Seed Conditioning Technology
(Part 2 of 2)

Agronomy / Horticulture 338
Seed Science and Technology
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Gravity Table Training History at ISU...

• Demo for ISU Agronomy class
• Digital Signage for Workshops
• WHO-TV Feature (Fall 2016)

Density Definition Review

Bulk Density (“Test Weight”)
• Weight of a given volume of seed, INCLUDING void spaces
• Seed size and shape effects

Particle Density (“Seed Density”)
• Weight of a seed volume EXCLUDING void spaces
• Independent of seed size & shape

Specific Gravity
• Ratio of particle density to water (specific gravity of water = 1.0)
• Tabulated values for various crops

Fluidization and Stratification

• Air velocity causes vertical stratification of product on the deck surface
• Insufficient air will not cause stratification
• Heavy particles sink to the bottom, displacing light particles to the top layer
• Depends on the interaction between particles to obtain vertical separation
• Excessive airflow adds too much energy to the seed mass, causing “bubbling” and mixing of the product
• High airflow also lifts seed away from the deck, reducing traction and moving the pattern down the slope

Destoner

• Seed Layer (3-7 Seeds Deep)
• Reciprocating Perforated Deck
• Eccentric Drive
• Heavy Seeds
• Light Seeds
Gravity Separator

Typical Separation Results:
- Density
- Size
- Shape
- Mixture

- Heavy
- Medium
- Light

Soybean Separation Examples

- Lot Variation
- Highest Corner
- Lowest Corner Inlet

Seed Science Center

Soybean Separation Examples

- Downy Mildew
- Peronospora manshurica
- Mechanically Damaged Soybeans
- Shriveled Soybeans
- Soil Peds

Gravity Deck Configuration

- Two common deck shapes
  - Rectangular deck
    - Long path for light seed
    - Popular for seed applications
  - Trapezoidal or Triangular deck
    - Long path for heavy seed
    - Used for applications that need heavy product separation

Removal of Ergot from Barley

- Ergot Percentage in Barley Fractions
- Compares Initial, Heavy, and Light Fractions
- Gravity was very effective at removing ergot
- Safe discard disposal may be a concern

Fusarium spp. in Maize Seed

- Gravity Light was a relatively small percentage of all size fractions
- Fusarium concentration was greatest in small round seed sizes and low density fractions within each seed size
- Low density small round seed comprised only 3.2% of seed lot weight but contained about 39.9% of total infected seeds

• Gillette et al., 1999

• Adapted from data provided by Dr. Gary Munkvold, ISU

• Image provided courtesy of Dr. Gary Munkvold, ISU
Discharge Sampling Locations

Based on Quality Requirements
- Typically based on Test Weight
- Limit can be based on actual values or other methods such as percent of overall range or transition points

Possible Sampling Locations:
- Overall range between light and heavy samples
- Overall fraction average
- Lightest or heaviest portion within each fraction

Gravity Separator Middling Alternates

- Possible Recovery of Good Seed from Intermediate Fraction
- Possible options:
  - Run Middling with Heavy Seed
  - Store & Rerun Middling Later
  - Recirculate over Same Gravity
  - Reclaim using Second Gravity, Color Sorter and/or Belt Separator

*** Minimize recirculation to increase net system capacity and reduce mechanical damage ***

Gravity Summary

- Destoners and Gravity Separators use a vibrating fluidized bed to “Float” lighter seed from heavy material.
- A Destoner is tilted on one axis and produces a two way separation between heavy and light product.
- A Gravity Separator is tilted on two axis and produces a continuous output range based on density. The operator selects the desired product from the gravity discharge using divider gates or valves.
- Destoners are commonly used to remove heavy foreign material, while gravity separators are used to remove lightweight low quality seed.
- Typical basic adjustments include Air, Speed, Side Slope, and End Slope.
- Air and Speed tend to have opposite effects on the deck pattern.
- Middling product is frequently re-circulated to minimize good seed loss.
- Proper Installation, Maintenance, and Adjustment are Critical to obtain good results from any destoner or gravity separator.

Color Sorting Technology

- Visible, Near Infrared, or UV Light
- Based on Color Differential
- Light and Dark Separation
- Remove Discolored & Broken Seed
- Low Density may be Removed IF Discolored

*** Minimize recirculation to increase net system capacity and reduce mechanical damage ***
Color Sorter Definitions

REJECTS
• Product diverted from main flow stream by sorting process

ACCEPTS
• Flows directly through machine - NOT rejected by sorting process
• Typically "good" seed for most applications
• Should comprise the largest percentage for capacity and efficiency

DEFECTS
• Undesirable product to be removed by sorting process
• Usually quantified visually unless other methods are available

BAD to GOOD RATIO (B:G)
• Ratio of "defects" to acceptable seeds in either "accepts" or "rejects"
• Typically measured on reject product due to high defect concentration

Color Sorter Samples – Soybeans

Color Sort – Red & White Waxy Wheat

Red Wheat (81.9%)  White Wheat (18.1%)

Color Sort Examples - Seed Corn

Yellow Dent Corn (2011, low trip level)

Color Sorter – Sunflower (bichromatic)

Clean Seed  Foreign Material & Discolored Seed

Sclerotia vs Sunflower

Color Sorter Functions

CONVEYANCE (FEEDING)
• Single stream of seeds flowing past sensors
• Uniform high seed velocity to obtain required capacity
• Seeds must be spaced apart for efficient separation

DETECTION
• Line cameras or other optical sensors
• Seed is typically viewed against a colored background
• Signal is compared to preset dark and / or light levels

EJECTION
• Compressed air ejectors used to reject product from stream
• Ejector timing is critical to maintain separation efficiency
Color Selection & Optical Layout

Transmittance

Light source → Sample → Optional Filter → Line Scan Camera

Reflectance

Light source → Sample → Optional Filter → Camera

Filter Selection Examples

- Front View -

- Rear View -

Camera Configuration & Color Mapping

Monochromatic Shared Camera

- Light Reject
- Accepts
- Dark Reject

Monochromatic Independent Cameras

- Light Reject
- Accepts
- Dark Reject

Bi-chromatic Color Mapping

- Trip Lines
- Accepts
- Rejects
- Good Product

Sortex Z+ Series Color Sorter

- Hopper & Feeder
- Front Cameras
- Rear Cameras
- Ejectors

Recent Lab Samples

- Dark Trip = 548
- Dark Level = 700
- Dark Level = 700

Corn Reject – Multiple Color Defect Levels

- Low
- Medium
- High
- Light

- Three Dark Color Defect Levels
- One Light Color Defect Level
- Light Trip is typically used to remove broken corn
- Frequently limited by bright kernels

Current trend toward RGB designs
**Color Sort – Selected Dark Defects**

- Accepts
- Rejects
- Hand Selected from Rejects

**Multiple Pass Sort – Coffee Beans**

- Dark Intermediates
- Dark Accepts
- Light Intermediates
- Light Accepts

**Typical Resort System**

- Multiple color sorters or split machine
- Adjust Primary Sensitivity to yield good final product
- Primary Sort Rejects are resorted to reclaim seed
- Adjust Resort Sensitivity to minimize good seed loss
- Resort Rejects to Discard
- Resort Accepts Blended with Incoming Product

**Sortex Z+ Installation**

**Primary and Resort Operations**

**Resort Example - Corn**

- Incoming Product
- Primary Rejects
- Resort Rejects

- Primary Accepts
- Resort Accepts
- Simulated Resort Samples
- Primary Sort Rejects are Resorted to Reclaim Seed
- Resort Rejects to Discard
- Resort Accepts Blended with Incoming Product
- Output Similar to Primary Accept Sample Shown

**Primary and Secondary Sort**

- Incoming Product
- Primary Sort
- Secondary Sort

- R
- A
- A
- R

- Primary Discard
- Final Product
- Secondary Discard

- Used with high initial defect rates
- Better final quality - critical applications
Dark Hilum Removal – Two Stage Sort

- Accepts: 96.2%, 1.9% defects
- Rejects: 3.8%, 98.1% defects

- Initial Sorting Efficiency ~ 66.8%
- Overall Sorting Efficiency ~ 89.8%

Color Sort – Black Soybeans

- Primary Reject (bichromatic)
- Secondary Reject (monochromatic)
- Secondary Accept (Final product)

- Accepts: 92.3%, 0.92% defects
- Rejects: 3.9%, 96.4% defects

Buhler Sortex Color Sorters

- A Series Color Sorting Equipment

Satake Color Sorter Examples

- 40 Channel RGB
- 80 Channel RGB
- Optical Cabinet

- Traditionally mono or bi-chromatic designs
- Newer machines are RGB ("true color") systems

Additional Color Sorters

- Delta Technology
- Cimbria (SEA)

- Multiple machines based on recent ASTA CSS Seed Expo Exhibits and related communications

Recent Small Batch Sorter Introductions

- VMEK
- Oliver (ASM)
- SATAKE USA

- Multiple machines based on recent ASTA CSS Seed Expo Exhibits and related communications
**Color Sorting Summary**
- Can use visible, near infrared (NIR), or ultraviolet (UV) light
- Most current seed applications use monochromatic reflected light
- Two way separation products - Accepts and Rejects
- Separation based on gray scale intensity in selected wavelengths
- Can be equipped for simultaneous light and dark separation
- Finishing machine used to remove discolored & broken seed
- Lightweight or shriveled seed may be removed IF also discolored
- Rapidly evolving technology with potential for improvement

Color sorting is a useful tool when appropriate for the application, operators are properly trained, and adequate maintenance and support can be provided

**Commercial Seed Treating Equipment**
- Designed for production plants
- Gradual trend toward batch operation
- Sophisticated chemical handling
- Relatively complex & expensive

**Ag Retail Treater Installations**
- Bulk Containers
  - Dealer applied treatment
  - Bulk seed handling
  - Short treating season
  - Price sensitive designs
- Outdoor Installation
- Portable Installation

**Seed Treatment Chemicals**
- Common Seed Treatment Products
  - Fungicides
  - Insecticides
  - Nematicides
  - Avicides
  - Polymers
  - Inoculants
  - Colorants
- Chemical Forms:
  - Powder (dust)
  - Slurry (suspension)
  - Liquid coatings

Treated seed MUST be colored and labeled to distinguish it from seed intended for human or animal consumption

**Application Rates**
- Obtained from Product Label
- Ratio of Chemical to Seed Amounts
- Units can be Volume or Weight Based
- Typical Application requires Multiple Rates

**Premix Tank Batch Formulation**
- Find Label Rate and Density for Each Chemical Required
- Estimate Total Slurry Application Rate
- Calculate Dilution Water Rate (Total less Sum of Chemicals)
- Estimate Seed Weight or Quantity to be Treated per Batch
- Calculate Product Required for Each Tank
  - Batch Volume is the Sum of Product Volumes
  - Batch Weight is the Sum of Product Weights
**Premix Tank Formulation Example**

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<th>Slurry Ingredient 4</th>
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**Automatic Batch Preparation**

- Similar to traditional batch methods
- Computer controlled pumps & valves
- Transfer pump for each chemical
- Typically metered by weight using single or multiple scales
- Optional 2nd tank (continuous flow)

**Automatic Inline Slurry Mixing**

- Primary chemicals mixed continuously
- Parallel operation, multiple pumps
- Typically metered by volume, possibly including flow meter for feedback
- Static mixer combines products prior to chemical application

**General Calibration Procedure**

Determine Application Rate
- Per Cwt: oz/cwt or cubic cm/cwt
- Per Seed: mg of AI per seed

Calculate & Test Seed Rate
- Weigh actual seed output

Calculate & Set Chemical Rate
- Check test volume or weight

Verify Proper Seed Coverage
- Adjust application & mixing time

Confirm Actual Rate based on Seed and Chemical Usage

**Review - Seed Treating Process**

**Basic Treating Equipment Designs**

Automatic Batch
- Lower Capacity
- High Chemical Application Rates
- Flexible - Multiple Chemical Layers
- Continuous Flow
- High Capacity
- Low to Medium Application Rates
- Single Treatment Chemical Layer

Images courtesy of Gustafson (BCS)
Seed Metering Systems

- Gravity Operated Weigh Pans with Adjustable Counterweight Arm
- Computerized Inline or Belt Scales
- Volumetric Rotating Seed Wheel

Chemical Metering Systems

- Weigh Arm Chemical Cups
- Volumetric Rotary Discs
- Variable Speed Metering Pumps
- Volumetric Tubes (batch verify)
- Flow Meters (volume or weight)
- "Loss in Weight" Batch Scales

GLCPS Treating System

- Chemical Tanks & Scales
- Inline Product Scale
- Rotary Chemical Application
- Rotary Hex Drum

Laboratory Batch Treaters

Sample treatment methods:
- Zip-Loc bag or coffee can
- Planter magazine treater
- "Cement Mixer" rotating drum
- Direct chemical application
- Rotostat
- Vertical drum with rotary bottom
- Atomizing disk chemical application

Batch Treating Systems

- Mixing bowl speed set at minimum level required for proper mixing
- Dual mixing vanes to "fold" product inward, avoid atomizing disk contact
Typical “Loss in Weight” Installation

- Treater, Premix Tanks, and Loss in Weight Chemical Metering System

Treatment Rate Verification

- Periodic Tests to Check Accuracy
- Seed & Chemical Usage Records
- Calculate ACTUAL chemical rate applied
- Adjust Equipment to Desired Rate
- Select Reasonable Sampling Interval

Sample AT LEAST once per lot or shift, NOT averaged over entire conditioning season

Secondary Drying

Treatment dryer applications
- Small, high value seeds
- Very high liquid application rates

Typical dryer designs
- Belt or vibratory conveyors
- Natural or heated air
- Conventional or fluidized bed

Advantages:
- Relatively fast & uniform drying

Disadvantages:
- Initial and operating costs
- Disposal of contaminated air

Fluidized Bed Dryers

Dust-Off Control & Monitoring

- Quantify dust-off during sample handling
- Loose dust particles captured in filter
- Filter results are used for analysis
- Apparent “standard” in Europe (ESTA)

Heubach Dustmeter

Large Chamber

Dust Filter

Treatment Summary

- Label rate is the proportion of chemical to seed
- Application rates may need to be converted to alternate units of measurement for calculations
- Key issues are batch vs continuous flow and metering methods used for chemical and seed
- Minimize excess abrasion during secondary mixing and drying operations to limit dust-off
- Verify actual applied rate in a timely manner
- Careful application and mixing procedures can provide superior treating results

References & Acknowledgements

IA Commercial Pesticide Applicator Series:
- Core Manual
- Category 4 (Seed Treatment) Manual

Bayer CropScience / Gustafson Equipment Division – Shakopee, Minnesota

USC, LLC – Sabetha, Kansas

Direct Enterprises, Inc. – Westfield, Indiana

West Central Cooperative – Boone, Iowa
Packaging

Package Type Factors:
- Market Requirements
- Volumetric Issues
- Desired Automation
- Downstream Handling
- Equipment Availability

Typical Large Seed Packages

Bag Styles
- Open mouth bags
- Valve pack bags
- Paper, plastic, poly-woven

Bulk Containers
- Bulk bags
- Plastic bulk boxes
- Other bulk seed methods

Basic Bagging Line

Primary Components:
- Overhead hopper
- Bagging scale
- Closing conveyor
- Bag top forming area
- Manual tag placement
- Sew head or heat sealer
- Coding wheel or Inkjet
- Bag incline conveyor

- Common configuration for smaller bagging operations
- Capacity is typically limited to a maximum of 5-7 bags per minute
- Manual operations typically limit throughput during extended operation

Bagging Scale Types

Gross Weigh
- Product weighed in bag
- Lower cost hardware
- Less height required
- Limited capacity
- Frequently less accurate

Net Weigh
- Product weighed overhead
- Relative complex hardware
- Substantial space required
- Needed for higher capacity
- Usually more accurate
- Single or duplex designs

Bulk Bagging Scale Types

Gross Weigh
- Product weighed in package
- Bag or box supported by scale
- Manual or automatic valve

Net Weigh
- Product pre-weighed in hopper
- Bag or box located on platform
- Dual automatic staging valves

Multiple Stage Filling

Single Stage Filling
- Speed vs Accuracy Issues
- Need low speed for accuracy
- “Overshoot” at higher fill speed

Two Stage Filling
- “Bulk and Dribble” operation
- High initial rate for speed
- Reduced rate near target
- Used to increase accuracy for operation at higher speed

Images courtesy of Chantland-MHS

Images courtesy of Taylor Products, Slidell, and Express Scale
Bagging Scale Calibration

• Calibrated using known weight and a certified scale
• Finished bag weights should be verified periodically
• Some scales can check scale calibration during operation using an automatic internal weight mechanism
• Scale accuracy is typically rated at 2σ (ex: +/- 0.75 oz)
• Target weight is increased to reduce percent of packages below Maximum Allowable Variation (MAV) levels
• Relatively expensive scales may be more economical due to reduced product required to meet regulatory limits

Bagging Scale Calibration Comments

• AVERAGE BAG CONTENTS for the lot SHOULD EQUAL OR EXCEED unit quantity shown on the package label
• INDIVIDUAL BAG CONTENTS should exceed unit quantity less the applicable MAV for the package labeling method used
• The MAV value is at least partially intended to compensate for sampling and testing variance during inspection procedures.
• Methods shown neglect inherent variance in sampling, seed count, and check weigh scale accuracy
• Many conditioners adjust to provide an additional safety factor when calculating bag target weights.

Packaging by Seed Quantity

• Seed companies traditionally sold corn by count & soybeans by weight
• Recent trends are moving toward selling soybeans by seed count
• Large seed bags are actually filled by weight, not seed count
• Bag weight calculations are estimates based on counted seed samples
• Can lead to potential errors due to variability in sampling, seed counter variation, seed size, seed moisture, and many other factors
• Care is needed to maintain compliance without excess product costs

Tag Placement

• Tags are typically added during bag closing
• May be sewn or attached with adhesive
• Multiple tags are frequently used
• Tag handling can be labor intensive
• Manual applications frequently used a "tag lifter" with concentric tubes & low pressure vacuum source
• Automatic tag placers are also available
• Tag size and consistency can be critical

Closing & Sealing

Sew Head Designs
• Portable or stationary applications
Heat Sealer
• Heated band or hot air
• Requires bag with heat sensitive glue line

Bag Coding and Printing

• Used to print text above sew line
• Coding wheel is simple and lower cost
• Inkjet coders are more expensive but feature programmable text, multiple font sizes, and more flexible text and graphic configuration
**Bag Closing Conveyors**
- Used to support and transport filled bags past the closing, bag top forming, and labeling equipment
- Vee trough conveyors can provide better support but are more complex and expensive
- Support rails are also commonly used for tall bags
- Height adjustment for use of multiple bag lengths
- Belt speed is determined by required bagging rate

**Palletizing Methods**
- Manual Palletizing
  - Shown with stacker & bull pen
- Conventional Palletizer
  - Partial or full auto layer forming
- Robotic Palletizer
  - Flexible, possible space savings

**De-Palletizing & Re-Bagging**

**Packaging Summary**
- Typically the final operation before warehousing or shipment
- Provides convenience, product protection, ease of shipment, product identification, and advertising visibility
- Common package types include small containers, open mouth and valve pack bags, bulk bags, and plastic bulk boxes
- Typical equipment includes a bagging scale, conveyor, closing device, and provisions for labeling and tagging finished package
- Packages are often palletized for ease of handling and shipment
- Similar operations can also be used to empty returned packages
- Final package appearance can be a critical marketing factor

**Pending Lab Equipment Demo - Soybeans**
- Soybean Process:
  - Air-Screen Cleaner
  - Spiral Separator
  - Gravity Separator
  - Color Sorter
  - Seed Treater
  - (Packaging)

**Pending Lab Equipment Demo - Wheat**
- Air Screen Cleaner
- Indent Cylinder
- Gravity Separator
- (Treater & Bagger)
Pending Lab Equipment Operations

• Cleaner Screen Selection – “bin run” soybeans
• Cleaner Sample Analysis – split removal efficiency
• Rotary Spiral Speed Test – discard, split, oblong %
• Bag Weight Estimate & Seed Count Variability
• Bag Weight Variability - vary bulk/dribble setting

1 – Cleaner Screen Selection

• Select one of four “bin run” samples
• Divide into two subsamples (round/slot)
• Sieve - sequential screen stacks (3-5 min)
• Weigh and document product in each screen fraction (note any low quality mat!)

Paired Groups – share round/flats data

2 – Cleaner Sample Analysis

• Select 1 of 4 discard samples
• Note sample weight & time
• Sieve sample using 10/64” slot
• Record “over” and “thru” weights

3 - Rotary Spiral Separator

• Run one sample at listed RPM
• Record run time & sample weights
• Obtain: Seed Count, Oblong, & Split concentration (OptiCount)
• Calculate: % Discard by Fraction, Split & Oblong Removal Efficiency
• Share data to compare speeds

Station 5: Net Weigh Bagging Scale

• Review basic components and operation
• Adjust to approximate “dribble” time listed
• Collect and weigh a total of five (5) “packages”
• Given: Additional values from remaining groups
• Calculate: MAV and minimum package weights
• Check: Which levels met NIST requirements?
**References & Acknowledgements**

- Seed Conditioning – Technology, Volume 2A-B. Gregg, B.R. 2010
- Seed Processing and Handling. Vaughn, Gregg & Delouche. 1968
- Managing Grain After Harvest, Bern. 2005 (AE 469/569 textbook)
- Seed Science and Agronomy Department archives
- ISU Seed Science workshop presentations (2006-2013)
- Various websites, including www.gipsa.usda.gov (seed images)
- Various Industry Brochures, Operator’s Manuals, and Discussions:
  - Advanced Sort Industries – Seymour, IN
  - AEC Enterprises – St. Charles, Iowa
  - ArrowCorp, Inc. – Winnipeg, Manitoba
  - Ball-Coleman (STS) – Chicago, IL
  - Buhler Sortex – Stockton, CA
  - Carter-Day Int’l – Minneapolis, MN
  - Cimbria Bratney Co. – Urbandale, IA
  - Crippen Manufacturing – St. Louis, MI
  - Forsbergs, Inc. – Thief River Falls, MN
  - Harada Sangyo – Ageo, Saitama, Japan
  - LMC Manufacturing – Donalsonville, GA
  - Kice Manufacturing – Wichita, KS
  - Oliver Mfg. – Rocky Ford, CO
  - Profile Industries – Rogers, MN
  - Westrup USA – Dallas, TX
  - Satake USA – Stafford, TX
  - Seedburo – Chicago, IL
  - Universal Industries – Cedar Falls, IA

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**Thanks for your continued support for the ISU Seed Conditioning Program**