spraying peanuts contains xylene (an industrial solvent), a very corrosive material. Use of the insecticide at storage facilities results in the rapid deterioration of the bucket elevator and overhead conveyor. Manual operation of the spraying system is common, and human error and equipment malfunctions often result in improper application, which produces serious quality problems that will be discussed later. Several new automated insecticide application systems have been developed that minimize corrosion and quality problems (Smith et al., 1981). Authorities in Australia and Texas have approved the application of malathion without xylene on peanuts.

In most farmers stock warehouses, ventilation and/or aeration systems are used to help maintain the quality of the peanuts. These systems remove excessive heat and moisture, equalize peanut moisture content and temperature throughout the mass of stored peanuts and reduce the differences between ambient and peanut temperatures (Woodward and Blankenship, 1974; Ghaly, 1978). The goal is to keep the conditions of the air in the pile of peanuts within the limits outlined on the psychrometric chart in Figure 8 and to prevent mois-

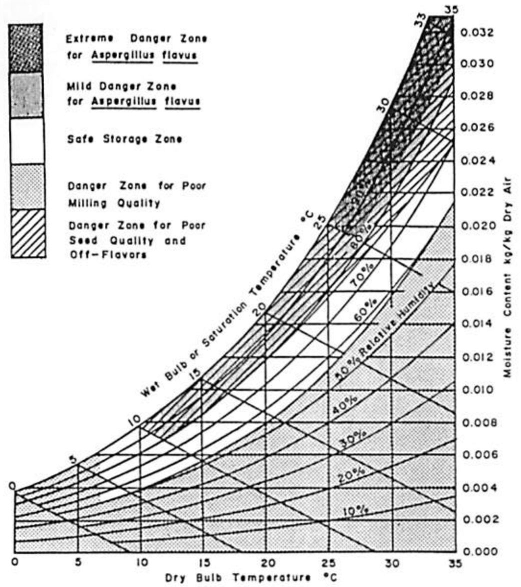


Fig. 8. Psychrometric chart indicating desirable and undesirable storage conditions for farmers stock peanuts.

ture migration and condensation inside the storage structure.

The moisture content of individual peanut pods when they are placed in storage will normally range between 5 and 15% w.b. The temperature of the peanuts as they enter storage generally ranges from 21 to 35 C. After a period of equalization, the temperature and relative humidity of the air within a pile of peanuts will correspond to the temperature and hygroscopic equilibrium moisture content of the peanuts and foreign material (Figure 9). The seed may transfer moisture to the hull resulting in a small amount of shrinkage and a loss of grade may occur during storage (Slay and Hutchison, 1972; Brown and Steele, 1973; Person, 1974). The greatest change in grade occurs during the first 5 days of storage.

During the early part of the storage season, the air temperature and relative humidities surrounding the peanuts are much higher than ideal. Peanut seed moisture contents greater than 7.5% w.b. and peanut temperatures above 10 C are undesirable, and a high potential for production of aflatoxin exists under these conditions. Primary sources of excess heat include the heat in the material as it was placed in storage, the heat of respiration of biologically active material including molds and insects, and solar radiation received by the storage structure. Primary sources of excess moisture are the peanuts themselves, foreign material, insecticide sprays, leaks, and condensation. Smith and Davidson (1980) and Davidson et al. (1980) have discussed in detail these moisture and heat sources and the effects of these variables on the storage environments. Estimates of the major sources of heat and moisture for a typical warehouse are shown in Table 6.

Airflow over and through the mass of peanuts during the first part of the season is needed to remove excess moisture, to reduce peanut temperature, and to

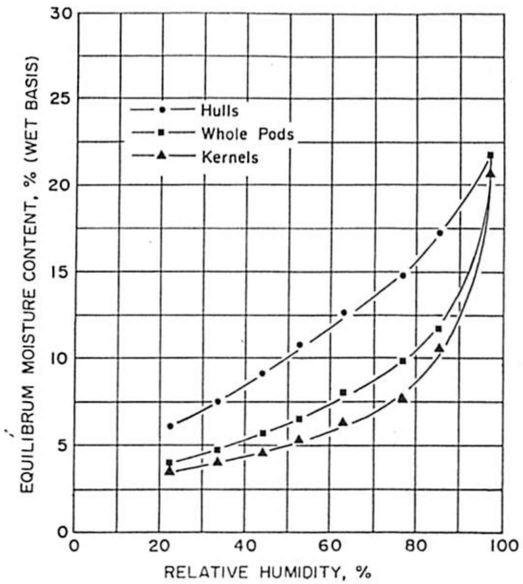


Fig. 9. Hygroscopic equilibrium of peanut components at 32 C. (Reproduced from North Carolina State Technical Bulletin No. 155, Beasley and Dickens, 1963).

Table 6. Estimates of excess heat and moisture that must be removed from a typical flat storage warehouse.

Source	Estimate of excess moisture[1]		Estimate of excess heat[2]	
	Kg/gross tonne	Liters/3000 tonne warehouse	KJ/gross tonne	KJ/3000 tonne warehouse
Peanuts	13.63	40,890	50,476	151,430,400
Foreign material	2.64	7,920	2,103	6,309,600
Insecticide application	1.48	4,440		

[1]Estimate does not include moisture from leaks or outside air. Moisture from these sources will be small if good storage practices are used.

[2]Estimate does not include solar heat gain and heat of respiration that must also be removed. Solar heat gain during the mid-afternoon in the southeast USA is estimated to be approximately 408.6 KJ/m²/hr. Heat of respiration is estimated to be very small in peanuts with seed moisture contents less than 8% wet basis.

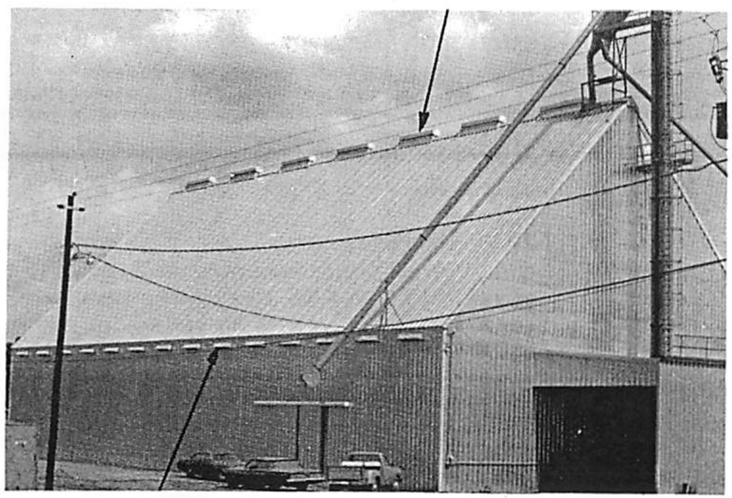
prevent moisture migration by reducing temperature and moisture variations throughout the peanut mass. Warm moist air rising from a pile of peanuts can reach its dew point and condense if not exhausted before it contacts a cool surface. Condensation can result in mold growth over the entire surface of the pile of peanuts. Condensation drip from the warehouse structure can cause the formation of molded clumps of peanuts (sometimes referred to as "soldiers"). During the first part of the storage season, overspace ventilation fans are operated continuously except during fumigation, short periods for applying insecticide, or long periods (24 hours) of humid weather (above 90%rh). Aeration systems are usually operated when the air drawn into the mass of peanuts is at least 5 C cooler than the peanut temperature and when the ambient relative humidity is 50-80%. After the peanuts have been cooled, the time of aeration is controlled to avoid overdrying the peanuts.

During the middle of the storage season, temperatures are usually lower than ideal and humidities generally average near ideal except in very arid climates such as parts of the southwest USA. After excessive heat and moisture problems (except for leaks) have subsided, the ventilation and/or aeration systems are operated only to maintain the desired psychrometric conditions. Temperatures lower than ideal for shelling are desirable if the peanuts will not be shelled until the last part of the storage season. Primary goals during this time are to remove the radiated solar heat and to maintain the proper peanut temperature and moisture content.

Conditions during the last part of the storage season are usually similar to those during mid-season with some exceptions. Condensation problems may develop because of the warm moist outside air coming in contact with the cool peanuts. The best procedure during a warming trend is to operate the ventilation and/or aeration systems to maintain the peanut temperature slightly below (0 to 8 C) the average daily temperature. Insect problems can develop very quickly as the weather warms and the insects become more active.

Overspace ventilation systems either consist of natural ventilation or forced draft (mechanical) ventilation. Natural ventilation (Figure 10) is normally provided by eaves and ridge vents (or louvered vents inside of a conveyor house). Vent area and draft (difference in height of ridge and eaves vents) are as large as possible to provide a high rate of ventilation. Warehouses with a roof slope less than 45 degrees do not provide sufficient draft. Muscogee and conveyor house type designs provide for maximum draft. Vents must be kept free of obstruction and peanuts must not be piled against the vents. Natural ventilation systems are low cost, usually maintenance free, and require no mechanical or electrical energy for operation. All dead air pockets may not be eliminated with natural ventilation and some types of vents are difficult to seal when fumigating the warehouse for insect control.

Air out ridge vents



Air in eave vents

Fig. 10. Natural ventilation in a typical peanut flat storage warehouse.

Mechanical ventilation (Figure 11) is normally provided by propeller-type fans that provide at least 1 air change every 3 minutes in the overspace when operating at a free static pressure of 0.63 cm of water. (A higher rate of ventilation is usually needed for small warehouses than for large ones.) When possible, fans should be installed on the end away from the prevailing winds to take advantage of the wind pressure. Large inlet louvers are installed on the opposite end of the warehouse to allow sufficient air to enter the building at velocities less than 152.4 m/min. Mechanical ventilation usually eliminates dead air spaces in the overspace but requires maintenance and close supervision to insure proper operation. Failure of a mechanical ventilation system at a critical time (e.g., sudden drop in ambient temperature during the first part of the storage season) will result in serious condensation and mold problems. Partitions extended to the roof inside the warehouse restrict air movement in the overspace and result in serious problems with obtaining sufficient ventilation with mechanical ventilation systems. The upper portion of these partitions must be removed or sufficient natural ventilation provided to eliminate this problem. Overspace mechanical ventilation systems may be controlled manually or automatically (by a time clock and/or thermostat).

Aeration systems are normally designed to move air down through the peanuts to prevent condensation in the overspace. Current designs utilize airflow rates of 0.1 m^3/min of air per m^3 of storage. At this flow rate, pressure loss of air passing through the peanuts is usually very small ($<$ 0.4 kg/m^2 per m depth of peanuts) and the pressure losses will be influenced more by the design of the air ducts rather than by the peanuts. Both ventilation and aeration systems should be interlocked with insecticide application systems, but shutdown periods for the ventilation and aeration systems should be kept to a minimum. Aeration systems normally consist of perforated steel corrugated ducts connected to centrifugal fans. The fans are located outside the warehouse. The ducts are often damaged by front end loaders unloading the warehouses. This damage can be

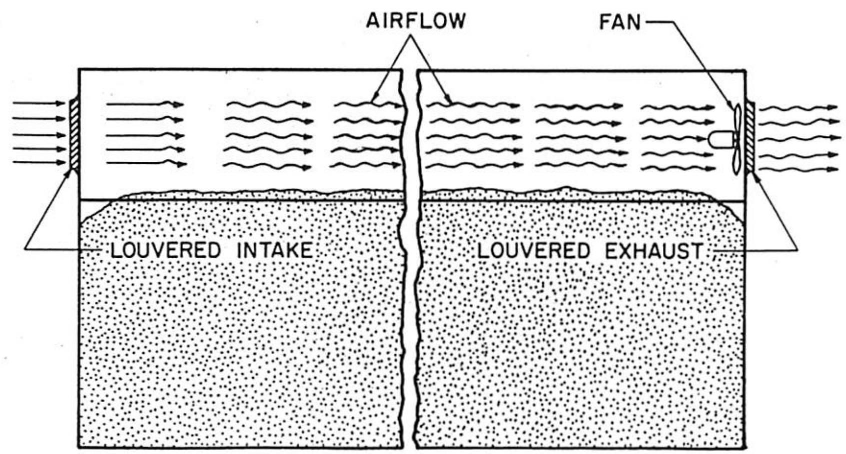


Fig. 11. Schematic showing a typical mechanical ventilation system installed in a farmers stock peanut warehouse.

minimized by painting danger zones on the floor around the duct to warn the driver and by installing flexible connections (Figure 12) to allow the duct to shift and avoid direct impact by the front end loaders. In new warehouses, under the floor ducts and unloading systems are often installed to provide aeration and more efficient loading and unloading. Strong removable floor grating is required to withstand the weight of the unloading machinery and to provide a means for cleaning out the ducts. Under floor ducts are spaced to avoid placement in front of doorways or in other areas where the grating will receive heavy traffic or be subjected to rotational forces (e.g., maneuvering point for front end loaders).

SAMPLING AND GRADING FARMERS STOCK PEANUTS

Grade factors for farmers stock peanuts have been established by the United States Department of Agriculture (USDA) and are used in the establishment of grades for price support purposes. Producers and commercial buyers of peanuts use the grades as guidelines for trading. Peanuts are graded by the Federal-State Inspection Service, which is supervised by USDA. Four types of peanuts are marketed in the United States: virginia, runner, spanish, and valencia type. Each type of peanut has slightly different grade requirements. A detailed discussion of the grade procedures and grade requirements are available from the USDA (USDA, 1963). Descriptions of the pneumatic sampler (Dickens, 1962a, 1964), the sheller and presizer (Dickens, 1962b), and the seed splitter and inspection belt (Dickens, 1961) which are used in peanut grading are available.

The grading procedure for farmers stock peanuts is summarized in Table 7. Most farmers stock peanuts are handled in bulk from the time they are harvested from the field through marketing and storage. When a lot of peanuts arrives

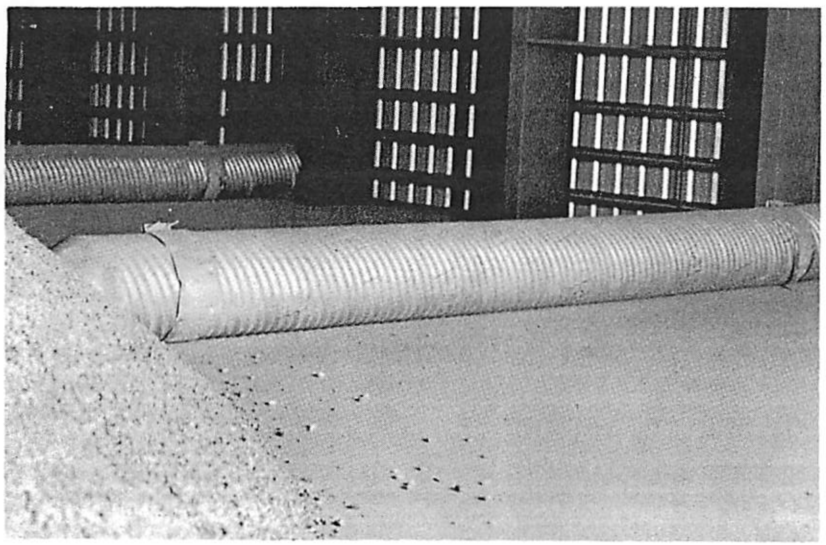


Fig. 12. Aeration ducts with flexible connections.

Table 7. Summary of grade procedures for farmers stock peanuts.

Sample Description and Procedure	Grade Factor	Grading Equipment[1]
Approximately 2-kg sample from lot. Includes in-shell peanuts, shelled seed and other material (foreign material). Take sample with pneumatic sampler. Separate in-shell peanuts, shelled seed and foreign material with sample cleaner.	% Foreign material = % FM = (wt. foreign material/wt. sample)100 % Loose shelled kernels = % LSK = (wt. shelled kernels/wt. sample)100	Peanut sampler Sample divider Sample cleaner
500-g sample of in-shell peanuts.[6] Process sample through presizing, shelling, moisture measurement, screening for size, visual examination for external damage, splitting, and visual examination for concealed damage.	% Fancy pods = (wt. pods over 17/32" roller/500)100[2] % Damage = (wt. damaged kernels/500)100 % Sound mature kernels = % SMK = ((wt. mature ker.-wt. damaged ker.)/500)100[3] % Extra large kernels = % ELK = (wt. SMK that ride 21.5/64" screen/500)100 % Moisture as determined by instrument[5]	Presizer Sampler sheller Moisture meter[4] Screen shaker Grading screens Kernel splitter and inspection belt

[1]Except for the moisture meter, all of the grading equipment may be purchased through Georgia Federal-State Inspection Service, P. O. Box 3050, Albany, GA 31706.
[2]Lots of peanuts with more than 40% fancy are graded as virginia type.
[3]Kernels which ride the designated screen openings are mature kernels: runner type over 16/64" x 3/4", spanish type over 15/64" x 3/4", valencia type over 15/64" x 3/4" and virginia type over 15/64" x 1".
[4]Steinlite Model PT2 Moisture Tester, Seedburo Equipment Co., 1022 Jackson Rd., Chicago, IL 60607.
[5]Except for seed peanuts, the moisture must be less than 10.5% moisture.
[6]500-g sample for lot sizes of 9080 kg or less and 1000-g sample for lot sizes greater than 9080 kg.

at market, it is sampled with a pneumatic sampler which takes cores 10 cm in diameter from top to bottom of the lot. The cores are taken at random locations throughout the farmers lot. The number of cores taken depends on the size of the lot. For lots up to and including 5,443 kg, 5 cores are taken. For lot sizes of 5,443 to 9,071 kg, 9,071 to 13,608 kg, and over 13,608 kg, 8, 10, and 16 cores are taken, respectively. Regardless of the number of cores taken, the material from all the cores is blended and subdivided so that about 2 kg of sample is taken for grade analysis.

The 2-kg grade sample is passed through a cleaner which separates the sample into foreign material, LSK, and inshell peanuts. The % LSK and foreign material is determined from this 2-kg grade sample. A 500-g sample of the cleaned inshell peanuts is processed by a presizer which separates the pods into 3 size categories by passing them over precisely spaced counter-rotating rollers. In the case of virginia type peanuts, those pods which pass over rollers spaced 13.49 mm (17/32 in.) apart are classed as Fancy size for grade purposes.

After presizing, the pods in each of the 3 size categories are shelled in a separate compartment of a 3-compartment sample sheller. The moisture content of a 250-g sample of the seed is measured with an electronic moisture tester. The seed are sized with screens which have the following openings: 6.35 x

19.05 mm (16/64 x 3/4 in.) for runner type mature seed, 5.95 mm x 19.05 mm (15/64 x 3/4 in.) for spanish type and valencia type mature seed, 5.95 mm x 25.40 mm (15/64 x 1 in.) for virginia type mature seed, and 8.53 mm x 24.40 mm (21.5/64 x 1 in.) for virginia type extra large seed. During the sizing operation, the screens are reciprocated by the cam action of a specially designed screen shaker. For peanut grading purposes "mature" refers to the size of seed rather than physiological maturity.

The whole seed and small, broken pieces of seed (less than 1/4 seed) that pass the designated screens are called "other kernels." The whole seed that ride the screen and split seed which pass the screen are examined for damage. The whole mature seed are passed through a seed splitter which breaks the cotyledons apart by impact, orients the cotyledons with the flat or inner surfaces exposed for visual examination and then inverts the cotyledons for inspection of their rounded or outer surfaces. When the large seed are split, the testae (skins) are usually removed from cotyledons so that discoloration beneath the skins is exposed. Seed or cotyledons with discoloration, mold, insect damage, sprouts or other defects are designated damaged seed. Concealed damage is that damage which is not visible until the seed it split. The mature seed without damage are designated "sound mature kernels" (SMK). The undamaged split seed are called "sound splits" (SS).

The grade results for a load of farmers stock peanuts are reported on MQ-94. An example of this form showing the grade results and price computations for a lot of virginia type peanuts is shown in Figure 13. Grade data and price information are obtained from a Peanut Loan Schedule (Figure 14). Grade factors are compiled by the Agricultural Stabilization Service of the USDA. Some av-

SECTION I - INSPECTION CERTIFICATE - FARMER STOCK PEANUTS

This certificate is issued pursuant to the Agricultural Marketing Act of 1946, as amended (7 U.S.C. 1621 et seq.) and is admissible as prima facie evidence in all courts of the United States. Any person who knowingly shall falsely make, issue, alter, forge, or counterfeit this certificate or participate in any such actions is subject to a fine of not more than $1,000.00, imprisonment for not more than 1 year, or both.

WEIGHT TICKET NO.: 0000001

INSPECTION MEMO NO. (FVQ-93) | OUT-GRADE ☐ | RESALE ☐ | VEHICLE NO.: AP-1

NO. BAGS | BULK: X | TYPE: V | SEGREGATION: 1 | CROP YEAR: 81 | TIME: PM 2:00

SMK 63 % + SOUND SPLITS 3 % = 66 %

Other Kernels 3 %

VISIBLE 1 % + CONCEALED 0 % = DAMAGE 1 %

Total Kernels 70 %

Hulls 30 %

Total Kernels and Hulls (Excluding LSK) 100 %

CONCEALED RMD 0.00 % | FOREIGN MATERIAL 5 %

FREEZE DAMAGE 0.00 % | LSK 4 %

A. FLAVUS NOT FOUND ☒ | A. FLAVUS FOUND (Seg. 3) ☐ | MOISTURE 10 %

REMARKS | FANCY 72 %

ELK 35 %

I, the undersigned, a duly authorized inspector of the United States Department of Agriculture, do hereby certify that at the request of the applicant and on the date indicated, samples of the above described products were inspected and the quality and/or condition as shown by said samples were as herein stated.

SIGNATURE OF INSPECTOR: J. Inspector | DATE: 10-20-81

WAREHOUSE DESCRIPTION AND BIN NO.: 000 - 111

DELIVERY POINT, IF NOT SAME AS WAREHOUSE

TYPE OF STORAGE | CONVERTED PENALTY RATE | PENALTY

SECTION II - SETTLEMENT SHEET

A.	Weight Including Vehicle	10720 Lbs.
B.	Weight of Vehicle	5990 Lbs.
C.	Gross Weight (A minus B)	4730 Lbs.
D.	Foreign Material (% of FM x C)	237 Lbs.
E.	Weight Less FM (C minus D)	4493 Lbs.
F.	Excess Moisture (% of EM x E)	90 Lbs.
G.	Net Weight (E minus F)	4403 Lbs.
H.	LSK (% of LSK x C)	189 Lbs.
I.	Net Weight Excluding LSK (G minus H)	4214 Lbs.
J.	Kernel Value Per Lb. (Excluding LSK)	21.72 ¢
K.	ELK Premium	0.79 ¢
L.	Total (J + K)	22.51 ¢
M.	DAMAGE — ¢ + EXCESS FM .05 ¢ + EXCESS SPLITS — ¢ = TOTAL	.05 ¢
N.	Net Value Per Pound Excluding LSK (L minus M)	22.46 ¢
O.	Value Per Pound Including LSK: N x I = $ 946.46; H x 7 ¢ = $ 13.23; TOTAL $ 959.69 ÷ G =	21.7963 ¢

Fig. 13. USDA form FBQ-95 where grade results are reported.

CENTS PER POUND VALUES (Line J) based on 0.3259 cents ($0.003259) per percent SMK and SS and 0.07 cents ($0.0007) per percent other kernels

(ELK Premium)**

% ELK	Premium Per Pound
50	1.13
49	1.10
48	1.08
47	1.06
46	1.04
45	1.01
44	.99
43	.97
42	.95
41	.92
40	.90
39	.88
38	.86
37	.83
36	.81
35	.79
34	.77
33	.74
32	.72
31	.70
30	.68
29	.65
28	.63
27	.61
26	.59
25	.56
24	.54
23	.52
22	.50
21	.47
20	.45
19	.43
18	.41
17	.38
16	.36

For lots with less than 16% ELK or more than 50% ELK, calculate the premium at 0.0225¢ ($0.000225) per pound per percent ELK. No premium if damage exceeds 4%.

Total % SMK & SS	PERCENT OF OTHER KERNELS: NONE	1	2	3	4	5	6	7	8	9	10	11	12
78	25.42	25.49	25.56	25.63	25.70	25.77	25.84	25.91	25.98	26.05	26.12	26.19	26.26
77	25.09	25.16	25.23	25.30	25.37	25.44	25.51	25.58	25.65	25.72	25.79	25.86	25.93
76	24.77	24.84	24.91	24.98	25.05	25.12	25.19	25.26	25.33	25.40	25.47	25.54	25.61
75	24.44	24.51	24.58	24.65	24.72	24.79	24.86	24.93	25.00	25.07	25.14	25.21	25.28
74	24.12	24.19	24.26	24.33	24.40	24.47	24.54	24.61	24.68	24.75	24.82	24.89	24.96
73	23.79	23.86	23.93	24.00	24.07	24.14	24.21	24.28	24.35	24.42	24.49	24.56	24.63
72	23.46	23.53	23.60	23.67	23.74	23.81	23.88	23.95	24.02	24.09	24.16	24.23	24.30
71	23.14	23.21	23.28	23.35	23.42	23.49	23.56	23.63	23.70	23.77	23.84	23.91	23.98
70	22.81	22.88	22.95	23.02	23.09	23.16	23.23	23.30	23.37	23.44	23.51	23.58	23.65
69	22.49	22.56	22.63	22.70	22.77	22.84	22.91	22.98	23.05	23.12	23.19	23.26	23.33
68	22.16	22.23	22.30	22.37	22.44	22.51	22.58	22.65	22.72	22.79	22.86	22.93	23.00
67	21.84	21.91	21.98	22.05	22.12	22.19	22.26	22.33	22.40	22.47	22.54	22.61	22.68
66	21.51	21.58	21.65	21.72	21.79	21.86	21.93	22.00	22.07	22.14	22.21	22.28	22.35
65	21.18	21.25	21.32	21.39	21.46	21.53	21.60	21.67	21.74	21.81	21.88	21.95	22.02
64	20.86	20.93	21.00	21.07	21.14	21.21	21.28	21.35	21.42	21.49	21.56	21.63	21.70
63	20.53	20.60	20.67	20.74	20.81	20.88	20.95	21.02	21.09	21.16	21.23	21.30	21.37
62	20.21	20.28	20.35	20.42	20.49	20.56	20.63	20.70	20.77	20.84	20.91	20.98	21.05
61	19.88	19.95	20.02	20.09	20.16	20.23	20.30	20.37	20.44	20.51	20.58	20.65	20.72
60	19.56	19.62	19.69	19.76	19.83	19.90	19.97	20.04	20.11	20.18	20.25	20.32	20.39
59	19.23	19.30	19.37	19.44	19.51	19.58	19.65	19.72	19.79	19.86	19.93	20.00	20.07
58	18.90	18.97	19.04	19.11	19.18	19.25	19.32	19.39	19.46	19.53	19.60	19.67	19.74
57	18.58	18.65	18.72	18.79	18.86	18.93	19.00	19.07	19.14	19.21	19.28	19.35	19.42
56	18.25	18.32	18.39	18.46	18.53	18.60	18.67	18.74	18.81	18.88	18.95	19.02	19.09
55	17.92	17.99	18.06	18.13	18.20	18.27	18.34	18.41	18.48	18.55	18.62	18.69	18.76
54	17.60	17.67	17.74	17.81	17.88	17.95	18.02	18.09	18.16	18.23	18.30	18.37	18.44
53	17.27	17.34	17.41	17.48	17.55	17.62	17.69	17.76	17.83	17.90	17.97	18.04	18.11
52	16.95	17.02	17.09	17.16	17.23	17.30	17.37	17.44	17.51	17.58	17.65	17.72	17.79

DEDUCTIONS

LINE 1 (Tax)

N. C. and Va. Excise Tax: $1.00 per ton (0.0005 per pound) net weight. Multiply pounds in Item P or S (Loan) by $0.0005 and enter Results on Line 1 (Tax) in appropriate Item P or S (Loan).

S. C. Excise Tax: $2.00 per ton ($0.0010 per pound) net weight. Multiply pounds in Item P or S (Loan) by $0.0010 and enter Results on Line 1 (Tax) in appropriate Item P or S (Loan).

LINE J (Deduct the following, if applicable, from the kernel value otherwise determined for this line)

MIXED TYPES, CONTAINING LESS THAN 90% OF ANY ONE TYPE: Use the Peanut Loan Schedule for the lower of the types making the 0.50 cent deduction for mixed types required by that schedule.

LOCATION

Missouri	0.50
Tennessee	1.25

LINE M

DAMAGE

1%	None
2%	0.17*
3%	.35
4%	.65
5%	1.25
6%	2.00
7%	3.00
8-9%	4.00
10% and over	5.00

FOREIGN MATERIAL

1-4%	None
5%	0.05*
6%	.10
7%	.15
8%	.20
9%	.25
10%	.30
11%	.35
12%	.425
13%	.50
14%	.575
15%	.65

and for each percent above 15 deduct an additional 0.10*

SOUND SPLITS

1-4%	None
5%	0.04*
6%	.08
7%	.12
8%	.16
9%	.20
10%	.24

and for each percent over 10 deduct an additional 0.04*

OTHER VALUES

LOOSE SHELLED KERNEL VALUE (Line O): 7 cents per pound

Peanuts with quality factors outside the range of the table: Calculate the kernel value per pound for Line J by adding the products of the percent SMK plus SS times 0.3259 cents and the percent OK times 0.07 cents. For example, if SMK and SS total 51% and OK is 14%, the calculation is (51 times 0.3259 cents) plus (14 times 0.07 cents) or 17.60 cents.

Minimum loan value of any lot is 8 cents per pound of kernels in the lot. To calculate multiply the net weight excluding LSK (Line I) by the sum of the percentages of SMK, SS, OK, and DK. Add the result to the pounds of LSK (Line H) and multiply by $0.08. Enter in appropriate Item P or S (Loan) the larger of the amounts determined by this calculation or determined from the schedule.

*Based on the following average quality ton quota support levels: National $456.00, Virginia type $451.60

**No premium for extra large kernels shall be applicable to any lot containing more than 4 percent damaged kernels.

***The 54.96 percentage was computed by dividing the national average support rate for quota peanuts ($456.00 per ton) into the national average support rate for additional peanuts ($250.00 per ton).

Fig. 14. Peanut loan schedule for virginia type peanuts.

Table 8. Some average grade data[1] for runner type peanuts.

Grade factor[2]	Crop year 1976 - 1978: 1976	1977	1978	Average
Sound mature kernels (SMK)	68.80	67.49	70.38	68.89
Sound splits (SS)	4.35	4.48	2.84	3.89
SMK + SS	73.15	71.97	73.22	72.78
Other kernels	5.19	5.54	4.72	5.15
Damaged kernels	0.74	0.57	0.50	0.60
Loose shelled kernels (LSK)	5.38	4.55	3.81	4.58
Seed moisture	8.67	8.87	8.87	8.80
Foreign material	4.11	4.19	3.64	3.98

[1]Information copied from USDA, Agricultural Stabilization and Conservation Service report.
[2]All values are reported in percentages.

erage grade factors for crop years 1976, 1977 and 1978 are presented in Table 8 for runner type peanuts.

A provision of the USDA Peanut Marketing Agreement (Peanut Administrative Committee, 1978) requires that all of the seed from each sample of farmers stock peanuts be examined for visible growth of the aflatoxin-producing mold *Aspergillus flavus* (Dickens, 1977). Lots found to contain seed with visible *A. flavus* growth are classified Segregation III. Lots with none of these seed but with more than 2% damaged seed or more than 1% concealed damage caused by rancidity, mold or decay are designated Segregation II peanuts. All other peanuts are designated Segregation I.

Under special arrangements, when peanuts are in short supply, Segregation II peanuts may be processed for edible purposes if the shelled peanuts meet grade regulations and pass aflatoxin tests. Essentially all Segregation III peanuts are processed for oil stock and the meal is restricted to fertilizer and other nonfeed uses. Segregation II and Segregation III peanuts may be processed for seed or oil stock, but they usually are processed for oil.

PEANUT MILLING (SHELLING)

The peanut milling process encompasses many operations that may include precleaning, presizing, shelling, separation, sorting, seed treatment, handling, and packaging. The types of operations needed will depend upon the intended use of the peanuts. The 3 primary uses of peanuts are for food (inshell

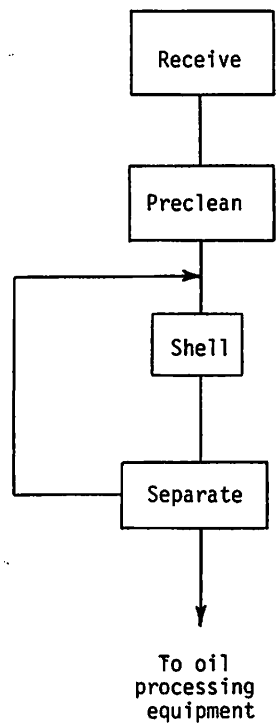


Fig. 15. Primary operations when shelling peanuts for oil processing.

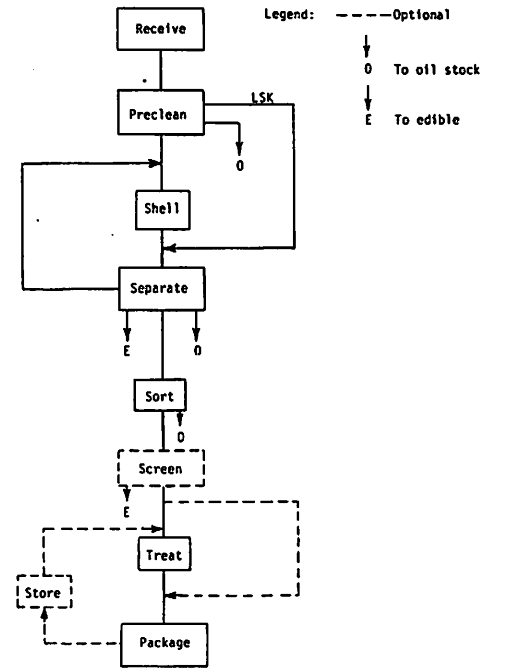


Fig. 16. Primary operations when shelling peanuts for seed.

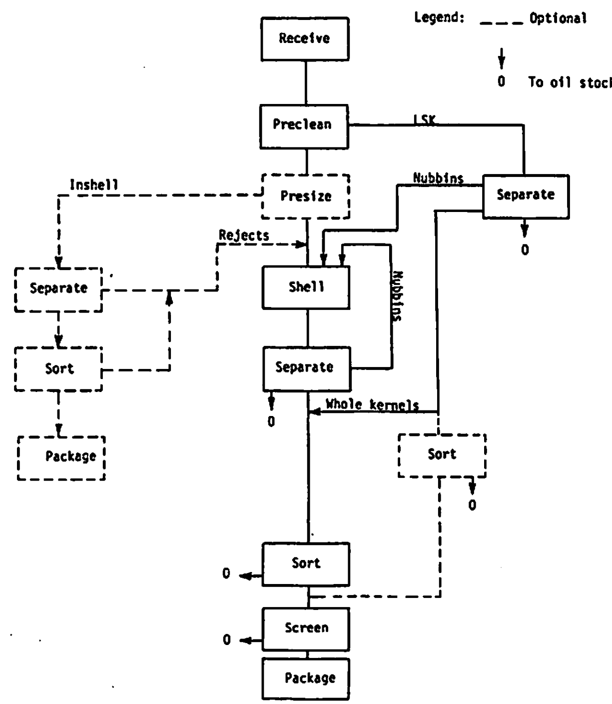


Fig. 17. Primary operations when shelling peanuts for edible markets.

and shelled), seed and oil. Flow process charts of the major operations for each of these requirements are shown in Figures 15 through 17.

Except for seed stock, most Segregation I peanuts are processed for the edible market. Most of the Segregation I valencia type and about 35% of the Segregation I virginia type pods (large undamaged pods) are processed for the edible inshell market. The remaining small pods and large undamaged pods of the virginia type are processed for the edible shelled market. Split and small whole LSK, small broken seed pieces, small immature seed, and pickouts are diverted to the oil stock market.

There are several properties of peanuts which affect (a) the amount of seed damage caused by shelling (milling quality), (b) the rate that the peanuts can be shelled (shelling rate), (c) the % of the peanuts that are shelled in 1 pass through the mechanical sheller (shelling efficiency), (d) the efficiency of separating the various components produced by the shelling operation (separation efficiency), and (e) the rate that the various components can be separated (separation or sorting rate). In general, the variety of peanut, growing conditions, harvesting and curing treatments, and storage treatments affect the milling properties of peanuts.

Milling Quality

Although poorly defined, primary properties that affect milling quality include those properties that affect the strength and cohesiveness of the skin and cotyledons of the peanut seed. Those properties which affect the difficulty of removing the hull from the seed, and thus the amount of impact received by the seed during the shelling process, also affect milling quality. In addition, the amount of foreign material that enters the sheller along with the peanuts will affect the amount of seed damage caused by the shelling operation. Several investigators have published research findings relating physical properties of peanuts, drying treatment of peanuts, moisture content of peanuts at time of shelling, temperature of peanuts at time of shelling, and other factors to the amount of seed damage caused by peanut shelling (Beattie and Kushman, 1947; Beattie, 1949; Reed and Coppock, 1952; Beasley and Dickens, 1963; Woodward and Hutchison, 1972; Woodward, 1974; Glueck et al., 1977).

Each variety has its own characteristic shelling properties (Davidson et al., 1976a). Certain peanut varieties are more susceptible to skinning and splitting than other varieties. USA peanut varieties Starr, Argentine and Tamnut generally have poorer milling quality than Florunner and Florigiant. In the USA the physical and mechanical properties of each new cultivar are usually evaluated prior to its release for production. Typical evaluations have been reported by McIntosh (1971a), Davidson et al. (1973a), Hsi (1978) and Mozingo (1980). Davidson et al. (1978a) reported that digging date, harvesting date, and harvesting method affected the milling quality of Florunner peanuts. Other research by Dickens and Khalsa (1967) reported the effects of digging date, harvest date and windrow orientation on the milling quality of virginia type peanuts. Turner et al. (1967) reported that high impact for virginia type peanut pods increased the amount of split seed when the peanuts were subsequently shelled.

Davidson et al. (1970) used a sheller developed by McIntosh and Davidson

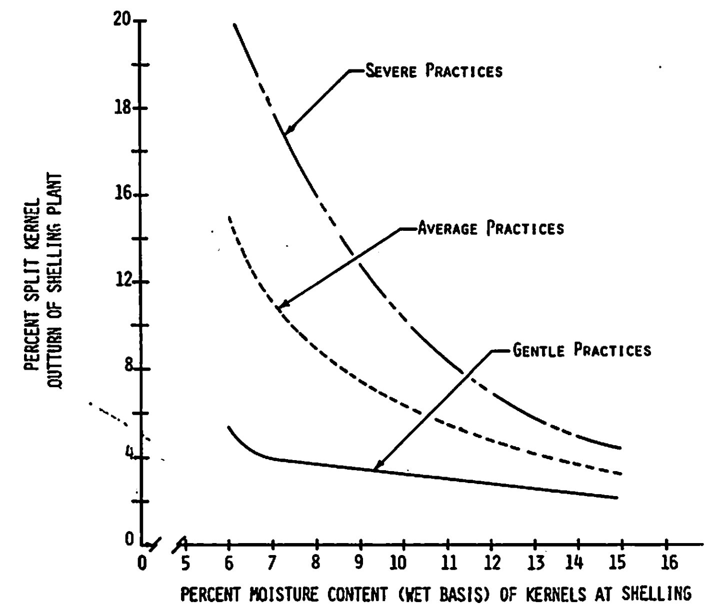


Fig. 18. Typical effect of mechanical harvesting and artificial drying practices on milling quality of peanuts.

(1971c) to investigate the effects of moisture and some harvesting and curing practices on milling quality. As shown in Figure 18, when peanuts were subjected to gentle harvesting and handling treatments and when the peanuts were dried slowly, there was little effect of moisture content on seed damage when the peanuts were shelled at kernel moisture contents above 7% w.b. When the peanuts were subjected to more impact during harvesting and handling, and when the peanuts were dried more rapidly, there was an effect of moisture content on shelling damage. For peanuts subjected to normal harvesting and curing treatments, less seed damage was found for peanuts shelled at a seed moisture content of about 14% w. b. than for peanuts at other moisture contents.

Several studies have been conducted to determine the effects on milling quality of restoring moisture prior to shelling. Both the aeration method investigated by Blankenship and Pearson (1975) and the wetting method investigated by Davidson et al. (1972) were relatively unsuccessful in restoring milling quality. Even though split seed outturns were often reduced, skinned seed outturns were increased by adding moisture back to the peanuts. The moisture conditioning methods also promoted excessive mold growth on the peanuts which may cause aflatoxin contamination. The best method for minimizing the effects of moisture loss on milling quality is to use gentle harvesting and curing practices and prevent overdrying during storage.

McIntosh and Davidson (1971b) investigated the effects of peanut temperature at time of shelling on milling quality, shelling rate and shelling efficiency for runner and spanish type peanuts. Seed damage was higher for peanuts shelled at 2 C than for peanuts at 18 C. Slay (1976) also found that impact damage to peanuts was generally higher for peanuts at 2 C than for peanuts at

18 C. Evidently the peanut hull and seed becomes more brittle at the lower temperature. Payne et al. (1970) found that insect infestation affects milling quality and milling loss. The amount of split seed and the amount of milling loss increased as the degree of insect infestation increased. Milling loss is the unaccountable loss of peanut materials during the shelling process.

Shelling Efficiency and Shelling Rate

The larger the difference between pod and seed thickness, the higher the shelling efficiencies. A large difference in thickness allows selection of sheller grates that will pass the largest seed, but shell most of the pods. Two types of pod thickness distribution have been found for commonly grown varieties. Starr, Tamnut and Florunner varieties have symmetrical type distributions, while some large pod varieties such as Florigiant have a double peak distribution. The logistic distribution described by Davidson et al. (1978b) adequately describes some symmetrical type pod thickness distributions. It also describes the seed thickness distributions for all varieties and cultivars evaluated by the National Peanut Research Laboratory and for a wide range of growing and harvesting conditions as reported by Williams et al. (1978).

In contrast to seed damage, shelling rate and shelling efficiency are higher for peanuts shelled at 2 C than for peanuts shelled at 18 C (McIntosh and Davidson, 1971b). Pod strength and shape (Figure 19) affect shelling rates and separation efficiencies. One-seeded pods are stronger and have lower shelling rates. One-seeded, tapered, and broken constricted pods have lower separation (specific gravity and screening) efficiencies than pods of other shapes. One-seeded, tapered, and broken constricted pods often escape into the finished shelled product. Tapered, odd, and constricted pods clog screens more frequently than normal or one-seeded pods. Many of the tapered pods are immature (raisins) and are very difficult to shell. Weathered pods are usually much weaker and have higher shelling rates than pods that were not exposed to inclement weather in the windrow. Hull thickness usually affects shelling rate and shelling efficiency. Varieties with thinner hulls (McIntosh and Davidson,

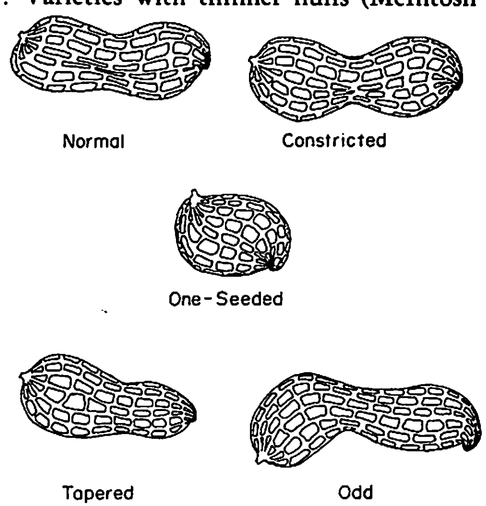


Fig. 19. Pod shape classifications for runner, spanish and virginia type peanuts.

1971a; Davidson et al., 1976a) usually have higher seed outturns, higher shelling rates and higher shelling efficiencies than thicker hull varieties.

Separation and Sorting

A large ratio of pod thickness to seed thickness increases the efficiency and rate of separating pods and shelled seed with screens. For inshell peanuts being sorted for the roasted inshell trade, pod color and damage affects sorting efficiency and rate of sorting. As the % of discolored and damaged pods increase, sorting rates must decrease to maintain acceptable sorting efficiencies. Discolored and damaged pods may result from pod disease, mold infestation, or weathering in the windrow.

Thickness, shape and length of seed greatly affect seed count per unit weight and screen selection for sizing seed. For example, the seed thickness distributions of Florunner and Florigiant are sometimes nearly equal, but the Florigiant seed are flatter and longer providing a much lower count per unit weight than Florunner. Varieties having minimum variation in pod and seed length, thickness and shape will also have uniform product appearance and count per unit weight. Davidson et al. (1976b) found that seed with widths 0.24 cm larger than seed thickness were noticeably flat. These flat seed were very difficult to separate from split seed, resulting in the loss of these seed and up to 15% of the split seed to lower shelled grades (other edibles or oil stock). Flatness appears to be a heritable trait. Flatness also appears to be affected by maturity, position on the peanut plant, and soil conditions. A greater degree of flatness appears to occur for more mature seed, seed in peanut pods that were grown wedged between a limb and taproot, and seed in pods grown in hard or compacted soil conditions.

A large difference between pod and seed specific gravities results in high separation efficiencies when removing unshelled from shelled peanuts. Large seeded varieties generally have a larger difference in pod and seed specific gravities than small seeded varieties.

Seed and skin color affect color sorting efficiency and rate. Some varieties or aged peanuts have dark skins. Seed damaged by mold, heat or moisture are discolored. Such peanuts with a high % of these seed require low sorting rates to obtain maximum separating efficiencies.

SAMPLING AND GRADING CLEANED INSHELL AND SHELLED PEANUTS

Standards

Standards have been established for shelled runner, spanish and virginia type peanuts and for cleaned virginia type peanuts in the shell (USDA, 1956, 1957a, 1957b, 1965). All valencia and a small quantity of runner type peanuts are cleaned and marketed in the shell, but standards have not been established for these 2 categories. The Southeastern Peanut Association has established additional specifications for shelled runner type peanuts. Descriptions of these specifications may be obtained from the Southeastern Peanut Association, P. O. Box 1746, Albany, GA 31702. A complete description of the procedures to be followed by the Federal-State Inspection Service in determining official USA grades has been published (USDA, 1974).

Shelled Peanuts

Commercial lots of shelled peanuts usually weigh between 9,070 and 90,700 kg. The peanuts may be handled in bulk, in large cartons weighing up to 907 kg each or in bags which weigh about 57 kg each. Sampling of shelled peanuts without splitting some of the seed and affecting their grade is difficult. Peanuts are usually sampled with in-line samplers (such as the one described by Slay, 1978) as the peanuts are packaged or loaded. Samples may be taken from bagged peanuts with a small trier by probing 1/4 of the bags in the lot.

Table 9. Summary of procedures and equipment used to grade shelled peanuts.

Grade Procedure	Equipment[1]
1. Take approximately 70 kg sample from lot. (65 kg for aflatoxin analysis and 4.5 kg for grade analysis.)	Spout sampler, scale sampler, or sample trier[2]
2. Blend sample and subdivide analytical sample of 1.0, 2.0, 2.5, 3.0, 3.5, or 4.0 kg.	Divider for shelled peanuts
3. Measure the moisture content of a 0.25 kg sample of seed from the analytical sample.	Moisture meter[3]
4. Weigh out and count the seed in a 0.9 kg sample to determine count/pound[5]	Electronic counter[4]
5. Screen the analytical sample over the prescribed screen (see Table 11).	Screen shaker Grading screens
6. Determine the splits, broken seed, defective seed, and other factors mentioned in Table 11.	
7. Split the seed open and inspect them for concealed damage.	Seed splitter and inspection belt

[1]Except where noted, the equipment may be purchased from the Georgia Federal-State Inspection Service, P. O. Box 3050, Albany, GA 31706.
[2]Spout sampler with 1 1/2" slot may be purchased from CEA Carter-Day, Minneapolis, MN 55418.
[3]Stienlite Model PT2 Moisture Tester, Seedburo Equipment Co., 1022 Jackson Rd., Chicago, IL 60607.
[4]Count may be made by hand or electronic counter. Counters are sold by The Old Mill Company, Savage Industrial Center, Savage, MD 20863.
[5]Count/lb. is only required for virginia type peanuts in U. S. Standards.

About 70 kg of peanuts are taken from each lot. As will be discussed in the next section, 64.3 kg are used for aflatoxin analysis. The weight of the sample analyzed for grade purposes ranges from 1 kg to 4 kg depending upon the size of the lot. Table 9 lists the procedures and equipment used to grade shelled peanuts. A summary of United States standard grades for the 3 types of raw shelled peanuts along with the appropriate tolerance is given in Table 10.

Testing Raw Shelled Peanuts for Aflatoxin

The USDA Peanut Marketing Agreement (Peanut Administrative Com-

Table 10. Summary of United States standard grades for shelled peanuts.

Grade Factors		U. S. virginia					U. S. spanish			U. S. runner		
Screen opening size that seed		Extra large	Medium	No. 1	No. 2	Splits	No. 1	No. 2	Splits	No. 1	No. 2	Splits
must ride	(inches)	20/64 x1	18/64 x1	15/64 x1	17/64 Round	20/64 Round	15/64 x 3/4	16/64 Round	16/64 Round	16/64 x 3/4	17/64 Round	17/64 Round
	(mm)	7.94 x 25.40	7.14 x 25.40	5.95 x 25.40	6.75 Round	7.94 Round	5.94 x 19.05	6.35 Round	6.35 Round	6.35 x 19.05	6.75 Round	6.75 Round
Tolerances (% of sample weight):												
Other types of peanuts[1]		0.75	1	1	2	2	1	2	2	1	2	2
Sound seed split or broken[2]		3	3	3	-	-	3	-	-	3	-	-
Damaged or unshelled seed[3]		1	1.25	1.25	-	-	1.5	-	-	1.5	-	-
Damaged or unshelled seed plus minor defects[4]		1.75	2	2	2.5	2	2	2.5	2	2	2.5	2
Foreign material[5]		0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.1	0.2	0.2
Sound whole seed which pass screen		3	3	3	-	-	2	-	-	3	-	2
Sound portions of seed which pass screen		-	-	-	-	-	-	6	2	-	-	-
Sound whole seed		-	-	-	-	-	-	-	4	-	6	4
Sound whole seed and portions which pass screen		-	-	-	6	3	-	-	-	-	-	-

[1]"Other types" refers to peanuts of distinctly different varieties. For example, spanish type should not be mixed with virginia type.
[2]"Split" means the separated cotyledon of a peanut seed. "Broken" means that more than 1/4 of the seed has been broken off.
[3]"Unshelled" means a peanut seed with part or all of the hull (shell) attached. "Damaged" means that the peanut seed is affected by 1 or more of the following: (a) rancidity or decay; (b) mold; (c) insects, worm cuts, web or frass; (d) freezing injury causing hard, translucent or discolored flesh; and (e) dirt when the surface of the seed is heavily smeared, thickly flecked or coated with dirt, seriously affecting its appearance.
[4]"Minor defects" means that the peanut seed is not damaged but is affected by 1 or more of the following: (a) skin discoloration which is dark brown, dark gray, dark blue or black and covers more than 1/4 of the surface; (b) flesh discoloration which is darker than a light yellow color or consists of more than a slight yellow pitting of the flesh; (c) sprout extending more than 1/8 of an inch from the tip of the seed; and (d) dirt when the surface of the seed is distinctly dirty and its appearance is materially affected.
[5]"Foreign material" means any substance other than peanut seed or peanut skins.

mittee, 1978) requires aflatoxin tests on all shelled peanuts sold for human consumption. The peanuts must be positive-lot identified and sampled by the Federal-State Inspection Service. The aflatoxin testing program is outlined in Table 11. One 21.8-kg sample is comminuted in a subsampling mill and a

Table 11. Aflatoxin testing program for shelled peanuts required by the USDA Peanut Marketing Agreement.

Step 1	Step 2	Step 3	Step 4	Step 5
Comminute 1st 21.8 kg sample in subsampling mill	Extract 1100-g subsample	Make duplicate analyses of extract (1A & 1B)	Let X = average of 1A and 1B	Accept if X ≤ 16 PPB Reject if X ≥ 75 PPB Go to Step 6 if: 16 PPB < X < 75 PPB
Step 6	**Step 7**	**Step 8**	**Step 9**	**Step 10**
Comminute 2nd 21.8 kg sample in subsampling mill	Extract 1100-g subsample	Make duplicate analyses of extract (2A & 2B)	Let Y = average of 1A, 1B, 2A, and 2B	Accept if Y ≤ 22 PPB Reject if Y ≥ 38 PPB Go to Step 11 if: 22 PPB < Y < 38 PPB
Step 11	**Step 12**	**Step 13**	**Step 14**	**Step 15**
Comminute 3rd 31.8 kg sample in subsampling mill	Extract 1100-g subsample	Make duplicate analyses of extract (3A & 3B)	Let Z = average of 1A, 1B, 2A, 2B, 3A, and 3B	Accept if Z ≤ 25 PPB Reject if Z > 25 PPB

1100-g subsample is sent to an approved laboratory (except for 2 independent laboratories, all approved laboratories are operated by federal or state government). The entire 1100-g subsample is extracted in 3000 mL methanol-water (55:45) and 1000 ml hexane or technical-grade petroleum ether. Duplicate 50-mL portions of the methanol-water extract are analyzed for aflatoxin by Method II of Association of Official Analytical Chemists (AOAC, 1975). The 2 independent determinations of aflatoxin concentration by thin layer chromatography (TLC) are averaged. If the average is 16 parts-per-billion (ppb) or less, an "aflatoxin-negative" certificate is issued and the lot is accepted. If the average is more than 75 ppb, the average concentration is shown on the certificate, and the lot is rejected. Otherwise, a 2nd, 21.8-kg sample is analyzed by the same procedure, and the 4 aflatoxin determinations from the 1st and 2nd, 21.8-kg samples are averaged. If the average is 22 ppb or less, an aflatoxin-negative certificate is issued. If the average is 38 ppb or more, the average concentration is shown on the certificate, and the lot is rejected. Otherwise, a 3rd, 21.8-kg sample is analyzed, and if the 6 determinations average 25 ppb or less, a negative certificate is issued. Otherwise, the average concentration is shown on the certificate and the lot is rejected. The results of all aflatoxin analyses are made available to the buyer of the peanuts.

A more detailed discussion of the sampling and testing program has been prepared by Dickens (1977). The procedure to be followed by the Federal-State Inspection Service in sampling and sample preparation for aflatoxin tests on peanuts and procedures to be followed in aflatoxin analyses on samples of peanuts have been published by the USDA (1974 and 1975).

Cleaned Inshell Peanuts

It is estimated that all valencia type (except seed stock), 35% of virginia

type, and a small fraction of runner type peanuts are cleaned and marketed in the shell. As mentioned earlier, United States standard grades exist only for cleaned inshell virginia type peanuts. However, these grade standards are used as guidelines when grading valencia and runner type peanuts in the shell. Therefore, only the sampling and grading of cleaned inshell virginia type peanuts will be discussed.

Samples are drawn from either a moving stream, such as a conveyor belt, by an approved automatic in-line sampler or by hand from burlap sacks. When sampling burlap sacks, the total sample must be cumulated by drawing small portions of peanuts from at least 10% of the sacks in the lot. For lot sizes up to 10,432; 45,359; 59,699; 68,039; 79,379; and 90,718 kg, a 1, 2, 2.5, 3, 3.5, and 4-kg sample is used, respectively, for grade analysis.

Once the sample has been obtained, a count per unit weight is estimated by averaging the number of pods in each of 4, 227-g samples. The peanuts are then screened. Virginia type peanuts in the shell can be graded as U. S. Jumbo or U. S. Fancy. U. S. Jumbo grade shall not pass through a screen having 14.7 x 76.2 mm (37/64 x 3 in.) perforations and not average more than 176 count per 454 g. U. S. Fancy grade shall not pass through a screen having 12.7 x 76.2 mm (32/64 x 3 in.) perforations and not average more than 225 count per 454 g. Valencia and runner type peanuts would be screened with different size perforations as specified by the buyer. After screening, the various grade factors would be determined. The grade factors for cleaned inshell Jumbo and Fancy virginia type peanuts are summarized in Table 12 along with the associated tolerances. The grade analysis for both shelled and cleaned inshell peanuts is reported on form FY-184 which is shown in Figure 20.

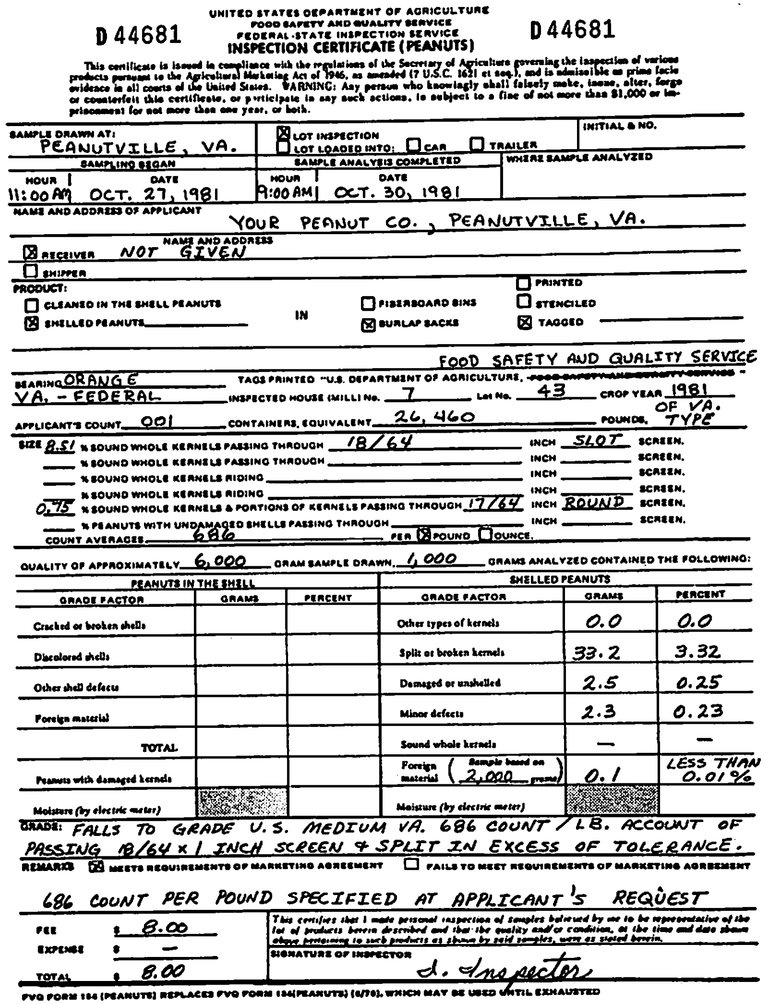
Table 12. Summary of United States standard grades for cleaned inshell Jumbo and Fancy virginia type peanuts.

Grade factor	Jumbo	Fancy
Screen size[1]	37/64" x 3"	32/64" x 3"
Count/pound[2]	176	225
Foreign material (maximum)	0.5%	0.5%
Defective shells[3]	10.0%	11.0%
Undersized peanuts with undamaged shells[4]	5.0%	5.0%
Damaged seed	3.5%	4.5%

[1]Must ride given screen size.
[2]Count/pound must not exceed given values.
[3]Includes pops, paper ends, discoloration (50% or hull surface discolored), undamaged loose shelled kernels, broken shells, etc.
[4]Peanuts that fall through screens with given size.

Aflatoxin Analyses on Cleaned Inshell Peanuts

Cleaned inshell peanuts are not required to be tested for aflatoxin unless the grade shows more than 1.0% seed damaged by mold. If an aflatoxin test is required, the Federal-State Inspection Service must take enough inshell samples to provide 3, 21.8-kg samples of shelled peanuts. The procedure for testing these samples is similar to the procedure outlined in Table 11.



UNITED STATES DEPARTMENT OF AGRICULTURE
FOOD SAFETY AND QUALITY SERVICE
FEDERAL-STATE INSPECTION SERVICE
INSPECTION CERTIFICATE (PEANUTS)

D 44681 D 44681

This certificate is issued in compliance with the regulations of the Secretary of Agriculture governing the inspection of various products pursuant to the Agricultural Marketing Act of 1946, as amended (7 U.S.C. 1621 et seq.), and is admissible as prima facie evidence in all courts of the United States. WARNING: Any person who knowingly shall falsely make, issue, alter, forge or counterfeit this certificate, or participate in any such actions, is subject to a fine of not more than $1,000 or imprisonment for not more than one year, or both.

SAMPLE DRAWN AT: PEANUTVILLE, VA. | [X] LOT INSPECTION | [ ] LOT LOADED INTO: [ ] CAR [ ] TRAILER | INITIAL & NO.

SAMPLING BEGAN: HOUR 11:00 AM DATE OCT. 27, 1981 | SAMPLE ANALYSIS COMPLETED: HOUR 9:00 AM DATE OCT. 30, 1981 | WHERE SAMPLE ANALYZED

NAME AND ADDRESS OF APPLICANT: YOUR PEANUT CO., PEANUTVILLE, VA.

NAME AND ADDRESS: [X] RECEIVER NOT GIVEN
[ ] SHIPPER

PRODUCT: [ ] CLEANED IN THE SHELL PEANUTS [X] SHELLED PEANUTS IN [ ] FIBERBOARD BINS [X] BURLAP SACKS [ ] PRINTED [ ] STENCILED [X] TAGGED

FOOD SAFETY AND QUALITY SERVICE

BEARING ORANGE VA. - FEDERAL TAGS PRINTED "U.S. DEPARTMENT OF AGRICULTURE, ~~FOOD SAFETY AND QUALITY SERVICE~~ - INSPECTED HOUSE (MILL) No. 7 Lot No. 43 CROP YEAR 1981

APPLICANT'S COUNT 001 CONTAINERS, EQUIVALENT 26,460 POUNDS, OF VA. TYPE

SIZE 8.51 % SOUND WHOLE KERNELS PASSING THROUGH 18/64 INCH SLOT SCREEN.
___ % SOUND WHOLE KERNELS PASSING THROUGH ___ INCH ___ SCREEN.
___ % SOUND WHOLE KERNELS RIDING ___ INCH ___ SCREEN.
___ % SOUND WHOLE KERNELS RIDING ___ INCH ___ SCREEN.
0.75 % SOUND WHOLE KERNELS & PORTIONS OF KERNELS PASSING THROUGH 17/64 INCH ROUND SCREEN.
___ % PEANUTS WITH UNDAMAGED SHELLS PASSING THROUGH ___ INCH ___ SCREEN.
COUNT AVERAGES 686 PER [X] POUND [ ] OUNCE.

QUALITY OF APPROXIMATELY 6,000 GRAM SAMPLE DRAWN, 1,000 GRAMS ANALYZED CONTAINED THE FOLLOWING:

PEANUTS IN THE SHELL			SHELLED PEANUTS		
GRADE FACTOR	GRAMS	PERCENT	GRADE FACTOR	GRAMS	PERCENT
Cracked or broken shells			Other types of kernels	0.0	0.0
Discolored shells			Split or broken kernels	33.2	3.32
Other shell defects			Damaged or unshelled	2.5	0.25
Foreign material			Minor defects	2.3	0.23
TOTAL			Sound whole kernels	—	—
Peanuts with damaged kernels			Foreign material (Sample based on 2,000 grams)	0.1	LESS THAN 0.01%
Moisture (by electric meter)			Moisture (by electric meter)		

GRADE: FALLS TO GRADE U.S. MEDIUM VA. 686 COUNT / LB. ACCOUNT OF PASSING 18/64 x 1 INCH SCREEN & SPLIT IN EXCESS OF TOLERANCE.

REMARKS [X] MEETS REQUIREMENTS OF MARKETING AGREEMENT [ ] FAILS TO MEET REQUIREMENTS OF MARKETING AGREEMENT

686 COUNT PER POUND SPECIFIED AT APPLICANT'S REQUEST

FEE $ 8.00
EXPENSE $ —
TOTAL $ 8.00

This certifies that I made personal inspection of samples believed by me to be representative of the lot of products herein described and that the quality and/or condition, at the time and date shown above pertaining to such products as shown by said samples, were as stated herein.

SIGNATURE OF INSPECTOR I. Inspector

FVG FORM 184 (PEANUTS) REPLACES FVG FORM 184(PEANUTS) (6/70), WHICH MAY BE USED UNTIL EXHAUSTED
MARCH 1969

Fig. 20. USDA form FV-184 showing grade analysis.

STORAGE OF RAW SHELLED PEANUTS

Shelling operations remove the hull (a natural barrier that protects the seed) and impart mechanical damage to the seed; thus shelled peanuts deteriorate more rapidly than unshelled peanuts. As with farmers stock, prestorage treatments are very important in obtaining acceptable storability of shelled peanuts (Vaughn, 1969; Baskin, 1970; Ketring, 1971). At peanut temperatures of 1 to 5 C and moisture contents of 7% w.b. or lower, good quality shelled peanuts of acceptable varieties can be stored for at least 1 year without significant loss in quality. At 6% moisture content w.b. and minus 18 C, good quality shelled seed stock of acceptable varieties can be stored from 2 to 10 years without significant loss in quality.

Unless a clean, cool dry storage environment is available, shelled peanuts are normally stored in commerical refrigerated-type storage 1 to 5 C and 55 to 70% rh. The primary considerations in refrigerated storage are to provide properly designed refrigeration units that will reduce the relative humidity of the air to the desirable range, provide an odor- and chemical-free environment, and maintain these conditions for all expected ranges of peanut moisture content. Peanuts will absorb chemicals such as ammonia and will absorb odors from such products as onions, garlic, cantaloupes, herb fruits, meat, cheese, and chocolate (Woolrich and Hallowell, 1970). Good air circulation patterns should be provided to remove excess heat and moisture during storage (Davidson et al., 1970). Several types of paper and cloth bags and bulk containers are acceptable (Bass, 1969; Clark, 1972). Polyethylene liners or bags tend to maintain the initial moisture content and should not be used unless the peanut moisture content is below 7.5% w.b. Peanut temperature even inside large containers or piles of bags will cool down to the desirable range within a few days. Myklestad (1968) determined the rates of cooling for shelled peanuts when stored in cold storage in a sealed container. He also developed relationships to describe the rate of cooling and to determine heat transfer coefficients.

Adequate insulation, vapor barriers and structural integrity of the building must be provided to eliminate problems with moisture, heat and rodents. Converting existing buildings to refrigerated storage is not usually recommended because of the difficulty in obtaining the critical storage conditions needed for preserving the quality of shelled peanuts.

Storage space required for shelled peanuts depends upon the bulk density, type of containers and stacking patterns. The bulk density of shelled peanuts normally ranges between 609 and 673 kg/m^3 depending on the size and grade of seed. The larger size and split seed have the lowest bulk densities. Bags (50 to 56.8 kg size) generally require less refrigerated storage cost than the 907 kg containers. However, the refrigerated storage cost per unit weight is about the same for the 2 methods because the additional handling cost of the bags offsets the savings in storage space. The 907-kg units are becoming very popular because of the ease of handling, shipping and storage. The Handling Committee of the National Peanut Council has been active in trying to standardize the configuration and specifications for the 907-kg containers.

The National Peanut Council has published a code of good practices for purchasing, handling, storage, sampling, processing, sanitation, and testing of raw shelled peanuts (Research Committee of the National Peanut Council, 1976). This publication emphasizes the use of good practices to prevent adulteration of peanuts by mold, rodents, insects, odors, and other contaminants. The publication indicates that peanuts removed from cold storage should be placed in a tempering room to allow them to reach ambient temperature before placing them in a rail car, truck or other transportation vehicle. Condensation and moisture migration problems associated with normal transportation of shelled peanuts appear to be minimal when the peanuts are kept sufficiently dry (kernel moisture content below 7.5% w.b.).

New methods of handling and storing peanuts are being developed. A reduction in the amount of energy required to store peanuts is needed. The peanut industry is showing considerable interest in bulk handling and storage of shelled peanuts. This method would make maximum use of the storage space and greatly reduce the cost of handling and storage. Mechanical damage imparted to the peanuts by impact and pressure forces is the major disadvantage of bulk handling and storage. Impact forces result from dropping peanuts (Slay, 1976). Pressure forces result from the weight of the peanuts. Myklestad (1968) and Silberstein and Rao (1977) have studied the deformation of the peanuts under pressure.

The use of low-oxygen and modified atmosphere handling and storage systems for shelled peanuts in lieu of refrigerated storage is being investigated (Pearson et al., 1977, 1978; Slay et al., 1978; Holaday et al., 1979; Slay, 1980). This method reduces energy, provides improvement in sanitation and minimizes problems with insects, mold, moisture loss, condensation, absorption of chemicals and odors, and mechanical damage. Penetration of sealed containers by rodents is possible, but no such incidents have been noted in several storage and shipping tests. Research is underway to develop low-oxygen handling, packaging and storage methods for small, 50-kilo and metric ton units. Development of methods for hopper cars and larger handling and storage units is also being considered.

DESIGN AND OPERATION OF PEANUT MILLS

General Considerations

Milling peanuts for seed and oil stock usually requires considerably fewer operations and less equipment and labor than for milling peanuts for edible use (Figures 15-17). However, milling peanuts for seed stock can become very expensive where several varieties are being grown and where several seed sizes are required. In order to maintain a constant labor force, mills (except for seed stock mills) are usually designed to operate 6 to 10 months of each year. Thus, the estimated annual supply of peanuts will often determine the capacity of the mill. Although many peanuts are transported by truck, railroad accessibility is a critical need for medium and large size mills. Storage and transportation requirements include those for farmers stock peanuts as well as the finished product. Farmers stock and cold storage warehouses located adjacent to the mill and railroad will minimize shutdown of the mill because of an interruption in transportation or marketing operations. The mill building should have sufficient temporary storage space for shelled peanuts to allow time for regrade, marketing and transportation. The lack of temporary storage space in the bagging area is probably the most common error found in the design of new mills. Versatility is probably the most valuable asset of a peanut shelling plant. Every year, the situation is different and changes in plant operation (and sometimes plant design) are necessary to accommodate these changes.

Since raw shelled peanuts sold to the edible trade are considered food products, only materials and procedures approved for food handling can be used to handle these peanuts. The mills must be designed to comply with good sanitation practices including provisions for control of rodents, insects, birds, and other potential sources of contamination.

It must also be designed to protect the workers from injury and to keep pollution and noise to a minimum. Dust sources (e.g., precleaning and hull removal equipment) are usually located away from the main plant. Essentially all in-plant air duct systems are of the negative pressure type so dust is contained inside the mill and is removed immediately. Generally, a soundproof, quality control office and a sorting room are provided for the workers. Woodward (1976, 1978) found that 2 major sources of noise in mills were the impingement of hulls in air duct systems and the impingement of peanuts on metal surfaces during the handling operations. Noise was effectively reduced by reducing impact velocities, increasing the thickness of metal surfaces, insulating metal ducts and surfaces, and by the use of modified handling techniques. The modified handling techniques also reduced mechanical damage to the peanut seed.

Good mill design and operation are necessary for peanut milling to be profitable. Penny (1952) and Moder and Penny (1954) conducted economic studies of peanut mills used to shell peanuts for the edible trade. The average cost of receiving, storing and shelling was \$28.12/t, of which \$6.52 was fixed cost and \$21.60 was variable cost. In the early 1970's, Glover (1974) conducted a feasibility study for constructing a mill in Georgia to shell approximately 39.5 kt of peanuts for the edible trade annually. Plants having an hourly capacity of 10.9, 16.3, 21.8, and 27.2 t/hr were considered. The cost of shelling, excluding cost of peanuts, was about \$35/t for all capacities. The largest equipment cost was for electronic color sorters. Since the 1970 study, the cost of labor, energy, equipment and interest have more than doubled. The cost to meet the demands of regulatory agencies has also escalated. Thus, the 1981 cost of shelling peanuts for the edible trade exceeds \$80/t.

Material Flow and Equipment Arrangement

General material flow diagrams and equipment used to mill peanuts for oil processing, seed stock and edible purposes are shown in Figures 21, 22, and 23. Such flow diagrams will vary considerably among plants. Low cost per tonne of peanuts shelled, low milling losses, and low foreign material content in the finished product are common goals for all 3 types of mills. Except for its effect on milling loss, kernel damage is of little concern when milling peanuts for oil. Aggressive shelling action may result in hulls absorbing oil from the broken and split seed and the loss of small pieces of seed. Foreign material may damage oil processing equipment.

Removal of foreign material and damaged seed, prevention of mechanical damage to the seed, and good fungicide treatment are major goals when peanuts are milled for seed stock (Davidson, 1976c). USDA Grade and State Seed Certification regulations limit the amount of foreign material, inert material, and other types of peanuts contained in a seed stock lot. The most undesirable foreign material are weed seeds such as nutgrass tubers or crop seed such as corn that have the potential of contaminating clean fields. The most common inert material are bald or skinned seed that have poor germination potential. Contamination by other types of peanuts is a major problem in areas where more than one variety or type is being grown. Thus, seed shelling plants should be designed for easy cleanout of all handling and processing equipment.

Because of the low tolerances on foreign and inert material, seed mills have electronic color sorters and handpickers to remove the undesirable materials. Split and small seed must be removed by screening equipment. Sometimes

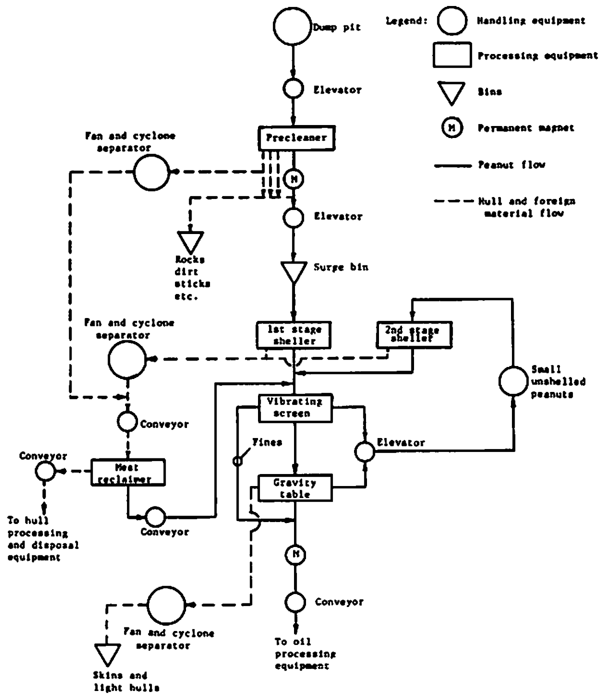


Fig. 21. Typical material flow and equipment used in peanuts for oil processing.

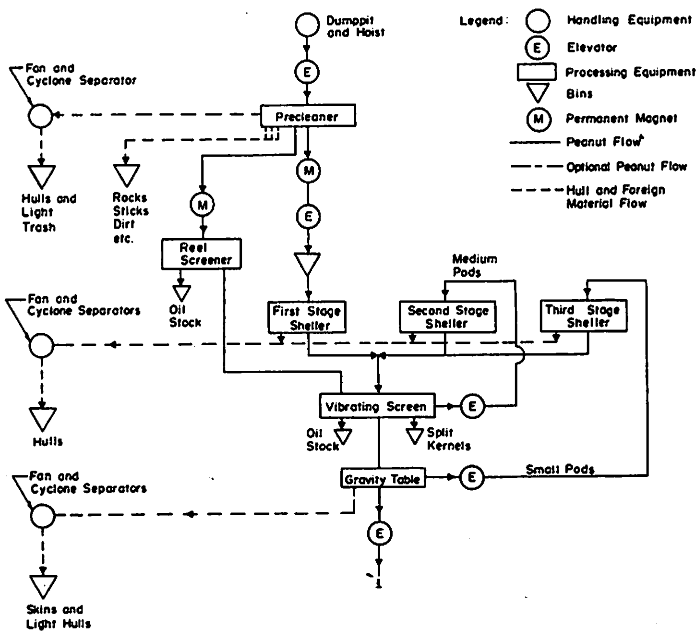


Fig. 22a. General flow diagram for milling seed peanuts (receiving, cleaning, shelling, and separation).

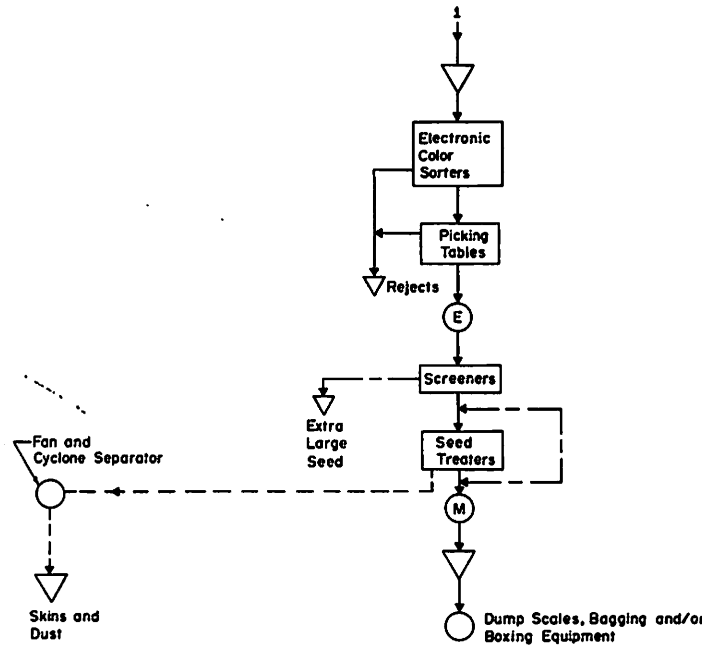


Fig. 22b. General flow diagram for milling seed peanuts (sorting, sizing, treating, and bagging).

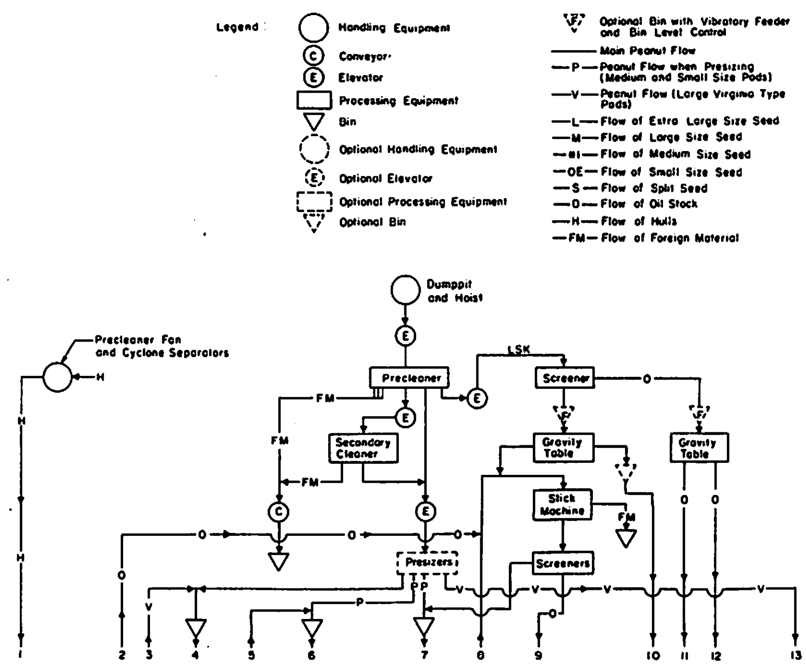


Fig. 23a. General flow diagram for milling edible peanuts (receiving and cleaning).

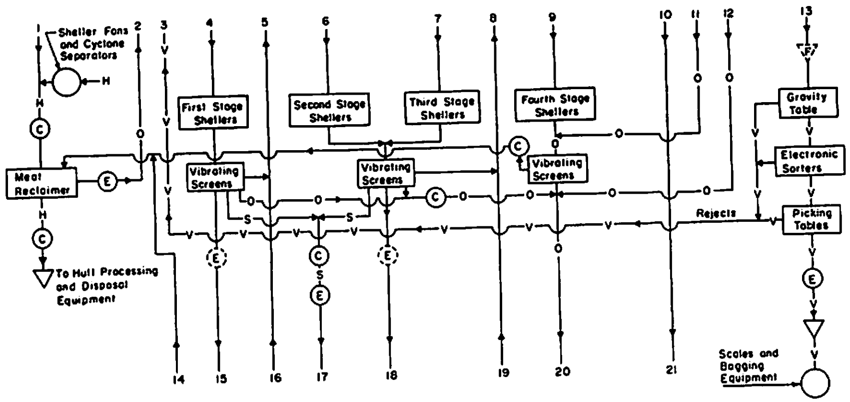


Fig. 23b. General flow diagram for milling edible peanuts (shelling and inshell processing).

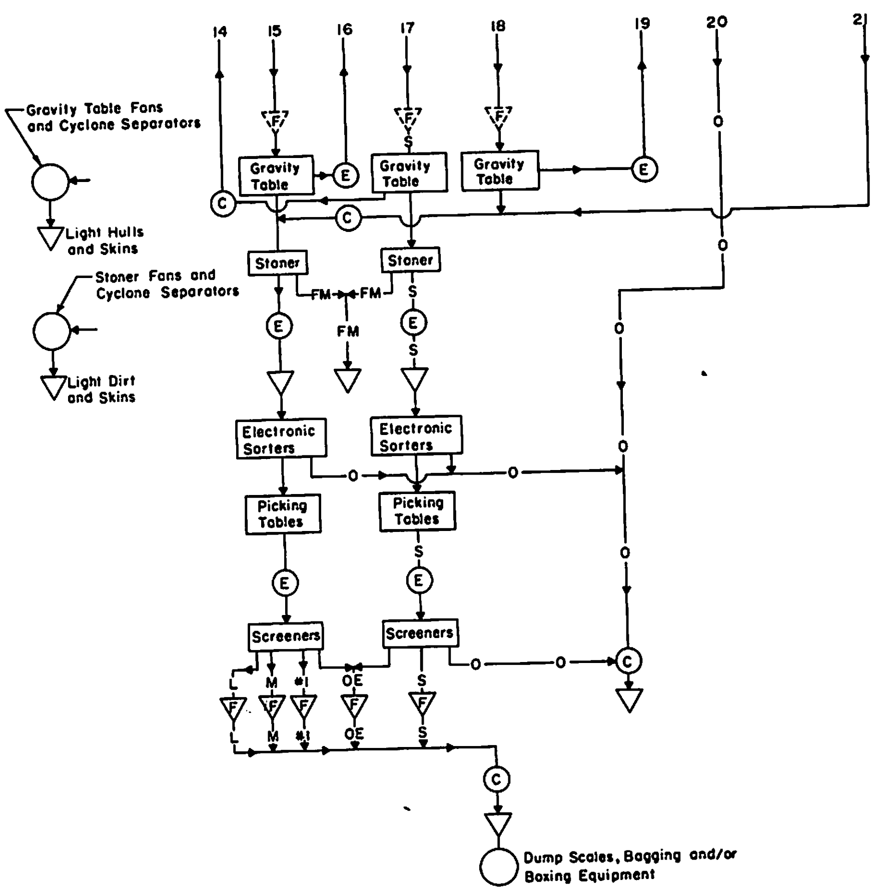


Fig. 23c. General flow diagram for milling edible peanuts (specific gravity separation, sorting, sizing, and packaging).

seed that are too large to be properly handled by planting equipment are removed and sold to the edible trade. Split seed and small seed are usually sold for oil stock. However, sometimes the split seed can be sold to the edible trade. Normally, seed shelling plants do not have meat reclaiming or hull processing equipment. However, milling losses and the increased utilization of hulls may often justify the purchase of such equipment.

Milling peanuts for the edible trade requires presizing to remove large pods for inshell grades, good removal of foreign material from the shelled seed, sorting the shelled product into the various market grades, good plant sanitation, and careful control of aflatoxin in the finished product. In addition, the sorting and storage facilities should be easily changed so the finished product can be altered to meet market demand.

Versatility is normally provided by plant layout, surge bins with vibratory feeders and bin level controls, 2-way valves, and optional sizing and packaging equipment. The plant layout normally provides for future expansion, remilling, and some independent operation of the precleaning, shelling, sorting, and packaging operations.

Receiving, Precleaning and Handling

The dump pit and bucket elevator receive the peanuts and usually transfer the peanuts to the precleaner. The dump pit and surge bin provide additional versatility in allowing some independent operation of the precleaning and shelling operations as well as insuring that an adequate supply of peanuts is provided to the precleaning and shelling equipment.

The dump pit and precleaner are similar to those described above for precleaning peanuts prior to storage. The standard-type precleaning equipment is supplemented by cleaning equipment for the farmers stock, loose shelled kernels and nubbin (small pods) circuits. This additional equipment usually consists of louvered and slotted screeners for removing additional sticks and specific gravity separators (stoners) for removing additional stones and heavy materials. Elevators are the bucket-type with handling components manufactured from materials that resist corrosion by peanut oil and meal. Conveyors are the screw- or vibrating-type that are designated for handling oil and meal products. Peanuts must be received and handled with care to minimize mechanical damage (Davidson, 1976c). Flow pipes should have slopes as shown in Table 13. Shelled peanuts should be handled with chain-type bucket elevators (boot-

Table 13. Angles for steel flowpipes providing satisfactory peanut flow with minimum damage.[1]

Product	Recommended angle
Farmers stock peanuts	38° - 45°[2]
Whole seed	18° - 25°[3]
Seed	30°
Oil stock	45°

[1]For round ducts and rectangular ducts without transitions.
[2]The smaller angles are for clean peanuts.
[3]The smaller angles are for 100% whole seed and the larger angles are for large percentages (up to 30%) of split and unshelled peanuts.

less and easy dump). Whole loose shell kernels are usually rerouted around the shellers to minimize further mechanical damage and the splitting of seed. All bins handling whole seed should have properly designed spiral letdowns to minimize impact damage.

Shelling

Peanut shellers (Figure 24) consist of a concave grate 30.5 to 35.6 cm in diameter that extends 180 to 270 degrees around a 25.4 to 30.5 cm diameter shelling cylinder, leaving an opening 7.6 to 27.9 cm wide at the top of the sheller grates for peanuts to enter the sheller. As the cylinder rotates (160 to 300 rpm), the peanuts are shelled and peanut fractions (whole seed, split and broken seed, and hulls) pass through slotted openings in the grates. The peanut fractions fall through 1 or more hoods where the hulls are removed by aspiration (305 to 457 m/min) and transported (762 to 1219 m/min) to meat recovery units and to hull collection and/or processing equipment. Meat recovery units are generally precision air separators or specific gravity separators (similar to stoners). Hulls are very light (80 to 128 kg/m^3) and may be ground or pelleted for transporting to end users. Hull properties and utilization have been investigated by Hellwig et al. (1971), Utley et al. (1973), Albrecht (1979), and others. Hulls are very difficult to handle because of their abrasiveness and because they bridge during static conditions. Hulls are also very hygroscopic and will quickly absorb and lose moisture as their environment changes.

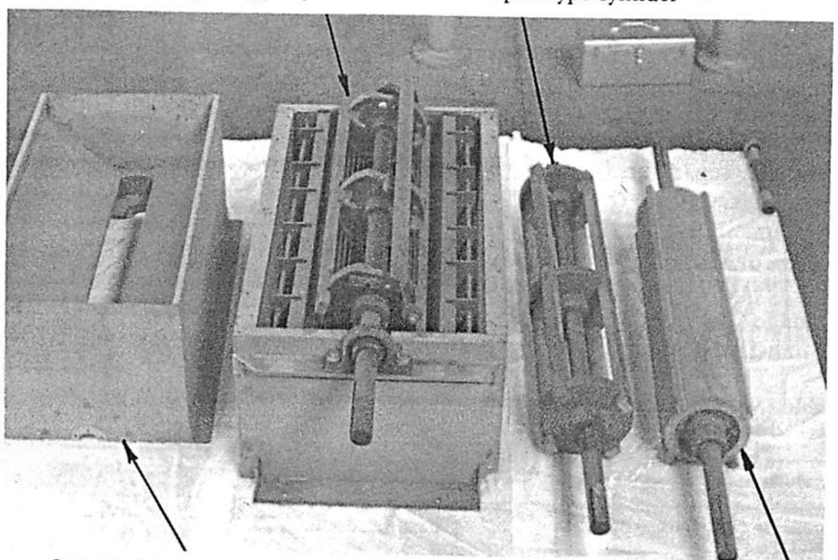


Fig. 24. Typical commercial-type sheller.

Good peanut sheller design, operation and performance increase whole seed outturn. Early investigations conducted by Reed and Coppock (1952) used 3 types of grates (perforated metal, steel bar and cast iron) and 3 cylinder designs (3 or 4 cast iron bar cylinder, 9-square bar cylinder, and angle iron bar cylinder). They concluded that all 3 types of grates caused about the same split seed outturns but the perforated metal grate with long slots provided the highest capacity. The 9-square bar cylinder provided the lowest split seed outturn but the lowest shelling capacity. Wide feed openings and sheller speeds of 250 to 300 rpm were recommended.

During recent years, 4 types of commercial peanut shelling equipment have been evaluated at the National Peanut Research Laboratory to determine the effects of numerous variables on sheller performance. These variables included milling quality, peanut type and variety, grate design, grate arrangement, surge hopper design, methods of directing peanuts into the sheller, width of sheller bars and shelling cylinder design, radial distance between grate and cylinder, grate (slot width) size, and cylinder speed. The 4 types of shellers were the cast iron, flat steel bar, perforated metal, and steel T-bar, respectively. The evaluation showed that the effect of these variables on sheller performance was similar for all 4 types of shellers (Davidson, 1974; Davidson et al., 1976a). Sheller performance is substantially improved by more efficient precleaning of the peanuts, by better maintenance of the shellers, by adjusting the shellers on the basis of the peanut shelling properties, by matching grates, cylinder and surge hopper design to provide an optimum supply of peanuts to the sheller, and by utilizing grates with a high % of open area and shellers that permit adjustments of the distance between cylinder and grate. Optimum designs and normal settings for each type of sheller when shelling seed peanuts are presented in Tables 14 through 17.

Several sheller materials such as urethane, high density polymers, steel alloys, and tungsten carbide have been evaluated for use in sheller grate and cylinder bars. Use of these materials have not provided significant improvements in sheller performance compared to the use of standard heat-treated steel. Heat-treated steel provided better abrasive resistance than the urethane and high density polymers and was easily sharpened by inexpensive grinding equipment. Tungsten carbide and chromium and molybdenum steel alloys had better abrasive resistance than heat-treated steel but components made from these materials were not easily sharpened. Rapid wear of shelling surfaces usually make perforated steel metal grates unacceptable for production type shelling. Flat steel and T-bar grates are durable and can be sharpened several times before they become unserviceable. Maintaining sharp shelling surfaces on the grate and sheller bars is probably the most important factor in obtaining good sheller performance.

Generally, the shellers are adjusted and operated on the basis of some compromise between maximum whole seed outturn and maximum shelling rate and efficiency. This compromise will depend upon the price differential between split and whole seed, interest rates, and other factors. For example, when the price differential between split and whole seed is small and interest rates (carrying charges for storing peanuts) and labor are high, it may become profitable to sacrifice an increase in split seed outturns to obtain an increase in shelling rate and efficiency. Adjustments and their effects on sheller performance have been discussed in detail by Davidson et al. (1976a). The primary adjustments are grate size, distance between cylinder and grate, cylinder

Table 14. Optimum design and normal settings for shelling seed peanuts with the cast iron type sheller.

Variable	Description of optimum design or normal setting
Grate design	Removable, heat-treated steel T-bar grates, 2, 120-degree circular sections with minimum of 65% open area.
Cylinder design	Open type with 3, 5-cm-wide cast sheller bars spaced 120 degrees apart.
Surge hopper design	Top centered feed opening extending entire length of sheller. Replaceable with circular deflectors having same diameter as inside edge of sheller grates. Surge hoppers needed with 7.6- and 10.2- cm-wide feed openings for shelling small to medium and large size pod varieties, respectively.
Cylinder speed	195 rpm
Distance between cylinder and grate	Small pod size varieties - 2.86, 2.54, and 1.90 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
	Medium pod size varieties - 3.18, 2.86, and 2.22 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
	Large pod size varieties - 3.49, 3.18, and 2.54 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
Grate sizes needed	Small pod size varieties - 0.64[3], 0.71, 0.79[2], 0.87, 0.95[1] cm
	Medium pod size varieties - 0.64, 0.71, 0.79[3], 0.87[2], 0.95, 1.03[1], 1.11 cm
	Large pod size varieties - 0.71, 0.79, 0.87, 0.95[3], 1.03[2], 1.11, 1.19, 1.27[1], 1.35 cm

[1]The grate size that is normally used in the 1st stage sheller.
[2]The grate size that is normally used in the 2nd stage sheller.
[3]The grate size that is normally used in the 3rd stage sheller.

Table 15. Optimum design and normal settings for shelling seed peanuts with the T-bar commercial-type sheller.

Variable	Description of optimum design or normal setting
Grate design	Removable heat-treated, perforated (long slots) sheet metal[1], U-shaped (180 degree of circle with 5-cm-long vertical section on each side). Minimum of 35% open area.
Cylinder design	Open type with 3, 1.27-cm-thick steel sheller bars with 1.27-cm-wide x 0.32-cm-thick heat-treated steel knife edge.
Surge hopper design	Top centered feed opening extending entire length of sheller. Replaceable with circular deflector having same diameter as inside edge of sheller grates. Surge hoppers needed with 7.6- and 1.02-cm-wide feed openings for shelling small to medium and large pod varieties, respectively.
Cylinder speed	200 rpm
Distance between cylinder and grate	Small pod size varieties-2.86, 2.54, and 2.22 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.

(Table 15 continued)

	Medium pod size varieties-3.18, 2.86, and 2.54 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
	Large pod size varieites-3.49, 3.18, and 2.86 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
Grate sizes needed	Small pod size varieites-0.56, 0.64[2], 0.71, 0.79[3], 0.87, 0.95[4] cm.
	Medium pod size varieties-0.64, 0.71, 0.79[2], 0.87[3], 0.95, 1.03[4], 1.11 cm.
	Large pod size varieties-0.71, 0.79[2], 0.87 0.95[3], 1.03, 1.11, 1.19[4], 1.27 cm.

[1]T-bar grates should be used for production-type sheller.
[2]The grate size that is normally used in the 3rd stage sheller.
[3]The grate size that is normally used in the 2nd stage sheller.
[4]The grate size that is normally used in the 1st stage sheller.

Table 16. Optimum design and normal settings for shelling seed peanuts with the flat steel bar type commercial sheller.

Variable	Description of optimum design or normal setting
Grate design	Heat-treated flat steel bar (3.81-cm-wide x 0.64-cm-thick) cage, enclosing 180 degree of circle. Minimum of 50% open area. Interchangeable grate assembly for each grate slot size selected.
Cylinder design	Open type with 4 heat-treated steel sheller bars 3.81-cm-wide x 2.54-cm-thick, spaced 90 degrees apart.
Surge hopper design	Top centered feed opening extending entire length of sheller. Replaceable with circular deflectors having same diameter as inside edge of sheller grates. Surge hoppers needed with 10.2- and 12.7-cm-wide feed openings for shelling small to medium and large pod varieties, respectively.
Cylinder speed	165 rpm
Distance between cylinder and grate	Small pod size varieties - 2.86, 2.54, and 1.90 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
	Medium pod size varieties - 3.18, 2.86, and 2.22 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
	Large pod size varieties - 3.49, 3.18, and 2.54 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
Grate sizes needed	Small pod size varieties - 0.64[3], 0.71, 0.79[2], 0.87, 0.95[1] cm.
	Medium pod size varieties - 0.64, 0.71, 0.79[3], 0.87[2], 0.95, 1.03[1], 1.11 cm.
	Large pod size varieties - 0.71, 0.79, 0.87, 0.95[3], 1.03[2], 1.11, 1.19, 1.27[1], 1.35 cm.

[1]The grate size that is normally used in the 1st stage sheller.
[2]The grate size that is normally used in the 2nd stage sheller.
[3]The grate size that is normally used in the 3rd stage sheller.

speed, and width of feed opening. Generally, the effect of grate size on split seed outturn is small (0 to 1.4%) as long as the slot is wide enough to allow the

Table 17. Optimum design and normal settings for shelling seed peanuts with the perforated sheet metal type commercial sheller.

Variable	Description of optimum design or normal setting
Grate design	Removable heat-treated, perforated (long slots) metal basket enclosing approx. 300 degree of circle. Minimum of 35% open area.
Cylinder design	Open type with 3 equally spaced (120 degrees apart) 1.59-cm square steel sheller bars with 1.27-cm-wide x 0.32-cm-thick heat-treated knife edges.
Surge hopper design	Top centered feed opening extending entire length of sheller. Adjustable feed opening width to provide feed opening widths of 10.2, 12.7, and 15.2 cm for shelling small to medium and large pod size varieties, respectively.
Cylinder speed	190 rpm
Distance between cylinder and grate	Small pod size varieties - 3.18, 2.86, and 2.22 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
	Medium pod size varieties - 3.49, 3.18, and 2.54 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
	Large pod size varieties - 3.81, 3.49, and 2.86 cm for 1st-, 2nd- and 3rd-stage shellers, respectively.
Grate sizes needed	Small pod size varieties - 0.56, 0.64[3], 0.71, 0.79[2], 0.87, 0.95[1] cm
	Medium pod size varieties - 0.64, 0.71, 0.79[3], 0.87[2], 0.95, 1.03[1], 1.11 cm
	Large pod size varieties - 0.71, 0.79[3], 0.87, 0.95[2], 1.03, 1.11, 1.19[1], 1.27 cm

[1]The grate size that is normally used in the 1st stage sheller.
[2]The grate size that is normally used in the 2nd stage sheller.
[3]The grate size that is normally used in the 3rd stage sheller.

largest whole seed to escape. However, the effect of grate size on shelling efficiency is large (11 to 25%), and grates with the narrowest slots always provided the highest shelling efficiency. The shellers usually shelled most of the pods that were 0.8 mm thicker than the slot width. Size of grate opening does not significantly affect shelling rate except for the large pod varieties. For these larger peanuts, grates with the widest slots provided 14 to 20% higher shelling rates. In more recent research the grate combination with the wider slots in the first stage sheller also split 10 to 15% fewer of the larger premium priced seed (ELK and jumbo runner).

Decreasing the distance between cylinder and grate (by 0.32 to 0.95 cm) from the optimum setting provided a 20 to 65% increase in shelling rate, a 1 to 6% increase in shelling efficiency, and a 2.5 to 11.2% increase in split seed outturns. The closer spacings are especially effective in the latter stage shellers in minimizing problems with foreign material and in providing higher efficiencies and shelling rates.

Significant linear and quadratic relationships were developed to describe the effects of cylinder speed on sheller performance. On the average, an increase in cylinder speed of 1 rpm provided a 0.4% increase in shelling rate, 0.1% increase in shelling efficiency, and 0.14% increase in split seed outturns. There ... of sheller speed with cylinder design, surge hopper design,

and grate size. The effects of sheller speed on sheller performance was minimized by a large number (more than 3) of wide (greater than 5.1 cm) sheller bars and by narrow feed openings. An increase in sheller speed for such situations produced very little change in sheller performance because the sheller bars and narrow feed openings restricted the flow of peanuts into the sheller. As cylinder speed was increased, split seed outturns increased at a much greater rate for poorer quality peanuts and for grates with the narrower slotted openings.

Increasing the width of the feed opening for shellers with 3 narrow sheller bars increased the supply of peanuts to the sheller and provided an average increase in shelling rate of 2.9%/cm; an average increase in split seed outturns of 1.7% cm; and an average decrease in shelling efficiency of 0.3%/cm.

Numerous other adjustments and modifications to commercial-type shellers have been developed and evaluated to provide higher shelling rates. Such developments include surge hoppers that permit off-center and/or end feed; surge bins and feed pipes that provide a high column of peanuts above the feed opening; solid-type shelling cylinder; and automatic cleanout devices. Surge hopper and bin designs that tend to force peanuts into the sheller will generally result in a tremendous increase in shelling rates (30 to 250%) with an increase in split seed outturns of 0.16% for each % increase in shelling rate. When compared to the open type, the solid-type shelling cylinder will normally provide a 60 to 100% higher shelling rate but also a 0.23% higher split outturn for each % increase in shelling rate. On the average the solid-type cylinder will also provide an 8% higher shelling efficiency than the open-type cylinder. An open-type cylinder with a cleanout bar has also been developed for the flat steel bar type sheller. Tests by the sheller manufacturer have been relatively unsuccessful because of difficulty in dynamic balancing of the cylinder. Research studies showed that the clean-out bar would completely clean the sheller and would eliminate long periods of shutdown for manual cleanout. A "ripple-type" grate in the secondary shellers has also proven effective in minimizing the need for cleaning out the shellers.

Presizing

Presizing consists of sizing the pods prior to shelling and selecting sheller grates of a specific size (width of slotted openings) to shell each pod size. Presizing is standard practice when shelling virginia type peanuts because of the need to remove the larger pods for the inshell market. Presizing is currently based on separations by pod thickness. These separations are accomplished by large reel screens, roller screens or flat vibratory screens. The reel and roller screens are less susceptible to blinding than the flat screens. The roller screens usually have a lower capacity than the flat and reel screens. The roller and flat screens occupy less building space, but generally require more maintenance. Presizing will generally increase plant production rates (25 to 50%) and provide 5 to 10% higher shelling and separating efficiencies. Elliott and Carmichael (1951) indicated that presizing by pod diameter would also reduce split seed outturns by 1 to 2%. Research by the National Peanut Research Laboratory on runner and spanish type peanuts has shown that presizing results in a slight increase in split seed outturns. The reason for increased splits is that medium- and small-size pods with large seed are shelled in the latter stages of shelling where slotted openings in the grates are too small (Figure 25). Recent research has indicated that a combination of presizing and separation by specific gravity will provide all the advantages of presizing without increasing split seed outturns (Table 18). The industry has not adopted the combination method of separation probably because of the high initial and operating cost of specific gravity separators. There is some indication that presizing and improved aspiration might be an effective and economical separation method.

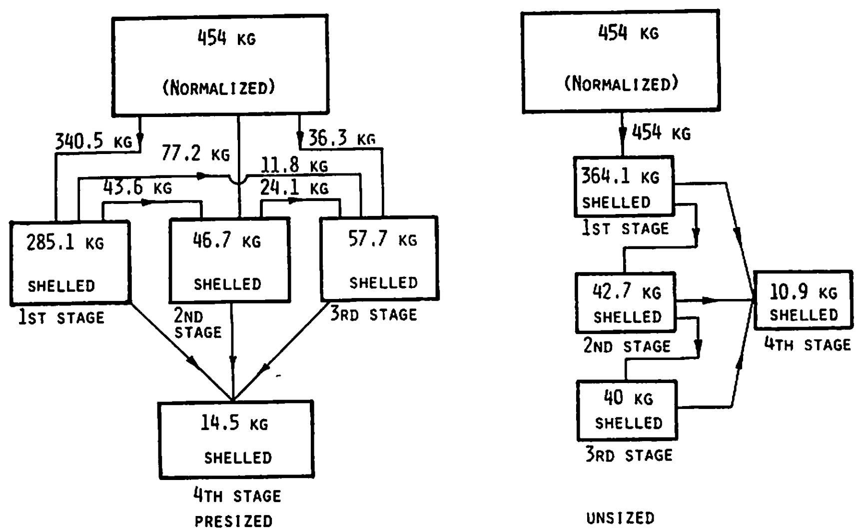


Fig. 25. Effect of presizing on the weight of spanish type peanuts shelled in each stage of a 4-stage shelling plant.

Table 18. Typical effect of various presizing methods on the split seed outturn and shelling efficiency of spanish and runner type peanuts.

Presizing method	Split seed outturn %	Shelling efficiency %
None	16.2	80.5
Pod thickness	17.0	90.0
Specific gravity	16.0	76.5
Pod thickness and specific gravity	15.1	89.8

Screening

The vibrating screens underneath the shellers are the flat counterbalanced 2-deck type where oil stock and dirt are removed first. The split seed and whole seed with small pods are then removed leaving the large unshelled seed for processing by the next stage sheller.

Design and operation of screening equipment are very important in obtaining good plant efficiency and in minimizing mechanical damage. The 2 basic types of screeners used are the flat and reel screeners. Each type of screener has

materials. The general performance characteristics are summarized in Tables 19 and 20. Generally, the flat screeners are used for high capacity precleaning and high capacity scalping when sizing peanut pods and seed and when removing large unshelled peanuts from shelled peanuts. Critical design features for flat screeners include heavy steel support framework with precision counterbalancing. Because of its susceptibility to clogging, the low frequency flat screeners (300 to 600 cpm) with rubber ball cleaning are best for most peanut shelling plant applications. The openings in the screens of medium and high frequency screeners are difficult to keep open because the amplitude of vibration is not enough to obtain effective ball cleaning action. The flat screeners should be driven by a variable speed drive so that frequency can be changed to accommodate changes in peanut shape and separation characteristics. Reel screeners are primarily used for precision sizing of pods and seed. Reel screeners impart some mechanical damage to whole seed and the reels are very susceptible to meal and oil buildup when handling split seed and oil stock. Round-hole reel screens have about 1/3 the capacity of slotted-hole reel screens.

A combination of flat and reel screeners can be used very effectively in sizing peanut pods and seed and in separating split seed from small whole seed. In the case of pod and seed sizing, the flat screens can be used to scalp off the large material as well as divide the flow between reel screeners. This procedure reduces the number of reel screeners required, provides more efficient separation, and minimizes mechanical damage. In the case of separating split and small whole seed, the flat screener can be used to make the width separations over round

Table 19. Advantages and disadvantages of using flat screeners in peanut shelling plants.

Type of separation	Advantages	Disadvantages
All separations	Low maintenance High capacity	Susceptible to clogging
Removal of foreign material from peanuts	Good stratification Very effieicnt in removing LSK	Poor efficiency in removing light materials such as sticks and vines
To size peanut pods	Fair efficiency in scalping off very large pods or passing very small pods	Poor efficiency in sizing most pods
To remove unshelled from shelled peanuts	Good stratification Very efficient with short slotted-hole screens	Poor efficiency with round-hole screens, especially for varieties with a large % of flat-shaped kernels
To remove split seed or oil stock from shelled and unshelled peanuts	Efficient with low frequency screens	Poor efficiency with high frequency screens
To size whole seed	Imparts very little mechanical damage	Poor efficiency Requires a large amount of floor space and additional elevators
To separate split seed from small whole seed	Very efficient in riding split seed and passing whole seed	Poor efficiency in riding whole seed and passing split seed. Requires a large amount of floor space and

Table 20. Advantages and disadvantages of using reel screeners in peanut shelling plants.

Type of separation	Advantages	Disadvantages
All separations	Very efficient	Low to medium capacity High maintenance
Removal of foreign material from peanuts	Virtually nonclogging	Requires large amount of building space
To size peanut pods	Nonclogging	Requires large amount of building space
To remove unshelled from shelled peanuts	Good stratification of material	Requires large amount of building space
To remove split seed or oil stock from shelled and unshelled fractions	Very precise in removing whole LSK from split LSK	Poor efficiency
To size whole seed	Precise Requires a minimum of floor area and elevators	Imparts additional skin slippage and splitting
To separate split seed from small whole seed	Especially suited for riding whole and passing split seed Requires a minimum of floor area and elevators	Poor efficiency when riding split and passing whole seed

holes and the reel screener can be used to make the thickness separation over slotted holes. (Flat screeners are not very effective in removing long shriveled seed from split seed.) This procedure takes advantage of the more efficient riding of split seed by the flat screener as well as the more efficient riding of the whole seed by the reel screener. It also reduces the number of reel screeners required as well as problems with meal and oil buildup in the reel screeners. The efficiency of both flat and reel screeners depends upon the flow rate and peanut material size distribution. The effects of flow rate and screen opening on screening efficiency are shown in Figure 26. Screen selection should be based on this information, on the logistic distribution model (Davidson et al., 1978b), and on procedures described by Feller and Foux (1976).

Gravity Tables

Gravity table design operation and performance are very important in minimizing mechanical damage and in the removal of foreign material. The 2-product type is more efficient for peanut separation than the 3-product type. The 3-product type also recycles the third product imparting mechanical damage to the seed (McIntosh and Davidson, 1971a).

Air velocity distribution and peanut flow rate are 2 of the most critical variables in obtaining good performance. The 2-product gravity table has 1 or 2 fans supplying air to the bottom of the separating deck while another fan removes the air from the top of the deck. The air velocity distribution with all

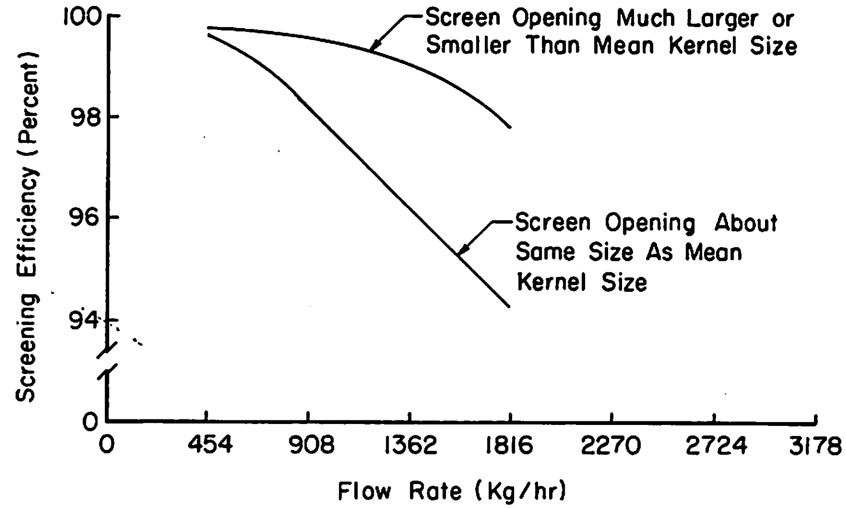
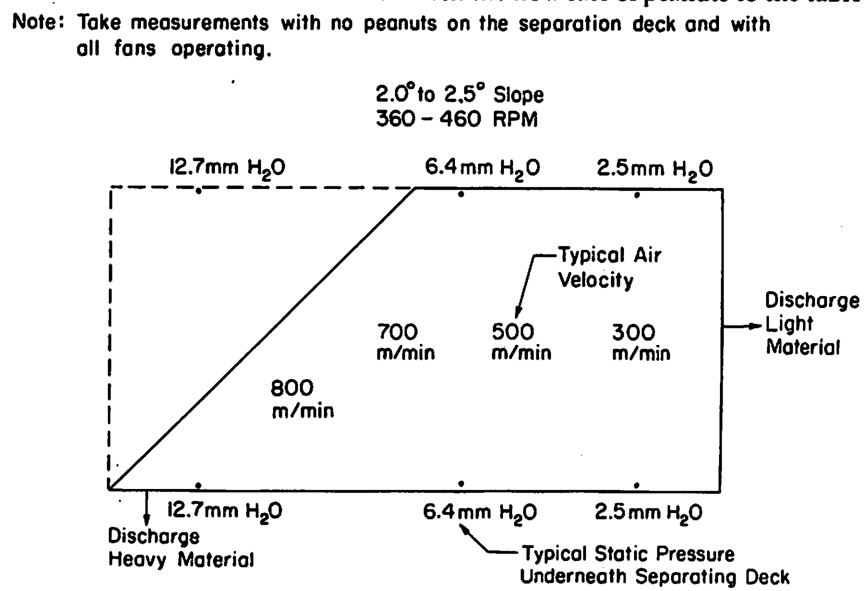


Fig. 26. Typical screening efficiencies for precision graders.

fans operating and no peanuts on the deck should be approximately as shown in Figure 27. The best method for setting and measuring air velocity distribution is to drill small holes underneath the deck, measure the static pressure at the points indicated, and make adjustments on air supplied by the fans underneath the deck. Static pressures should increase linearly from the rear of the deck to the front, as indicated. There should be no variation in static pressure across the deck. Poor air velocity distributions have been noted on several gravity tables, especially those having 2 fans supplying air (instead of 1) underneath the deck. The air flow should be set to match the flow rate of peanuts to the table.



Peanut flow rate should be maintained relatively constant. A change in flow rate will affect performance of the gravity table even when using damper and counterbalanced gates. Gravity tables should be designed to allow adjustment of the deck slope (0 to 4 degrees) and deck speed (300 to 550 rpm) to accommodate differences in peanut size and shape. Decks should be easily removed for cleaning or replacement.

Electronic Sorting

Color sorting is required to remove both dark and light materials. The electronic sorters are much more efficient if they are not overloaded and if they are setup and maintained properly. The sorters drop the seed a distance of 1 to 2 m through an optical field to compare colors of the seed with standard acceptable colors. Seed that differ in color substantially from the standard are rejected. Mechanical damage to the seed can be reduced by gradually reducing the speed of the seed as they exit the electronic color sorters. Handpicking is very slow and does not normally remove a significant amount of material. However, it provides a means of removing critical foreign material (nutgrass tubers, stones, glass, corn, etc.) and will alert plant personnel to problems.

Electronic sorting equipment and handpickers are used primarily to remove moldy, discolored, shriveled, or damaged seed since aflatoxin is most frequently found in such peanuts (Banes, 1966). Dickens and Whitaker (1975) determined the efficiency of electronic color sorting and handpicking in removing aflatoxin contaminated kernels from 40 commercial lots of shelled peanuts. These lots contained an average concentration of 48 ppb aflatoxin and were sorted 3 to 5 times and then handpicked. Although an average of 72% of the aflatoxin was in seed that were removed by this multisorting procedure, prediction equations indicated that the aflatoxin would be reduced by only 16% when employing the normal plant sorting procedure. The efficacy of aflatoxin removal with electronic sorters was extremely variable among lots, indicating the need for pretesting each lot for aflatoxin to minimize the expense of color sorting and to minimize loss of good material to pickouts. The rapid assay method such as the Holaday minicolumn method (Holaday, 1976) would be very useful in setting up the electronic sorters.

Tiemstra (1977) has discussed in detail the use of electronic color sorters in removing contaminated seed from blanched peanuts. He also discussed the potential benefits of concentrating the suspect seed prior to sorting into a small fraction of seed by screening, specific gravity, and other plant separation methods as well as of resorting the rejects to minimize losses. These same principles should also be valid for sorting raw shelled peanuts.

Seed Treatment

Mechanically shelled seed must be treated prior to planting with an approved fungicide. Complete coverage of the seed by the protectant is required to minimize deterioration of the seed from seed and soil-borne organisms. Treatment with the fungicide renders the peanuts unfit for human or animal consumption and thus seed are normally not treated until seed quality has been determined to be acceptable by tetrazolium or germination tests. Seed treatment equipment usually consists of dust-type applicators that gently roll or brush the fungicide dust on the seed. A dust capture and collection system must be provided to prevent air pollution. A new type of liquid seed treatment has been developed by Gustafson, Inc. This method has been evaluated extensively and found to have excellent potential for replacing the dust-type treaters. Tests at the National Peanut Research Laboratory indicate that the new liquid seed treater does not impart additional skin slippage except for the seed that have nicks or pieces of skin removed prior to entering the treater. Seed treatment rooms for both dust and liquid equipment must be located in a room or building separated from the rest of the shelling plant to insure that edible peanuts are not contaminated by the fungicide.

Assembly and Operation

Historically, the assembly and operation of mills have been based upon experience and trial and error methods. However, procedures have been developed at the National Peanut Research Laboratory to setup and operate mills. Some of these procedures are outlined in Table 21. These procedures are based upon pod and seed size distribution data, shelling data obtained with the NPRL Model 3 or 4 sheller (Davidson and McIntosh, 1973b; Davidson and Hudgins, 1979; Davidson et al., 1981), and other data obtained over the past several years.

Table 21. A procedure for setting up commercial-type peanut shellers and screening equipment.

Step A. Selecting grate and screen sizes for shelling.

1. Obtain a large farmers stock sample (at least 15 kg) and divide out a small (at least 500 gm) sample for handshelling and 6, 2,000 gm samples for machine shelling.
2. Handshell the small sample and weigh the hulls and seed.
3. Size seed over slotted-hole screens to find largest slot needed to drop all seed.
4. Largest screen will indicate grate size of 1st stage shellers and screen size of primary shaker.
5. Select 2 or 3 grate sizes around size selected and conduct shelling tests with each grate size using 2, 2,000 gm samples per grate size and the Model 3 or 4 NPRL sheller.
6. Weigh outturns and calculate percentages.
7. Take small sample of pods that passed through 1st stage sheller above, handshell, weigh hulls and seed.
8. Put seed over slotted-hole screens and proceed as in Steps 3 through 6. The best grate size for the 2nd stage will generally be approximately 0.04 cm larger than largest screen size.
9. Proceed in the same manner for 3rd stage.

Step B. Estimating outturns and seed count

Take all seed from the 2 samples shelled with the best grate combination selected by Step A and screen them over market size screens. Weigh and count the seed in the various size categories.

Step C. Selecting screen sizes for separating split and small whole seed

Separate split and whole seed from Step B. Screen the split and the whole seed over different combinations of slotted- and round-hole screens to determine best combination.

Step D. Checking commercial-type sheller performance

1. Obtain large sample of peanuts from the top of the sheller (at least 4 kg) and from underneath the sheller (at least 2 kg). If possible, cut off air to sheller prior to taking sample underneath the sheller.
2. Separate and weigh bald seed (W_b), whole seed (W_w), split seed (W_s), oil stock (W_o), hulls' (W_h), and unshelled (W_u).
3. If air to sheller was cut off, then proceed to Step 5.

Table 21 (continued)

4. If air was not cut off, calculate the hull weight W_h, corrected weight of shelled peanuts (W_{sh}), and corrected total weight of sample (W_t) as follows:
   $W_h = h(W_b + W_w + W_s + W_o)/(100-h)$,
   where W_h = weight of hulls (to be calculated)
   h = percent of hulls (from farmers stock grade or estimate)
   $W_{sh} = W_h + W_b + W_w + W_s + W_o$
   $W_t = W_{sh} + W_u$.
5. Calculate[2] actual percentages (P) and shelling efficiency (E) as follows:
   $P_b = 100W_b/W_{sh}$ $\quad P_w = 100W_w/W_{sh}$
   $P_s = 100W_s/W_{sh}$ $\quad P_o = 100W_o/W_{sh}$
   $E = 100W_{sh}/W_t$
6. Using the Model 3 or 4 NPRL sheller and the same grate size as used by the commercial sheller, shell at least 2, 2,000-gm samples of the peanuts taken from above the commercial sheller. Weigh outturns and calculate percentages and efficiency.
7. Using published correlation curves (Davidson et al., 1981), compare performance of NPRL sheller and commercial sheller. If commercial sheller performance is poorer than that of NPRL sheller, adjust or modify commercial sheller to obtain better performance.

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[1]Use calculated W_h if Step D4 applies.
[2] See Step D4 for definitions of W_{sh} and W_t.

OUTLOOK

Over the past 20 years considerable improvements have been made in grading, cleaning, storage, milling, and marketing of peanuts. Much of the progress can be attributed to the farmers, handlers, warehousemen, shellers, manufacturers, and researchers working together to find solutions to mutual problems. While competition in the peanut industry is very keen, members realize the value of unity in solving technical as well as legislative problems. Essentially all segments of industry have recently increased funding and support for research and promotion. Thus, we expect unity and progress to continue. Considerable efforts are being exerted to develop foreign markets and to provide better quality peanuts at the lowest possible cost. Major research priorities in the area of grading, cleaning, storage, milling, and marketing include prevention, detection and removal of aflatoxin seed; improved removal of foreign material; and improved handling and storage methods. The peanut industry intends to remain in the forefront as a dependable supplier of high quality peanuts at the lowest possible cost.

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