Animal and Plant Health Inspection Service

Processing Equipment Inspection Training Module

Authors

H. Mark Hanna

Extension Agricultural Engineer
Department of Agricultural and Biosystems Engineering

Darren H. Jarboe

Program Coordinator
Center for Crops Utilization Research

IOWA STATE UNIVERSITY
Extension and Outreach

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Processing usually involves a system of processing equipment components. Not every piece of equipment or every type is covered in this module. The operation manual from the manufacturer should be consulted for specific instructions. No endorsement is intended by the producers of this module of products mentioned, nor is criticism implied in similar companies or their products not mentioned.

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Background

Since field testing of federally regulated genetically engineered (GE) plants began in the late 1980s, proper equipment clean-out and subsequent compliance inspection have gained national and international importance. Adventitious presence of regulated GE seed or plant material, unintentionally introduced through processing equipment into food or feed channels, could result in losses of billions of dollars, with long-term impacts on the survivability of affected market sectors. In 2000, unintentional introduction of StarLink™ corn, a federally regulated GE corn line not approved for human consumption, caused millions of dollars of food products to be pulled from store shelves and resulted in sudden negative responses by trading partners.

Experience with high-risk GE pharmaceutical-trait plants by the Animal and Plant Health Inspection Service (APHIS) has shown that due diligence in equipment clean-out and sanitation, including processing equipment is a critical step in preventing inadvertent introduction of material into the environment and the subsequent potential damage to the integrity of food and feed supplies. To aid in managing this complex regulatory issue, this training guide on processing equipment has been prepared by Iowa State University for APHIS.

Introduction of value-added traits, identity preservation programs, federal organic standards, and the advent of field testing of federally regulated genetically modified plants have necessitated equipment clean-out and sanitation procedures to address production, marketing, and regulatory concerns. In a growing number of cases, federal regulations by United States Department of Agriculture agencies under Marketing and Regulatory Programs, in the areas of certified organic production, plant protection and quarantine, and Biotechnology Regulatory Services, require that equipment be cleaned of seed and biomaterial before use, interstate transport, or return-to-service.

In the past, APHIS has been concerned with plant pest and disease pathway analysis and disease epidemiology related to the rapid spread of plant pests and diseases from one field location to another or to their introduction into the country via equipment. An example of APHIS's regulatory concerns and practices is its quarantine program for Karnal Bunt disease of wheat. In order to effectively contain this serious fungal disease and prevent its spread, interstate movement of equipment used for seed-conditioning of wheat was regulated, and this equipment was cleaned of residual biomaterials, disinfected, and inspected prior to moving to another location.

Currently, APHIS Biotechnology Regulatory Services (BRS) annually issues permits and notifications for field testing of regulated GE crops at over 5,000 domestic field test sites. In recent years, two new classes of GE plants have appeared, one class that expresses traits for the synthesis of pharmaceuticals and the second class that expresses traits for synthesis of industrial compounds. BRS's regulation of pharmaceutical or industrial trait-expressing plants is more rigorous than that for traditional GE crops containing agronomic traits such as herbicide or insect resistance. Processing may be in dedicated equipment. Such equipment used to process these high-risk traits must be cleaned, inspected, and in some cases opened by dismantling prior to return-to-service for processing of traditionally bred crops. The need for a trained cadre of compliance inspectors with both knowledge and experience in the area of processing equipment clean-out and inspection is an Agency imperative.

Because of the need for more scrupulous clean-out and sanitation, identity-preserved markets are generally developed around on-farm storage with the grower delivering product to transport vehicles directed to the first level processor with limited intermediate storage. Some type of processing is often necessary, and typically is a significant means for adding value. The relative level of cleaning and inspection required will depend on the needs of the marketplace, end-use customer, suppliers, regulatory requirements, and the public good (e.g., disease prevention, integrity of food or feed chain).

Overview

Processing operations are used to add value to harvested plant products. Typically one or more mechanical components perform individual functions to complete a process. When used in a sequence, these components form a complete processing system. To inspect and clean processing equipment, it is important to identify product flow through the overall system and within its various components.

An extremely wide and constantly growing variety of systems exists for processing grain, seeds, and plants into feed, food, fuel, fiber, and other items. It is impossible to cover all devices in a short training module, but a representative set is provided. The approach taken here is to gain familiarity with several individual components commonly found in processing systems. Because crop products are more likely to become segregated for customer end-use after some initial processing steps, processing components that clean, sort, and pre-condition will be emphasized rather than product refining processes (e.g., milling and size reduction, extrusion, drying, roasting, cooking under pressure). Keys for equipment inspection and cleaning are to recognize product flow paths, the function(s) performed by individual components, and the ability to anticipate problem areas likely to harbor residual material within individual components.

In this module a section on basic concepts for cleaning and inspecting equipment highlights typical processing equipment. It also provides examples of how individual processing equipment components are put together to form a processing system. A short section on tools used for cleaning and inspection is followed by more detailed descriptions of several common components found in processing.

Processed plant products include a wide variety of grain, seeds, straw, leaves (e.g., tobacco), and fiber. Processing components in different formats such as oscillating screens, washers, hoppers, tanks, and conveyors may be used for many of these products. The term "grain" is commonly used throughout these sections to denote product flowing through processing components, or residual material within the component. Although grain is used as an example, the reader should understand that concepts presented are similar for other processed products. Even though the larger size of some products (e.g., edible beans, coarse grains) prevents them from becoming trapped in areas of small volume, broken pieces similar in size to small grain and seeds may be residual material requiring inspection and clean-out.

Specific safety issues peculiar to individual processing components will be mentioned within their descriptive sections that follow. A safety summary is presented at the end. Post-harvest processing takes place in an industrial rather than field environment. Material flow through the processing plant is likely to be continuous, or at least in continuous batches, during plant operation with power supplied by electricity. Inspection and clean-out should be closely coordinated with plant management so that equipment power is locked out, making it impossible for it to restart automatically. Those responsible for the equipment must be aware that scheduled inspection and/or cleaning is occurring. Hazardous functions within component machines are often physically guarded, making it difficult to gain access inside the machine. If guards and shields are removed for cleaning and inspection, they must be replaced prior to machine start-up. Pesticides are used in seed treatment areas. Cleaning chemicals may be caustic.

Basic concepts of processing equipment inspection and clean-out

Because processing is often a complex system of many steps, it is helpful to think of the system as a series of components using individual pieces of equipment. Individual steps are different sets of components or pieces of equipment. An entire processing system can be thought of as a series of functions, sometimes interrupted by intermediate storage, joined together by some means of transport or conveyance. Steps can be sub-divided into functional components or storage components linked by transport or conveyor components.

A typical example of a processing system is a seed processing plant (figure 1). A second example would be a dry grind ethanol plant (figure 2).

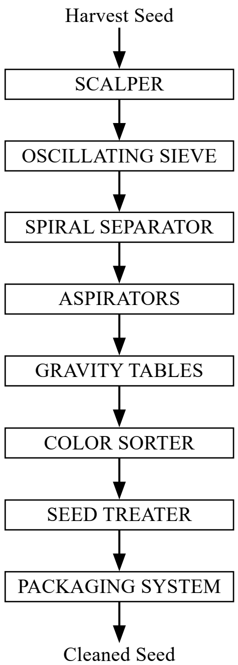

Figure 1. Flow diagram of a soybean seed processing plant

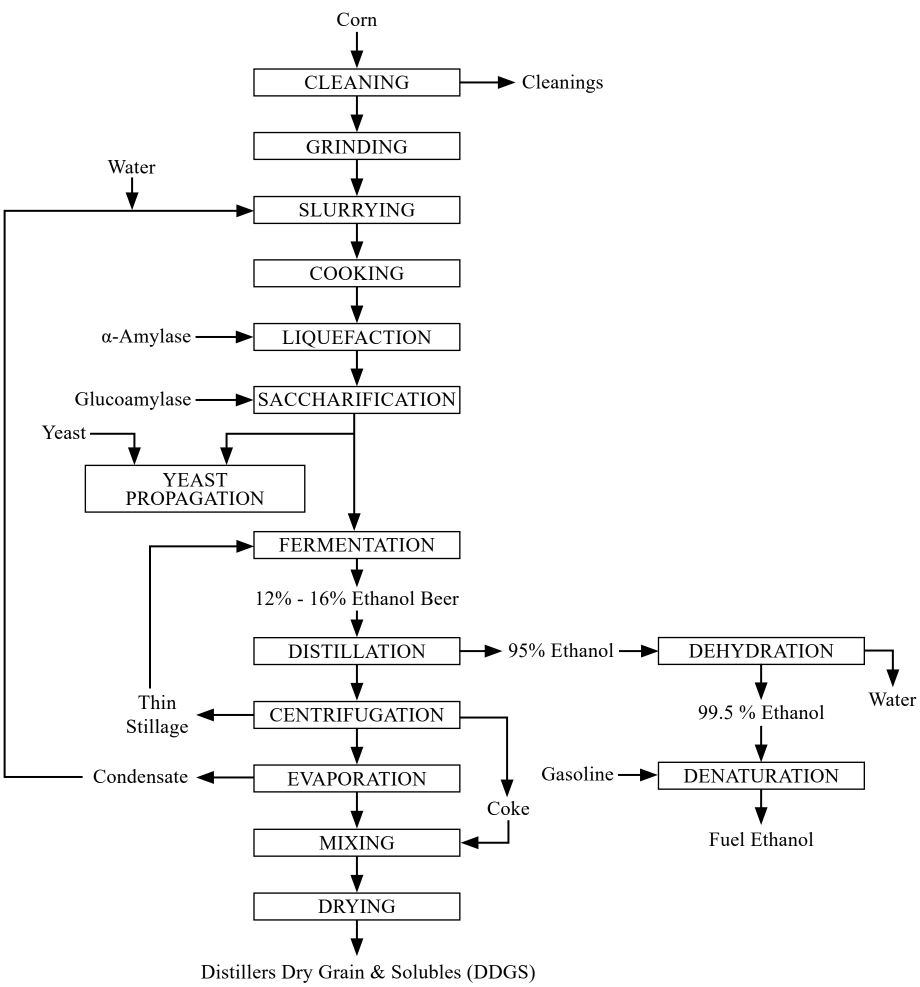

Figure 2. Flow diagram of a dry grind ethanol plant

Cleaning and sorting grain is used to segregate materials for downstream customers. Various functional equipment components are commonly used for cleaning and sorting. Oscillating sieves, including equipment such as a scalper or fanning mill, sort materials by trapping sizes atop the sieve greater than the openings in the sieve below it. Pneumatic devices, such as an aspirator, separate materials based on their drag force in a stream of flowing air. A gravity table combines an oscillating surface and airflow for separation. A spiral separator uses rolling inertia to separate round from flat objects, such as soybean and corn seed, respectively. A cylinder or disc separator is used to separate objects with different lengths (e.g., small-seeded grains). Other common functional components such as a corn sheller or cotton gin are used within the processing plant to further separate harvested field crops for later processing steps. De-germing or de-hulling equipment is common in some pre-processing streams.

Storage components are necessary within a processing system to temporarily hold product between processing steps with different material flow rates. Storage may also be used when product requires a detention time for mixing, heating, cooling, and/or interaction with a chemical process. Storage for dry materials is commonly a bin with a hopper-shaped bottom. In addition to tempering product with heat flow into (i.e., heating) or out of (i.e., cooling) the material or chemical interaction, the storage hopper may be used as a dump scale to individually weigh and segregate batches. If water has been added or product has been made into a slurry, the storage component is a tank, which may be additionally used for stirring, mixing, adding enzymes or chemicals, or decanting liquid.

Transport from one processing step to another is accomplished by some type of conveyor such as a screw auger, chain conveyor, flat belt, pneumatic tube, or pipe for liquids.

The degree of inspection and clean-out is typically determined by the collection of processing system components to be seen or accessed, including disassembly of equipment in a reasonable time period. The amount of access by equipment disassembly varies according to regulatory, customer, and supplier needs. Requirements should be carefully assessed by cleaners and inspectors on a case-by-case basis to maintain integrity of the food or feed chain within the marketplace. For example, is removal of just whole “grain” (or other product) necessary or will removal of smaller broken pieces of biomaterial and other foreign material be required?

Grain removal tools

Tools for inspection and cleaning include both functional items to physically remove materials and personal protective equipment (PPE) to protect the person doing the inspecting and/or cleaning. During initial cleaning it may be more efficient to remove larger amounts of residual materials with a small scoop or broom if access permits. Vibrating or tapping sloped surfaces with a rubber mallet allows loosened materials to fall to a lower level. Dry materials are frequently removed by vacuum air with a device such as a large shop vacuum with adequate airflow and negative pressure to remove material. Pressurized (compressed) air or perhaps a portable leaf blower is also commonly used unless a dust explosion hazard exists in a confined space. Pressurized water is used for cleaning in liquid systems, and may be considered in dry systems if surface corrosion, exposed bearing surfaces, and other nearby equipment can tolerate water exposure. A flathead screwdriver or another type of picking tool may be required to dislodge smaller materials trapped in joints, cracks, or between closely fitting parts. Portable lighting (i.e., a flashlight, headlamp) may be required when inspecting and cleaning in dark recesses with limited ambient interior lighting.

Required PPE (figure 3) depends on the type of exposure during cleaning and inspection. A hard hat or bump cap protects the head when working around equipment and is often required in an industrial processing area. A two-strap dust mask or respirator protects lungs from inhaling dust and foreign material. Safety glasses protect eyes from potential flying debris if grain is dislodged with a pick and hammer. Hearing protection may be needed when operating cleaning equipment or if other processing equipment is operating. Gloves protect hands from abrasive surfaces. Chemically resistant rubber gloves may be required in some instances (such as around treated seed). To avoid cross-contamination during subsequent cleaning or inspecting jobs, tools and equipment should be cleaned following each use.

Figure 3. Personal protective equipment including two-strap dust mask, ear plugs, hard hat, safety glasses, and gloves

Oscillating sieve

The oscillating sieve or screen, sometimes called a screen shaker, is a widely used device to sort grain and other dry materials by size (figures 4 and 5). The pitched screen oscillates horizontally and slightly vertically in an elliptical motion. Materials placed on the screen are lifted vertically by screen movement and move horizontally in the direction of the moving screen as the screen falls away slightly underneath it. As materials “walk” across the screen, smaller pieces fall through screen openings. Material large enough to stay on the screen is collected in a bin or catch tray at the far end of the screen after being bounced across it. Multiple screens (two or more) are often present with smaller screen sizes at lower levels trapping ever smaller particles. An oscillating sieve may have multiple stages. Each stage consists of one or more screens similarly pitched so that materials flow toward one side of the sieve. Materials not trapped by an upper stage of sieves fall onto the top screen of the next lowest stage of screens. These screens are pitched so that materials flow toward the opposite side of the sieve, thus re-using most of the screen surface as it flows through this second stage. The material flow path begins as materials drop, usually metered from a large hopper-bottomed bin, at the top of the oscillating sieve onto the top screen. From there, materials gradually move to collection bins at the end of each screen as they keep falling to lower screens. A bottom collection bin collects the smallest particle size. The first screen (with the largest openings) receiving materials is termed a scalping screen or scalper.

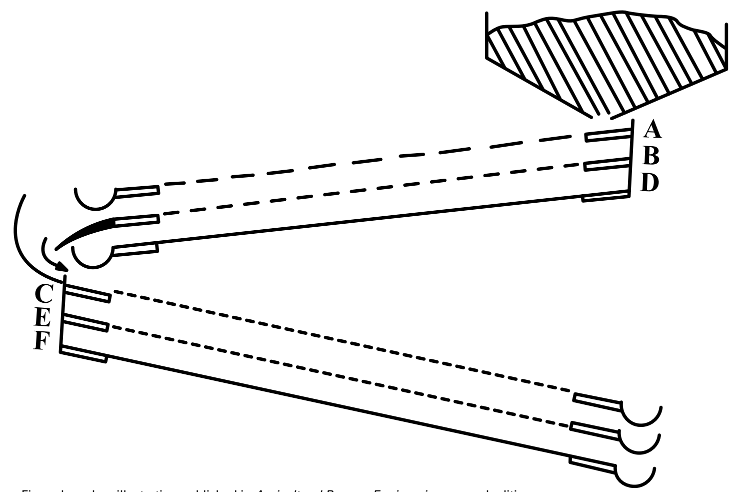

Figure based on illustration published in *Agricultural Process Engineering*, second edition.
Courtesy of the American Society of Agricultural and Biological Engineers, St. Joseph, Michigan.

Figure 4. Two-stage oscillating sieve. Largest and smallest sizes of materials are collected on screen A and pan D, respectively. Materials collected on screen B are further sized on screens C and E and pan F.

Figure 5. An oscillating sieve machine in a processing plant

Screens (figure 6) can be easily removed for cleaning and inspection since screens are frequently changed for different sorting requirements. Accessibility in other areas, particularly the oscillating drive mechanism, may be limited. Typical areas for residual materials to collect include sloping surfaces and bends of the feed hopper, metering device, or collection bins; corners and edges of the screens; and the frame that holds the screens inside the oscillating sieve.

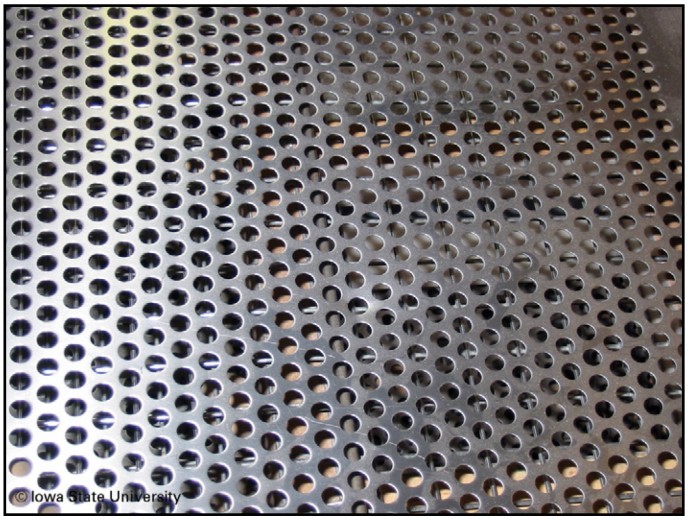

Figure 6. Surface of round-hole screen

One common variation of an oscillating sieve uses a directed air stream (pressure and/or vacuum) across materials as they enter or exit some of the screens for further separation. The combination of an oscillating sieve and directed air flow with fans and internal ducts is called a fanning mill or air screen mill.

Aspirator

Pneumatic separation devices, such as an aspirator, separate materials by the effect of air drag or friction on particles of different shapes and densities. The principle is illustrated by early grain harvesters winnowing grain away from lighter plant material after it had been threshed. In one form of winnowing, grain and lighter material on a cloth sheet were thrown into the air by workers holding the edges of the sheet. Wind carried the lighter chaff and plant materials away while the heavier grain fell back onto the sheet. In effect, lighter material with a larger surface to weight ratio (chaff) is caught by moving air and carried away from the more compact, dense grain. Pneumatic separation only depends on differing drag in the fluid (in this case air) of the particles to be separated. Water could also be used in place of air as the separating fluid in situations with different material properties.

Moving air can be pressurized, blowing past the materials to be separated, or drawn by vacuum or negative pressure through the materials from the intake side of the fan. If drawn, the device is called an aspirator (figures 7and 8). The flow path of materials generally begin from an upper feed hopper. As materials drop through a column of air, the fraction with increased air drag becomes entrained in passing air and is separated by moving to another location, or perhaps out through the fan in a vacuum aspirator design. The trajectory of materials less affected by air drag fall through the device to a different collection bin or hopper. Material collected and carried by moving air may be separated from moving air and exit the device at the bottom of a cyclone separator. Centrifugal force throws material against the wall of the cyclone, and it falls to the bottom of the funnel exit as lighter air exits the center of the top.

Figure 7. Laboratory-sized aspirator with plexiglass side. Centrifugal fan within upper-left corner of aspirator sucks (and separates) lighter material from grain falling past it.

Figure 8. Commerical aspirator

Because of high volume air movement, pneumatic equipment is generally more self-cleaning than other equipment. Limited access may be gained by opening or removing doors and side panels. As with other equipment, residual material may hang up on irregular surfaces of feed hoppers or collection bins. Other areas with greater chances of residual material are any location where air flow slows such as at flow path bends. Slowing air flow allows material to drop out of the air stream.

Gravity table

A gravity table separates materials with different densities by using the table top as an oscillating conveyor and by pneumatic lifting of the materials. For given size and power requirements, its capacity is more limited for sorting than other devices, but it can successfully sort materials with small density differences. It is often used after other sorting steps. A common application is to separate lighter weight infertile seed from seed stock to improve germination percentage.

Materials enter the gravity table (figure 9) by falling on one corner of the table surface. The surface is sloped in two directions, perpendicular to each other. In one direction, the table surface oscillates on an eccentric drive, “walking” heavier materials up a slope, across the surface. As the heavier materials are more firmly caught on the abrasive surface, it is thrown up the “side” slope in the direction of oscillation (figure 10). The heaviest material traverses up this positive side slope “walking” across the table toward the opposite corner before falling from the part of the table surface furthest away from the entry corner.

In the second direction (perpendicular to the side slope), the table surface is negatively sloped downward (the “end” slope, figure 10). Air moving up through perforated openings in the table surface partially fluidizes the mat of material, decreasing the ability of lighter density particles to be caught on the table surface and thrown up the side slope to the far corner of the table. Instead, these lighter particles tend to simply move downward along the end slope to the adjacent corner before falling from the surface.

Figure 9. Gravity table

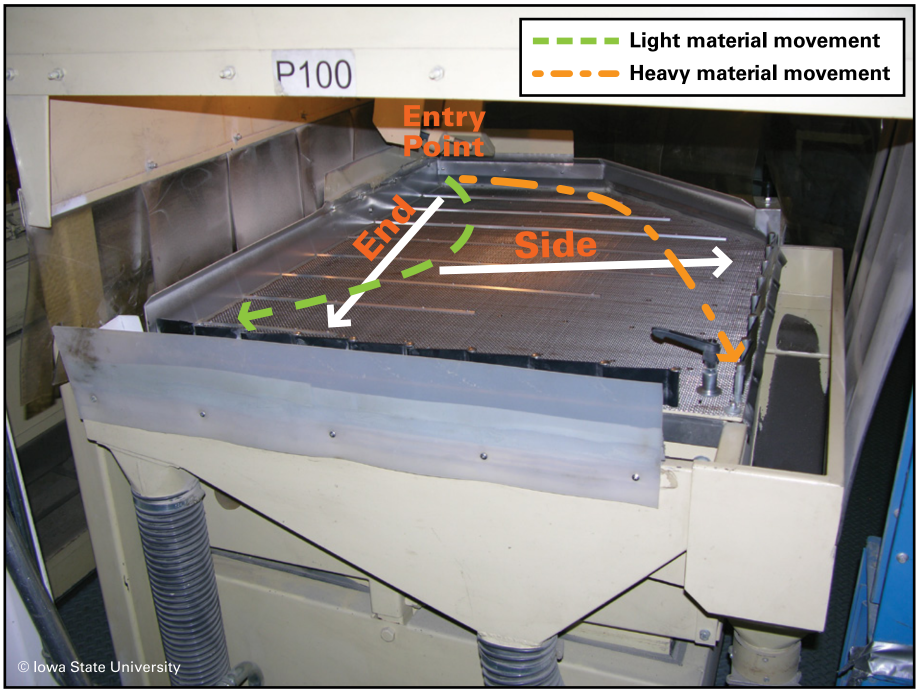

Figure 10. White arrows show side-slope (positive) and end-slope (negative) on a gravity table surface. Colored arrows show movement of materials.

Materials flow from a feeding hopper onto the entry corner, across the table surface, and into collection bins or hoppers along other sides of the table. Residual materials may be held in the entrance hopper, the exit bins, or on the table surface. It may be necessary to open a table cover or hood to gain access to the surface. Perforated holes in the table surface are routinely cleaned of small bits of material, but the surface should be removed and cleaned, and the frame and area underneath it inspected and cleaned. Residual materials may also have settled in air ducts or around the fan in areas of reduced air flow.

Spiral separator

A spiral separator (figure 11) divides material by shape as it rolls down an inclined plane configured in a helix. The separator consists of two or more helices. Materials are fed through a funnel-shaped hopper on an inner or center helix. As round shapes pick up speed rolling down the helix, centrifugal force moves them to the outer edge of the helix and they fall into an outer helix. Shapes that roll slowly never leave the inner helix or leave it at a lower point in the spiral. Bins collect shape-sorted materials at the bottom of each helix.

Figure 11. Spiral separator

Materials follow a helical flow path. Architecture inside the helices is generally open, although the device itself may be enclosed to reduce dust generation and noise as well as prevent some of the fastest falling material from bouncing out of an outer helix. Helices are designed to be self-cleaning, but dust or small material may be present as well as high moisture, "sticky" material that moves sluggishly down the spiral. Check for materials in the entrance hopper, at the exits to collection bins, and those falling outside the separator.

Cylinder/disc separator

A cylinder or disc separator has the ability to separate or grade materials by length or width. A cylinder separator consists of a drum rotating on a horizontal axis (figure 12). The internal surface on the drum has a series of indentations. By carefully selecting the size of indentations, some material will fit into indentations as the drum rotates and be carried to a higher elevation than other materials not easily picked up by the indentations. An exit conveyor in the upper part of the drum collects material that has been caught in the indentations and is carried to a higher elevation. Materials not picked up in the indentations simply roll near the floor of the rotating drum where they are skimmed onto an exit conveyor.

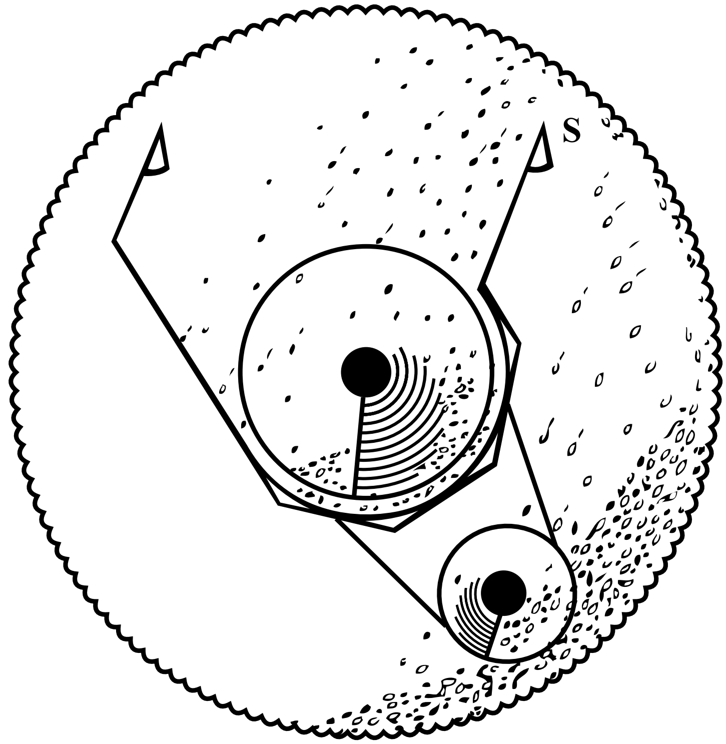

Figure based on illustration published in *Agricultural Process Engineering*, second edition.
Courtesy of the American Society of Agricultural and Biological Engineers, St. Joseph, Michigan.

Figure 12. Cylindrical separator

A disc separator operates on the same principle. A series of discs rotating on a horizontal axis inside a cylindrical drum have indented "pockets" to pick up a specific size or shape. Material carried upward by these indentations in the disc surface is dumped into an upper exit conveyor. Materials not caught in the disc surface stay near the drum floor and exit onto a lower conveyor.

The inner flow path of material is generally accessible because the rotating cylinder or internal discs must be changed to meet grain conditioning requirements. Material generally follows a circular arc after entering the rotating sorter and before exiting. Typical areas for residual materials to collect are the entrance hopper, transfer augers or conveyors to collection bins, and lower areas of the separators that collect falling materials. Indented drum or disc surfaces are designed to collect material of certain shapes. They are routinely inspected and cleaned when sorting requirements change.

Another device also termed a cylinder separator does not use indented pockets to lift different shapes, but instead uses a rotary or cylindrical screen (figure 13). Similar to an oscillating sieve, materials separate by moving through openings. As the screen rotates about the axis of the cylinder, grain larger than the screen size moves slowly to the far end of the slightly sloped cylinder. Smaller pieces falling through the screen openings are collected separately (figure 14).

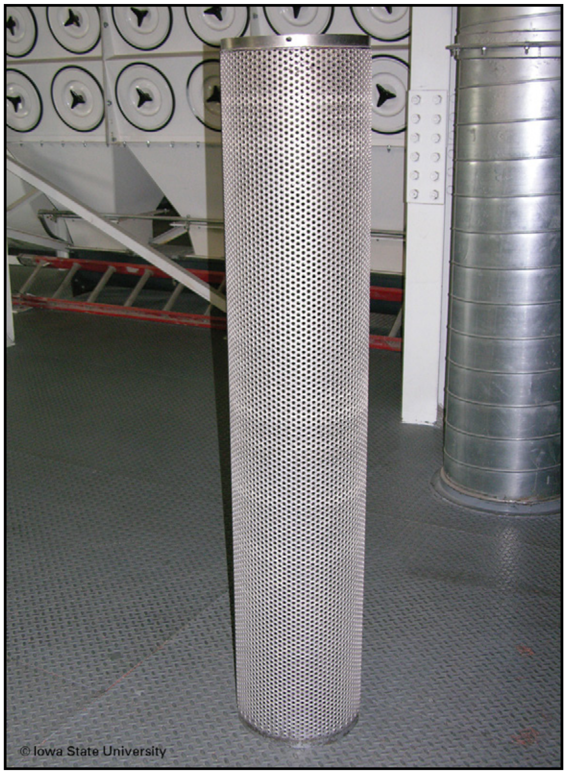

Figure 13. Cylindrical screen

Figure 14. Cylindrical screen separator with a cover removed to expose cylindrical screen (note feed tubes on right side of machine)

Thresher/sheller

Seed corn is field harvested with seed (i.e., corn kernels) and husks still attached to the ear. Husks are removed from the ear by husking beds either in the field or in the processing plant (figure 15). Inclined rolls take husks off as ears move down the bed parallel to roller axes. Kernels are separated from the cob in a stationary sheller (figure 16) in one of the processing operations at a seed corn plant. Threshing seed from the cob by the sheller is done in similar manner to the threshing cylinder or rotor and concave on a field combine during harvest (see threshing section in harvest equipment module in this series for additional information). Areas to inspect and clean in the thresher include the rotating rasp bars and open-mesh concave as well as the feeding and collection or exit areas.

Figure 15. Rolls of a husking bed underneath safety grate

Figure 16. Stationary sheller with rotor surrounded by open wire concave (note bits of cob wedged between concave bars in upper left and general cob "dust" atop concave in lower left foreground)

Magnetic separator

Steel particles or pieces may inadvertently be introduced to biomaterial during harvest, storage, transport, or processing operations. Steel is a foreign material to the crop for food, feed, fuel, or fiber and also negatively impacts many steps in processing. Use of a magnet to separate steel from biomaterial is a common processing step. A magnetic field pulls steel pieces from the material stream as it passes during a transport operation such as within a drop tube or on a flat belt conveyor. Cleaning and inspection is similar to that of transport equipment with the exception of residual materials that may become entrapped around the magnetic device.

Color sorter

Sorting grain by color (figure 17) separates seed with similar size, shape, and density, but dissimilar colors. Grain flow from a hopper/feeder is metered into the sorter so that flow is only a single seed deep as it passes by a color sensor. If the wavelength of light supplied by the sensor and then reflected back from the seed surface is not within a pre-determined range of wavelengths, the seed is re-directed into a separate bin. Seed typically falls down a steeply inclined plane within a number of adjacent but separate channels past a color sensor within each channel. In some systems a "puff" of air generated by a computerized controller pneumatically redirects seed down a different path after the sensor has alerted the controller to an off-colored seed. Areas to clean and inspect include the metering area where seed flow is restricted to produce flow only one seed deep, in the area of the sensor and redirecting mechanism, and other areas in the flow path that may slow, restrict, or redirect grain flow.

Figure 17. Color sorter (overhead feed hopper supplying single-seed depth flow down lower black channels past color sensor into separate flow streams at bottom)

Cotton gin

In addition to actually separating seed from the cotton lint (i.e., ginning) within a gin stand, modern cotton ginning incorporates several processing steps or components, including steps to remove trash and foreign material as well as package cotton lint into a bale. Cleaning steps often use rollers and sieves, or pneumatic devices to clean and control material feed rate. The gin stand itself uses rotating saw blades to pull cotton lint between closely spaced bars or ribs, stripping the cotton seeds from the lint as it passes between the bars. A faster rotating brush or air jet strips (doffs) lint from the saw after it has passed between the bars. A huller, pulling seed cotton between more widely spaced ribs, may be located in front of the saw to aid in feeding seed cotton more uniformly to the saw blades. Roller and saw surfaces are necessarily rough and aggressive to pull fiber through the system so appropriate PPE should be used when working near them. Cleaning and inspection are necessary for roller, saw, sieve, and screen surfaces as well as points in the material flow path that may restrict or slow flow.

Storage

Temporary storage is a common processing step because of time delays, different feed rates of material into other functional components, or the need to hold material for tempering with heating or cooling, for mixing (figure 18) and stirring, or for interaction with chemicals (e.g., enzymes, pesticides for seed treatment). Material safety data sheets (MSDS) with detailed information on safety hazards associated with the chemical should be available for pesticides or other toxic or caustic chemicals. Dry material is typically stored in hopper-bottomed bins. The upper portion of the bin may be cylindrical, square, or rectangular. The lower portion is funnel-shaped with a pitch intended to be steep enough to be generally self-cleaning.

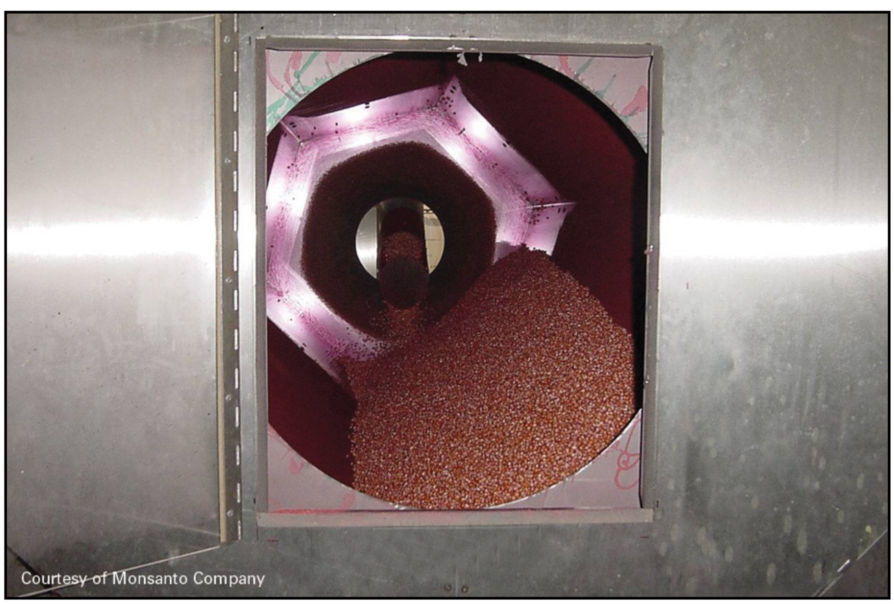

Figure 18. Interior of tumbling mixer used to uniformly mix chemical treatment onto the coats of individual seeds

Despite the intention to be self-cleaning, residual material can hang up in several places (see the grain bin section within the storage equipment module in this series). Common locations for residual materials are bends or transitions in the bin wall surfaces such as where the lower funnel-shaped hopper meets upper vertical sidewalls and any seams where materials are joined together or bent. Although residual materials are more likely to be found on lesser slopes in the funnel-shaped hopper bottom, higher moisture content or "caked" material can cling to vertical sidewalls. A permanently placed vibrator (figure 19) may be used on bins requiring frequent cleaning. A rubber mallet striking the side of a bin helps to loosen dry material so that it falls to the bottom. Opening and closing gated openings can also help to dislodge and empty residual materials. A wash with pressurized water may be allowed in storage areas without mechanical bearings, and if corrosion is not a factor and drainage can be controlled. Inspect and clean around the bin entrance and exit openings where material may hang up or be spilled on surrounding surfaces. If a metering device such as smaller weighing hopper, typing bucket, or fluted wheel is present, inspect and clean it. If interior stirring, heating, or cooling equipment is present, inspect and clean surfaces and any supporting infrastructure.

Figure 19. Pneumatically operated vibrator mounted on bottom exterior of storage bin

Liquid systems

Materials may begin processing in a dry state, but after addition of water or other fluid, they become liquid slurries or liquids (after decanting or filtering). Slurries in particular are generally non-homogeneous, and embedded solid particles may have a tendency to settle out around bends, corners, or other areas of lower flow velocity. Instead of hopper-shaped bins and augers, belts, pneumatic, or chain conveyors, liquid systems use tanks for storage and pipes and pumps for material transfer.

Tanks may have outlets for decanting liquid above a bottom outlet or tank dividers to affect material holding time. In addition, heating, cooling, mixing, stirring, or chemical injection equipment may be present. Pipe interiors are not easily accessed for cleaning and inspection except at entry, exit, inspection, or repair points. Pump wear parts such as the impeller or check valves may be accessed as necessary. Flushing with water, steam, or suitable inert cleaning liquid is often used for the interior of pipes and pumps.

Transport

Materials must be transported or conveyed between each functional or storage step of a processing system. A wide variety of conveying equipment may be used including screw-type augers, pneumatic tubes, flat belts (figure 20), chain conveyors, bucket elevators, vibrating pans, and pipes and pumps for liquid materials. Conveying equipment is usually enclosed both for worker safety and to contain material without introducing foreign substances. Without major disassembly, access is often limited to the entrance and exit of the conveyor along with any inspection or repair openings. Detailed descriptions of conveying equipment, where residual materials occur, and methods to inspect and clean conveying equipment can be found within the handling equipment section of the storage equipment module of this series.

Figure 20. Flat belt conveyors

A location that may require inspection and cleaning is the area where materials are first received at the processing plant. This receiving area may be a drive-over hopper covered by a flow-through grate or a separate hopper adjacent to the transport vehicle (figure 21). Materials fall by gravity from the transport vehicle into the receiving hopper. At the bottom of the hopper, a conveyor moves materials to the first processing component or step. Horizontal grate surfaces and sloping sidewalls of the hopper bottom should be inspected and cleaned. Spilled materials may have accumulated on ground surfaces adjacent to the receiving hopper unless the area has been routinely cleaned.

Figure 21. Receiving hopper for ear corn at a seed corn processing plant (truck unloads from empty bay on right into hopper and ears are moved on vibrating pan surface to flat conveyer belt in background)

Safety

Processing is usually accomplished in a controlled industrial setting inside a building. This contrasts with field equipment, grain storage, and transport vehicle sanitation activities that are usually conducted outside. Processing is generally continuous or in continuous batches during plant operation. Control systems automatically start and stop processing equipment during plant operation as processing components interact. Electricity is used as the power source for most components.

Unexpected equipment operation

Electrically powered equipment should be physically locked out of operation during inspection and cleaning so there is no opportunity for equipment to become unexpectedly operational. Power drive components such as gears, chains, sprockets, belts, and pulleys operate too quickly for human reaction time to avoid an accident. Electrical lock-out or disconnect (figure 22) procedures should already be in place for equipment maintenance or repair. Anyone inspecting or cleaning equipment should work closely with processing plant staff to ensure those involved are always aware when inspection and cleaning are taking place. Pinch point areas can still exist around unpowered equipment such as the narrow clearance between a screw auger and housing. Rotary or other moving parts may unexpectedly turn or displace slightly by manual pressure or other disturbance during physical inspection and cleaning and cause a cut or pinch. Movable parts may need to be blocked to avoid unwanted movement. Some surfaces, particularly those that handle bulk fiber or straw, may be rough or aggressive and require additional protective measures or PPE during cleaning or inspection.

Figure 22. Disconnecting electrical power to rotary screen cleaner

Accessibility and guards

Important areas of processing equipment may have limited accessibility without major disassembly. Aggressive handling components are guarded by location inside the machine so that the opportunity for human exposure is close to nonexistent. On the other hand, areas requiring frequent or occasional user maintenance are likely accessible. Replace guards, shields, and inspection doors before operation if they have been removed for inspection or cleaning.

Confined space

Organic dry fine material or dust suspended in the air in the right combination with oxygen can produce a dust explosion. Although this type of explosion is more frequently associated with dry grain storage, it can occur in dry processing operations. General cleanliness in equipment areas before cleaning for residuals or inspections minimizes this hazard. Avoid suspending large amounts of biomaterial dust into the air in a confined area. If large amounts of dry biomaterial are present, use a broom or scoop before using compressed or vacuum air, the latter may temporarily elevate dust levels and introduce an ignition source. Open doors or hatches to avoid the possibility of rapid pressure build up and explosion. Consider the possibility of pre-wetting material if large amounts of dust are difficult to avoid.

If processing equipment is large enough to hinder communication with outside workers during interior inspection or cleaning, a confined space hazard exists. Evaluate a confined space situation for possible toxic substances and inadequate oxygen levels before entry. Have a communication plan for visual or other contact with an outside person during work inside the space.

Chemical safety

Some processing steps (e.g., seed treatment) involve application of pesticide. Other processing may include the addition of chemical enzymes, acids, or bases. Cleaning may include the use of chemical products. Such materials may be toxic, caustic or both. Toxic exposure can be through the skin (dermal), lungs (respiratory), ingestion through the mouth, or into the eyes. Check with processing plant staff to determine if chemical exposure hazards may be present. MSDS should be present on-site to give information on the hazards involved with specific chemicals and the PPE that may need to be worn by cleaners or inspectors.

Inspection principles

The following general inspection principles are offered to help cover other processing equipment not included in this module. These principles should be carefully considered as much as possible prior to actual inspection and cleaning.

1. Evaluate the function of equipment and typical flow path of material through it.

2. Note where material flow velocity may slow or be restricted for subsequent investigation of residual material.

3. Likely locations that harbor residual material may be along joints, edges, seams between materials or parts, and at sharp bends or corners along flow paths. Horizontal surfaces, either on the interior such as structural flanges, or on the exterior are natural places to collect material either flowing through the equipment or inadvertently spilled onto it.

4. Assess safety risks before starting inspection or cleaning. How is the equipment powered and has power been locked out or disconnected so that restart is not possible? Are sharp or abrasive surfaces present? Can anything hazardous fall on you or can you slip and fall from an elevated height or sloping surface? Is a confined space hazard present? Do other workers know of your presence and activity? Is a chemical treatment being used and if so is there a toxicity hazard?

5. Investigate entry, exit, and available access points. The entry may include a restricted metering mechanism to more uniformly feed the device. Interior flow paths are often guarded to restrict entry for safety reasons during operation. Available access points may include those required for routine maintenance (e.g., lubrication), cleaning, or changing operating conditions of the machine (e.g., changing screen size).