Importance of Grain Cleaning for Food Production

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Goal in Wheat Cleaning

- Remove Non-Wheat Material
  - Metal
  - Foreign Material (Debris)
  - Stones
  - Grains other than wheat (soybean, corn, sorghum,… etc.
  - Weed Seeds
- Remove Wheat not-fit for Milling
  - Shrunken & Broken
  - Diseased & Damaged

Non-Wheat Material

Wheat not-fit for Milling

Shrunken/Shriveled

Diseased- Scab

Insect Damaged

Black Tip (color defect)

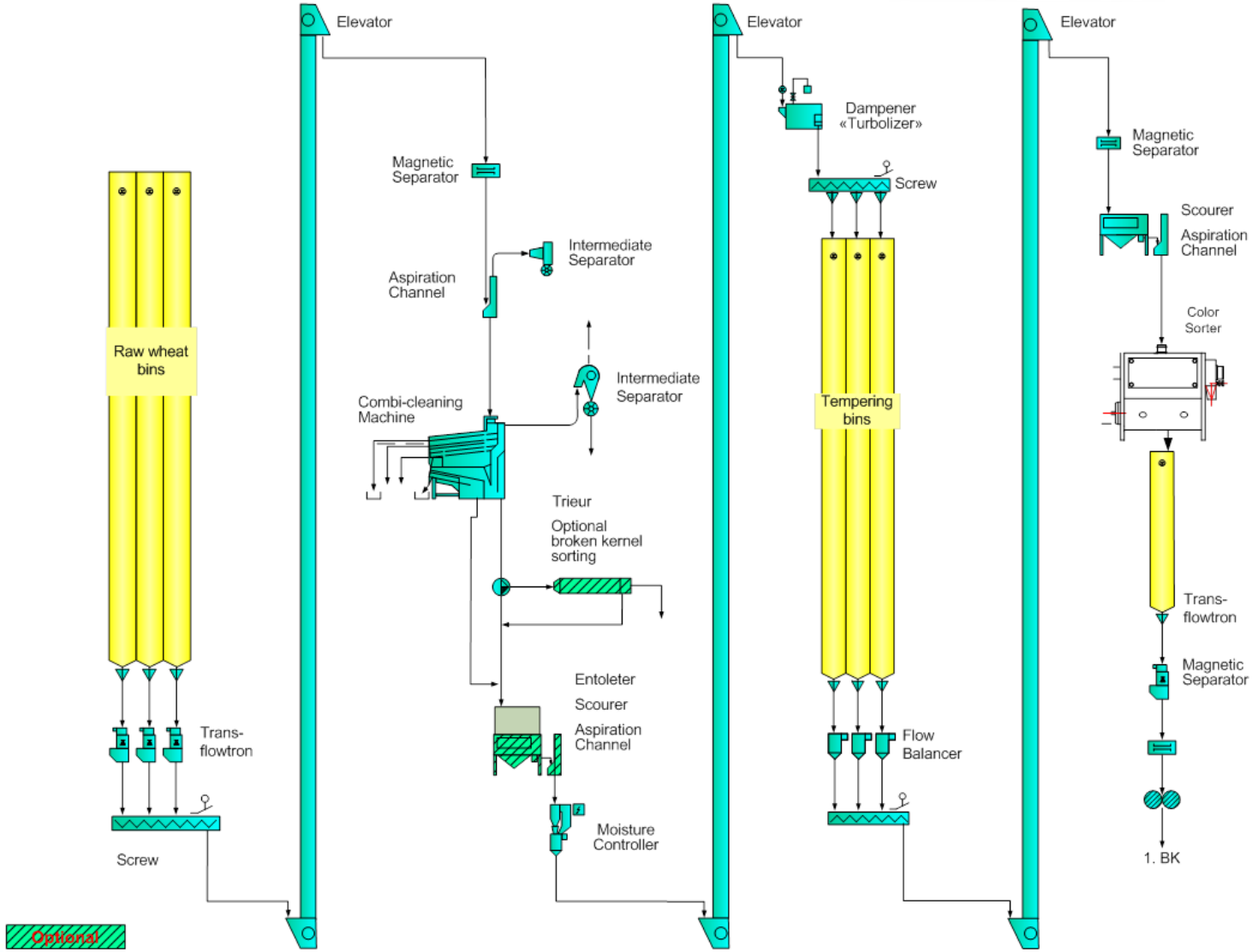
Ergot

Heat Damaged

Physical Properties of Common Impurities

- Impurities are separated from wheat based physical differences which aid their removal.
- Magnetic properties
- Flow in air properties
- Size and shape
- Density
- Friability (easily broken by impact)
- Surface characteristics (color and texture)

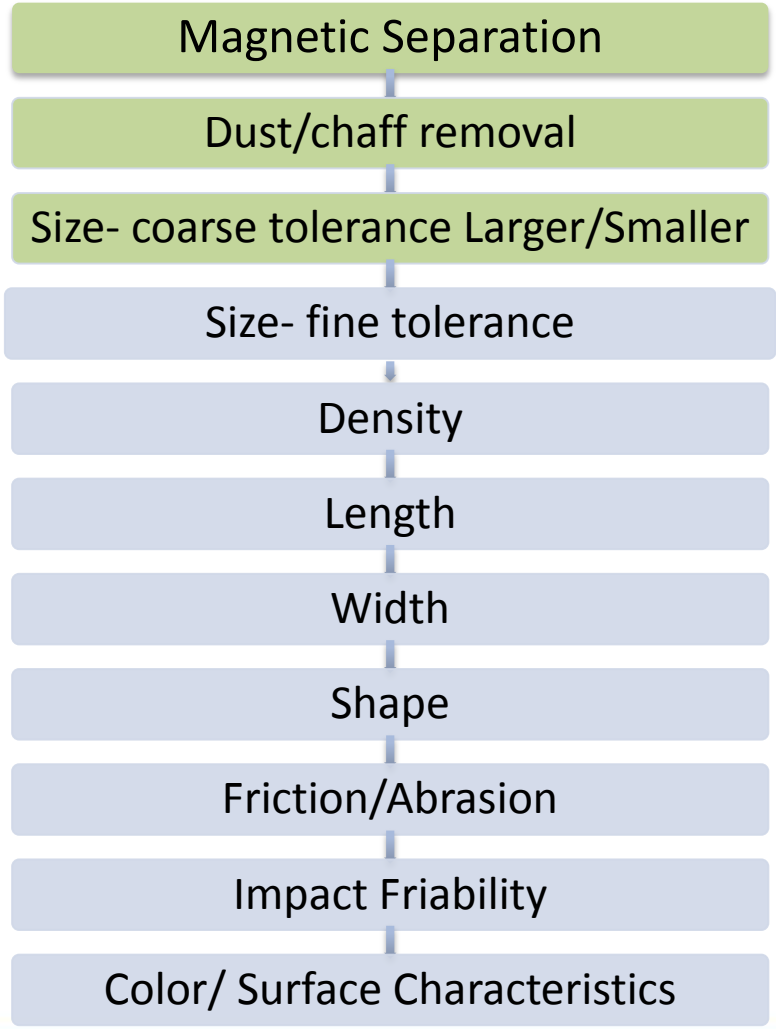
Wheat Cleaning System



Cleaning System Design Principle

1. Eliminate impurities that pose a significant health and safety risk first.
   - Ferrous Metal (grain dust explosion hazard).
   - Grain Dust (explosion risk, health/safety risk).
2. Eliminate impurities which impact downstream machine efficiency.
   - Light chaff and dust (bulky, poor flow characteristics, decreases screening efficiency).

Generic Cleaning Flow Principle



Pre-Cleaning for Wheat Storage

Benefits of Pre-Cleaning

- Decrease infestation risk.
- Improve sanitation and dust control.
- Decrease microbial growth.
- Improves flow of grain through the bin.
- Increases storage life of grain.

Generic Cleaning Flow Principle

Grain Dust Explosion Risk.

Magnetic Separation

Explosion risk, sanitation, health and safety risk.

Greatly improves equipment efficiency.

Dust/chaff Removal

Least similar to wheat based on size.

Easy to remove.

Reduces bulk.

Larger/Smaller than wheat

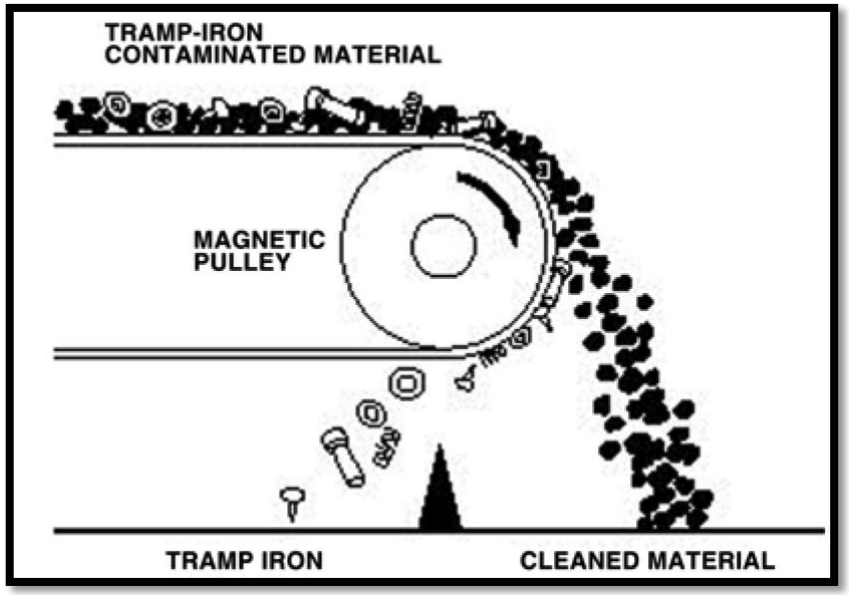
Lighter than wheat.

Stones and mud removal.

High and low density separation.

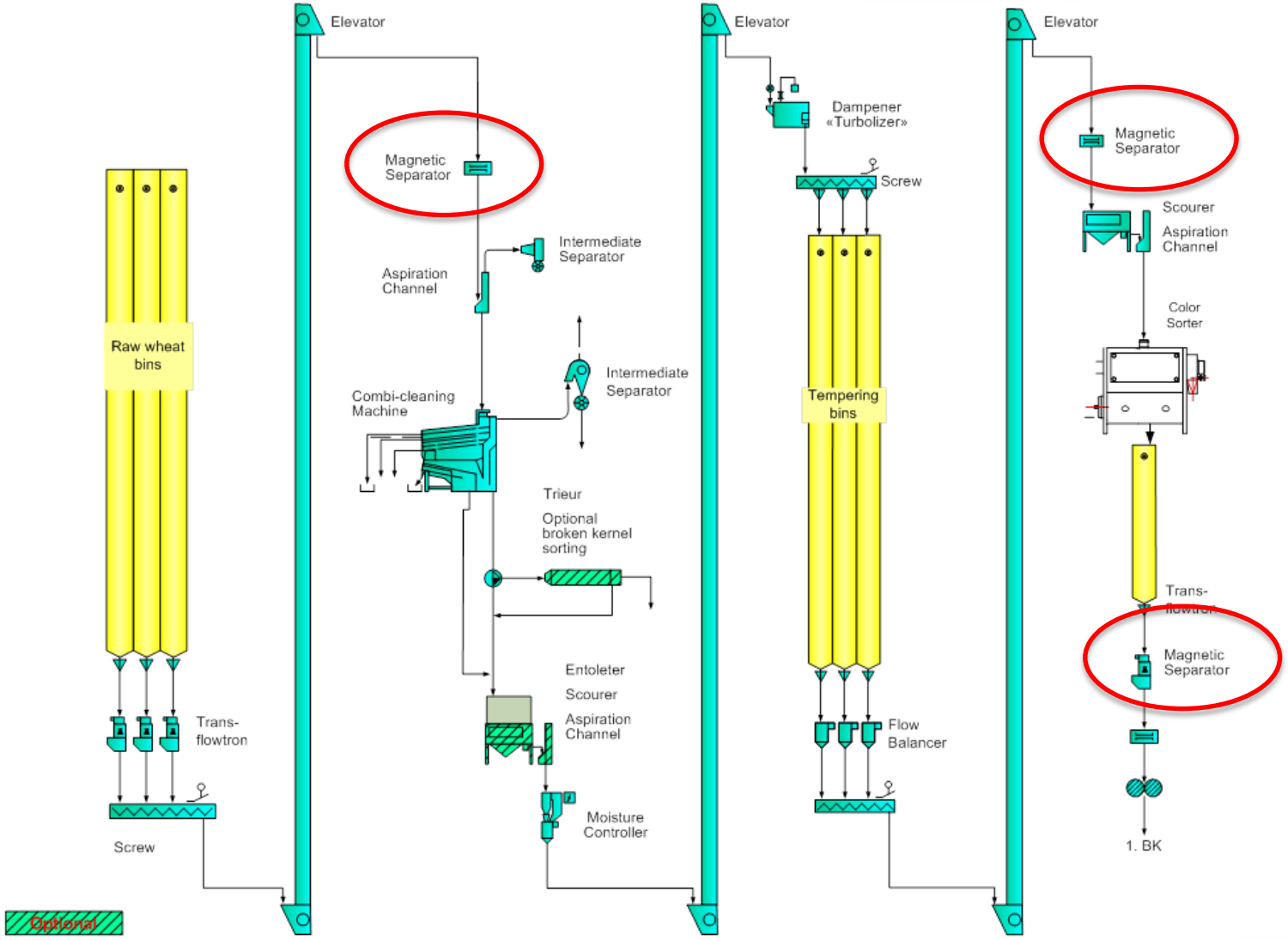
Density

Magnetic Separator

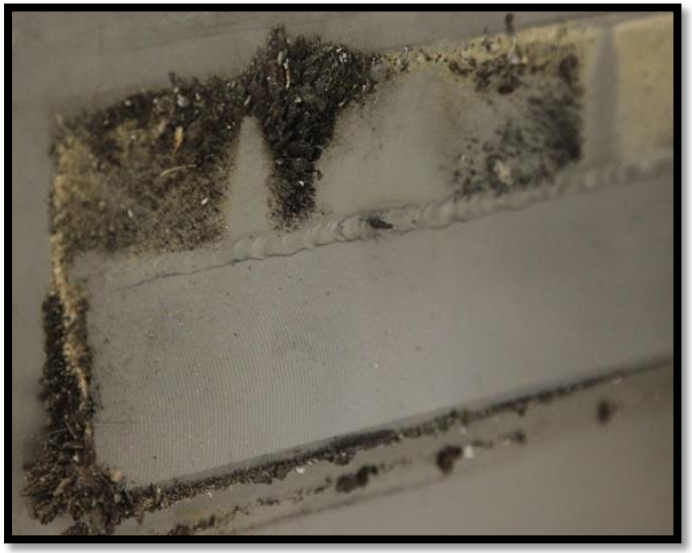


- Tramp Iron or Tramp metal is metal brought in with grain at recieveing.
- Tramp metal is removed at grain unloading. Magnets within the milling process are designed to remove metal generated from equipment failure.
- Rare Earth Magnets are called ferro-magnets because they attract ferrous metals.
- Ferrous metals are made from iron, (Fe) and iron alloys (contain iron).

Magnetic Separator



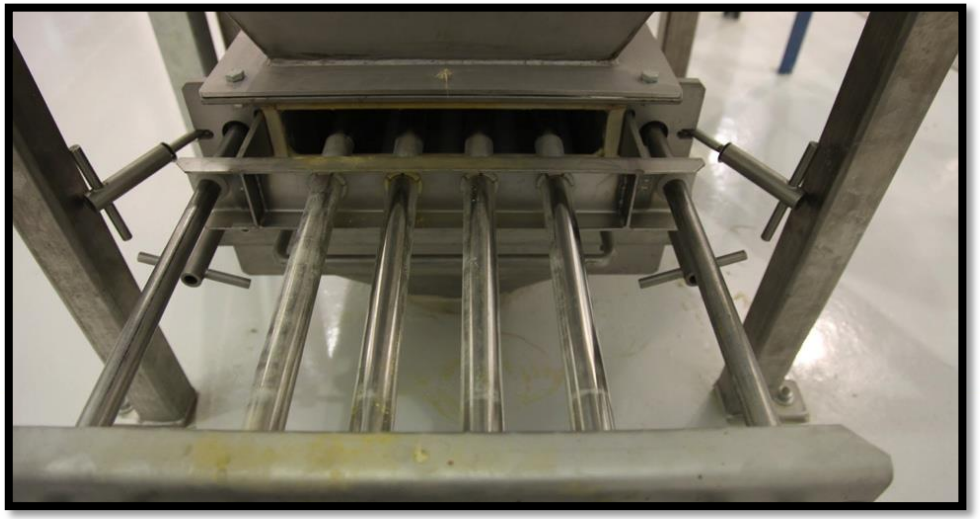
Magnetic Separation Equipment



Hump Style Plate Magnet

Bar Style Magnet

- Material passes over the magnetic bars where metal contaminates are removed.
- To clean the bar style magnet the magnetic rods are pulled out and the metal drops off the bar.



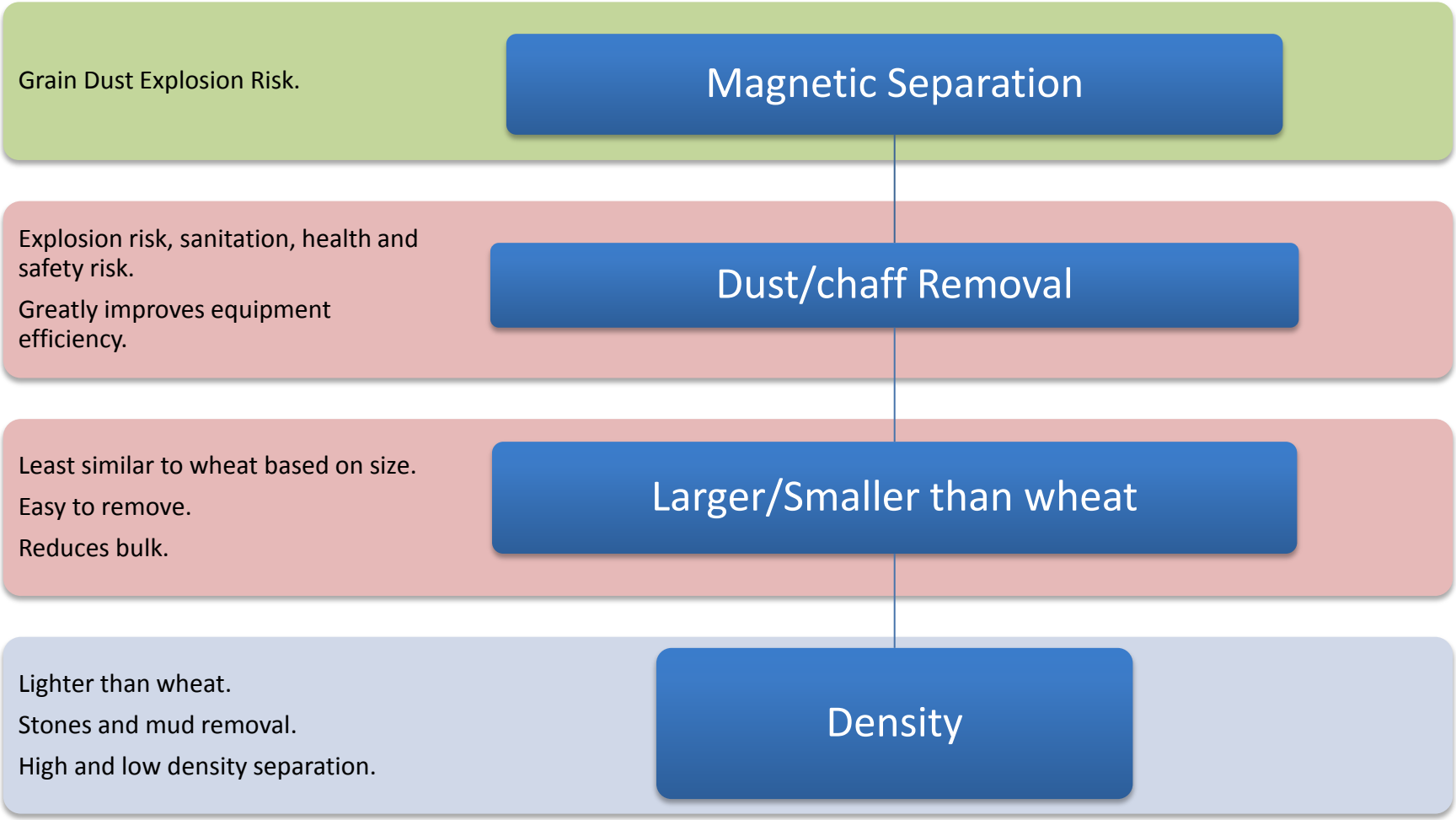
Magnet Maintenance

- Magnets must be cleaned regularly to remove attracted ferrous metal.
  - Magnets have a limited ability to hold ferrous metal. Once overloaded, metal contamination will pass by without being removed.
- Magnet pull strength should be measured and recorded on a routine basis (once per year).
- Magnets with lost strength should be replaced.

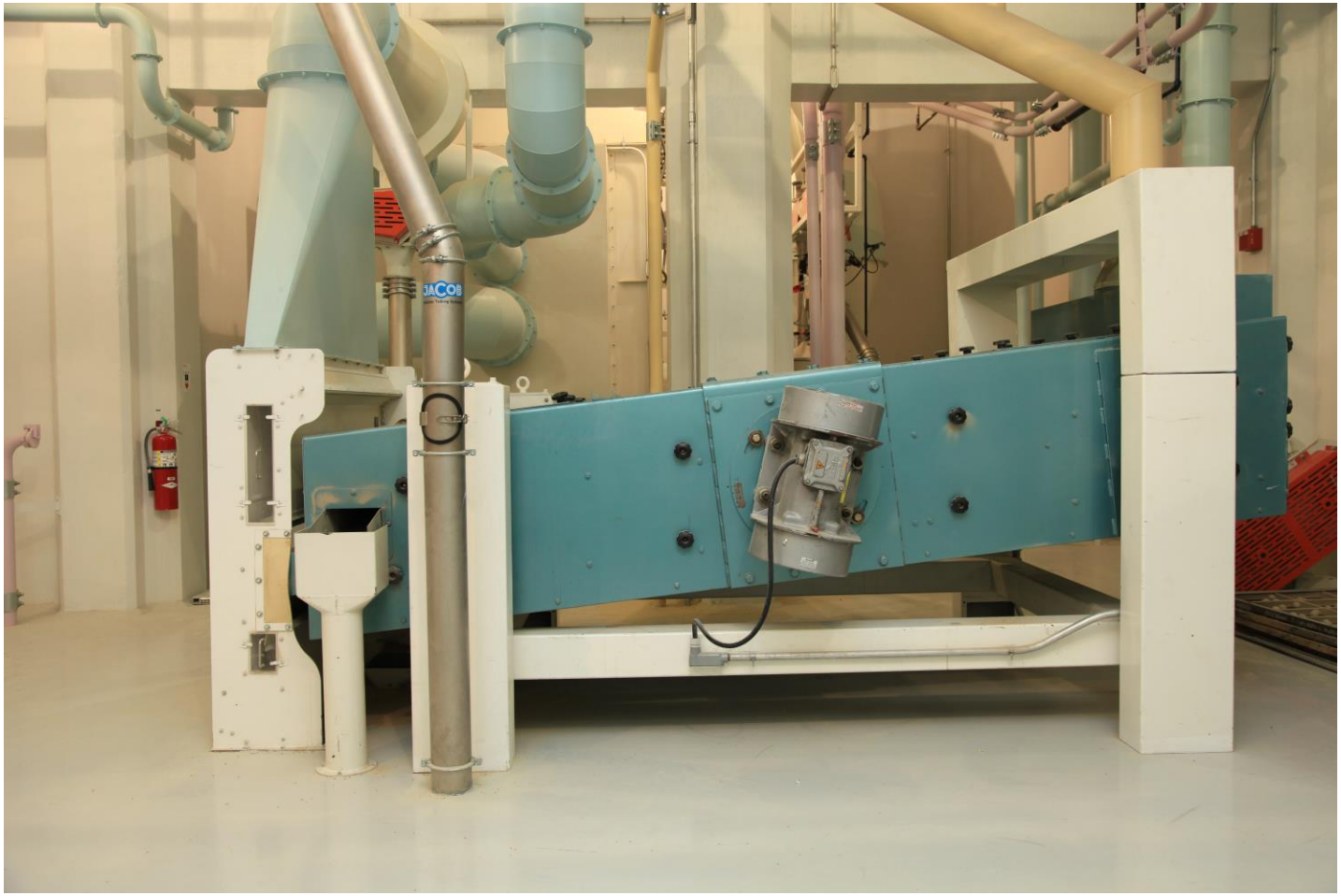
Plate Magnet-Mill

Magnet overload resulting from poor monitoring and neglected cleaning.

Generic Cleaning Flow Principle



Receiving Separator



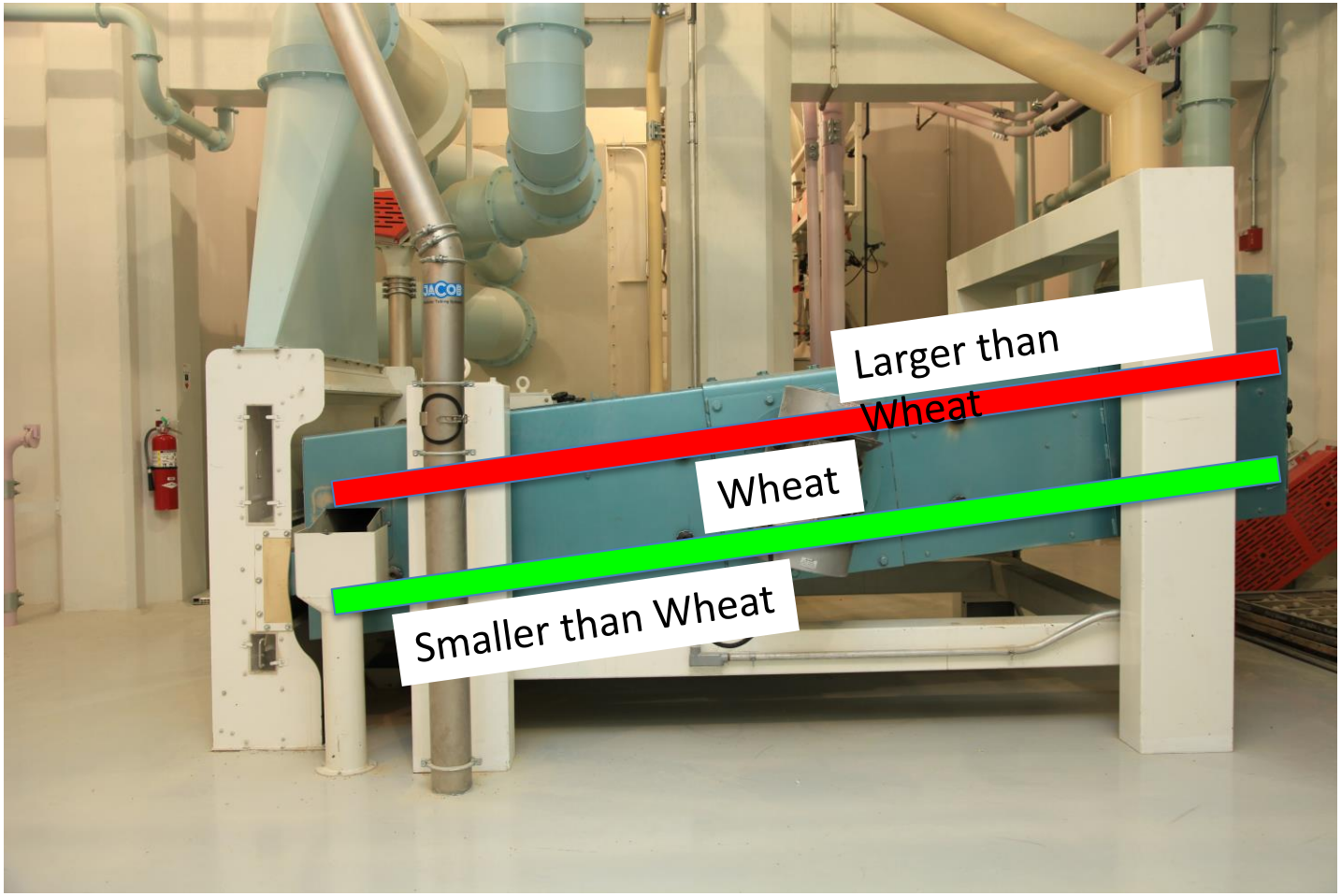
Pre-Cleaning

Larger than Wheat

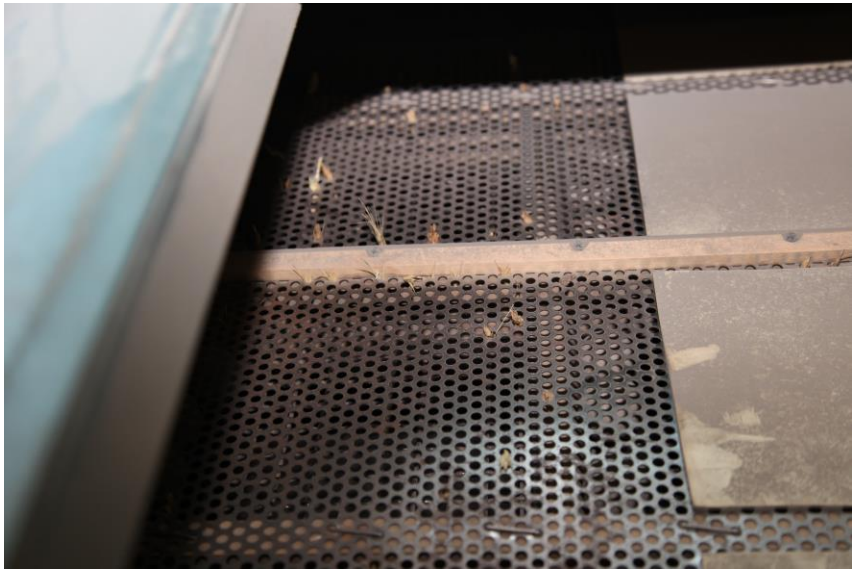
Smaller than Wheat

Lighter than Wheat

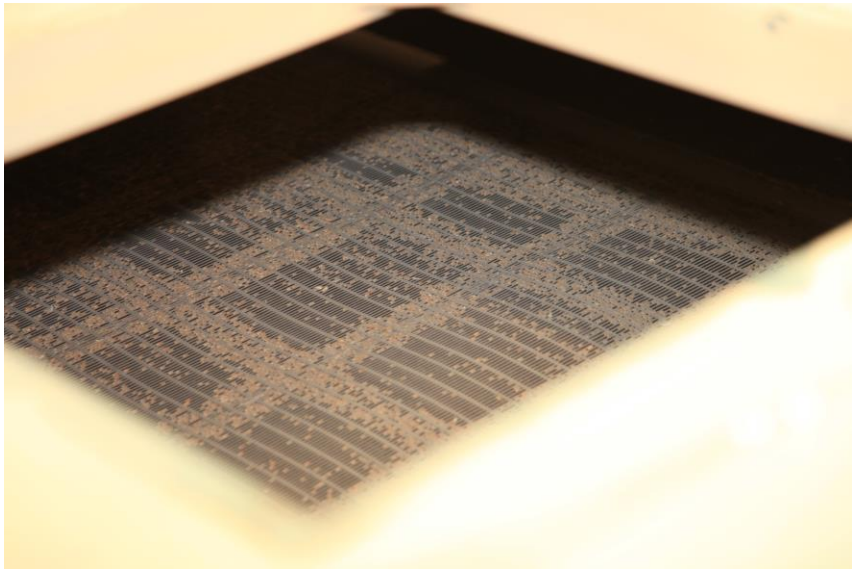
Receiving Separator 2 decks = 3 fractions

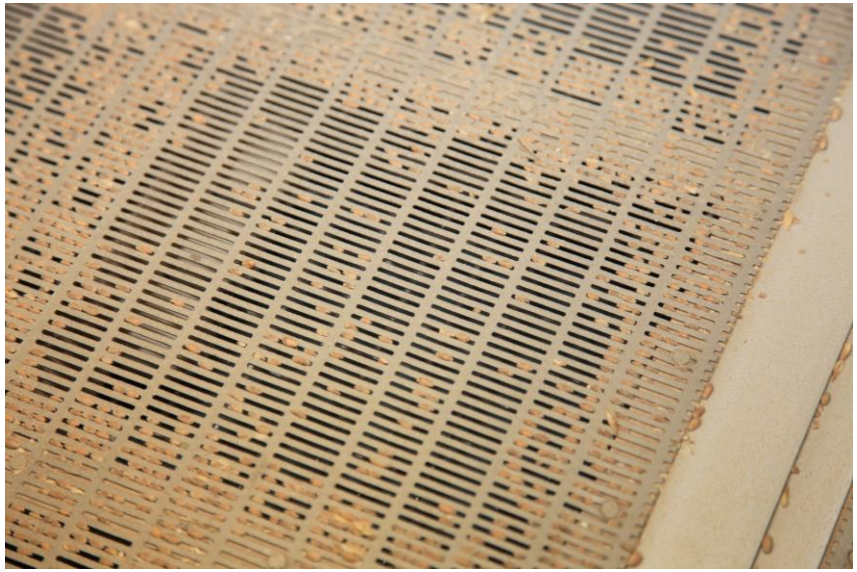


Perforated Metal Screens



Receiving Separator Slotted Screen

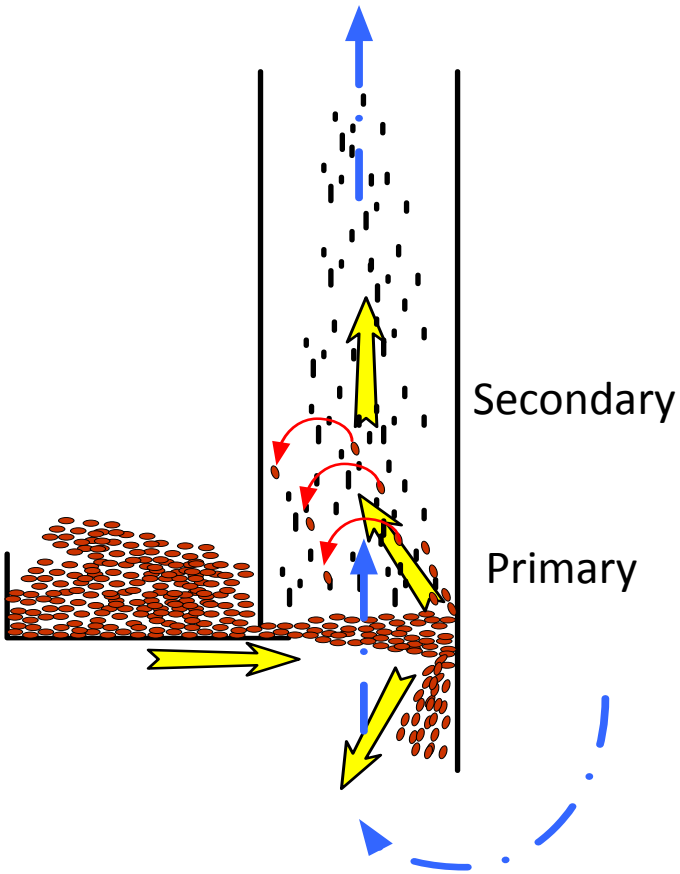




Channel Aspirator

Flow In Air (Resistance to Air Flow)

Aspiration Channel



- Grain enters the primary separation zone at the rear wall of the channel aspirator.
- After impact the light product will lift into the channel.
- Majority of heavy product exits the machine.
- Some heavy particles will lift and fall creating a secondary separation zone of aspiration higher in the channel.

Pre-Cleaning

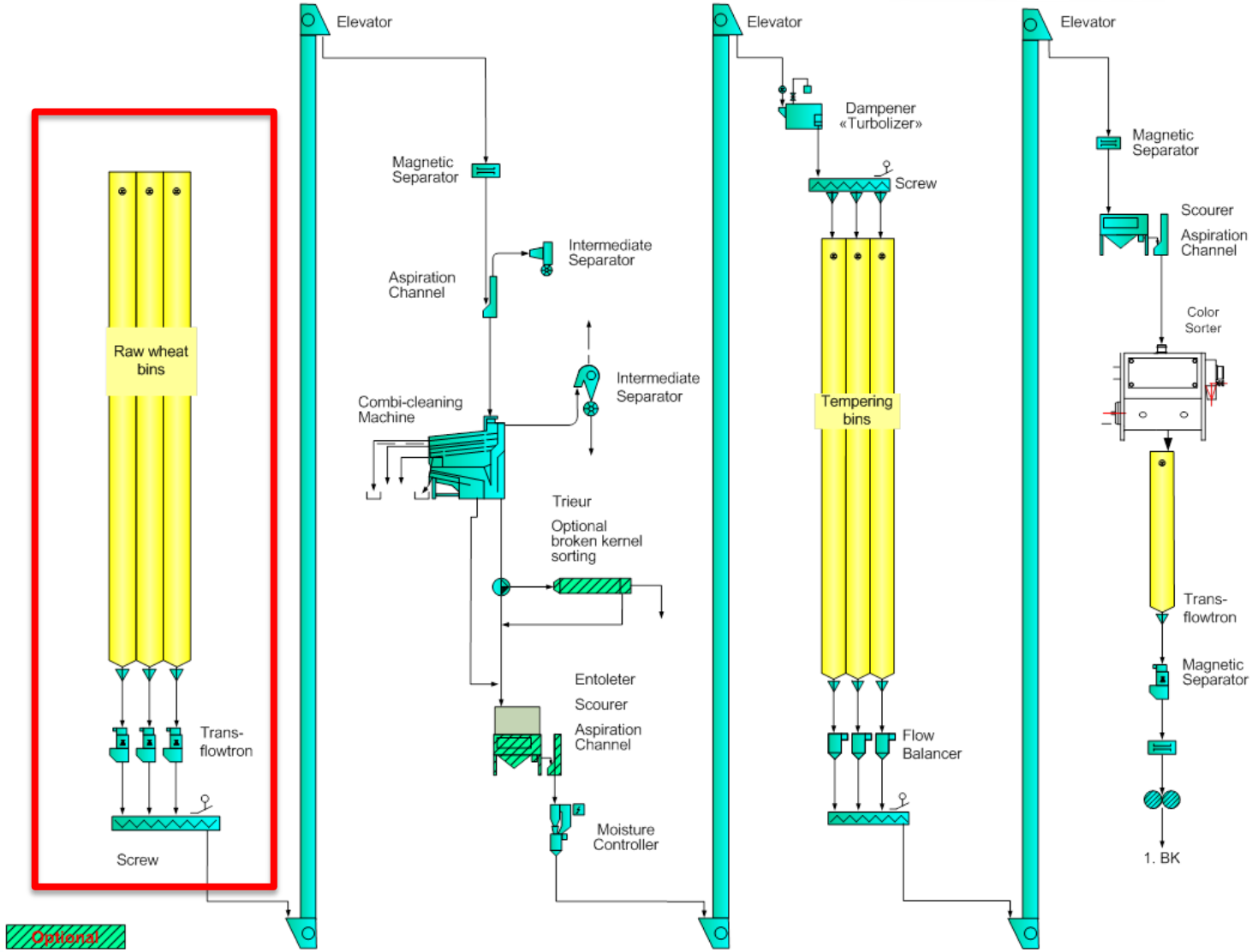
Larger than Wheat

Smaller than Wheat

Lighter than Wheat

Raw Wheat Storage (Partially Clean)

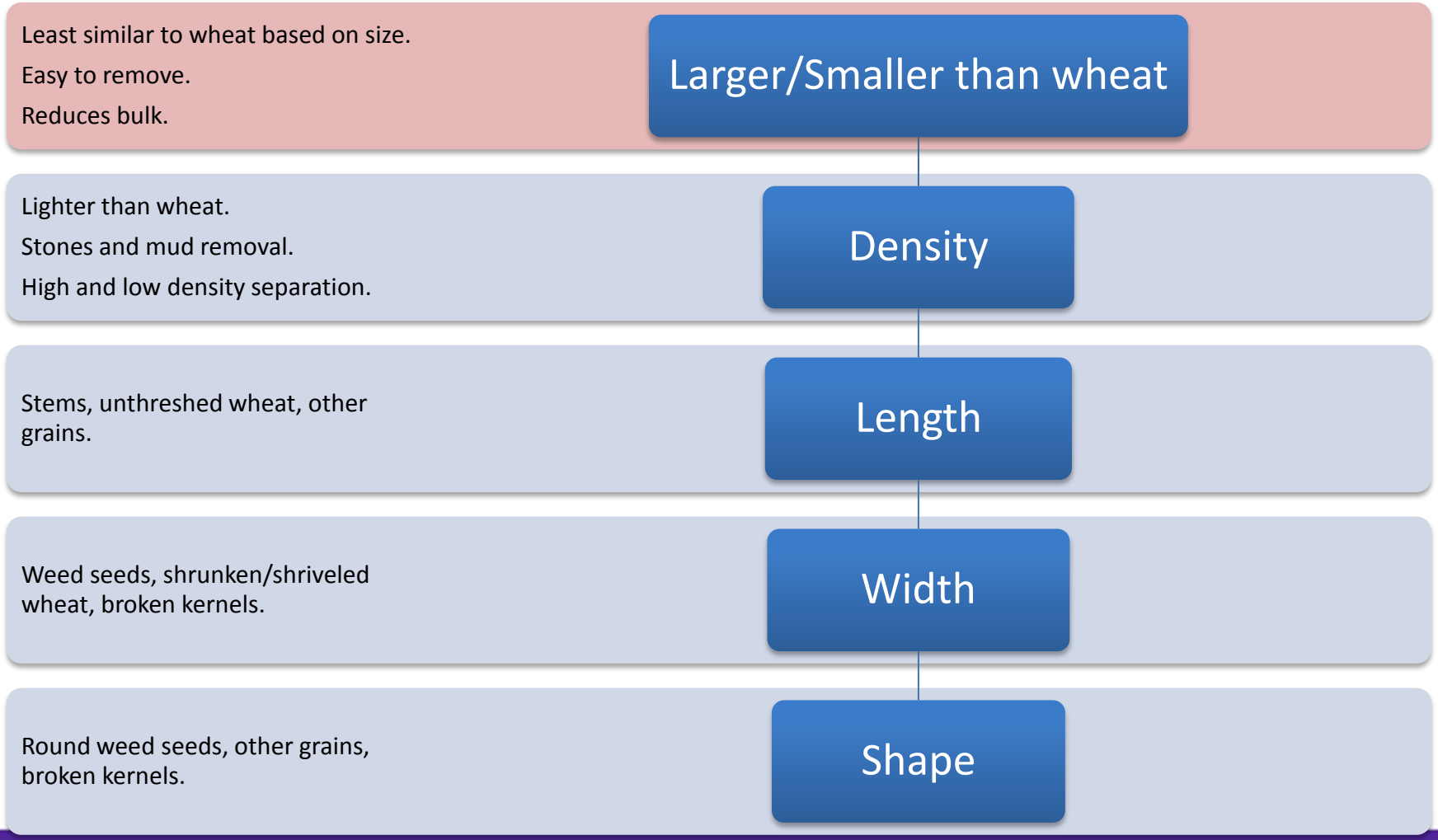
Wheat Cleaning System



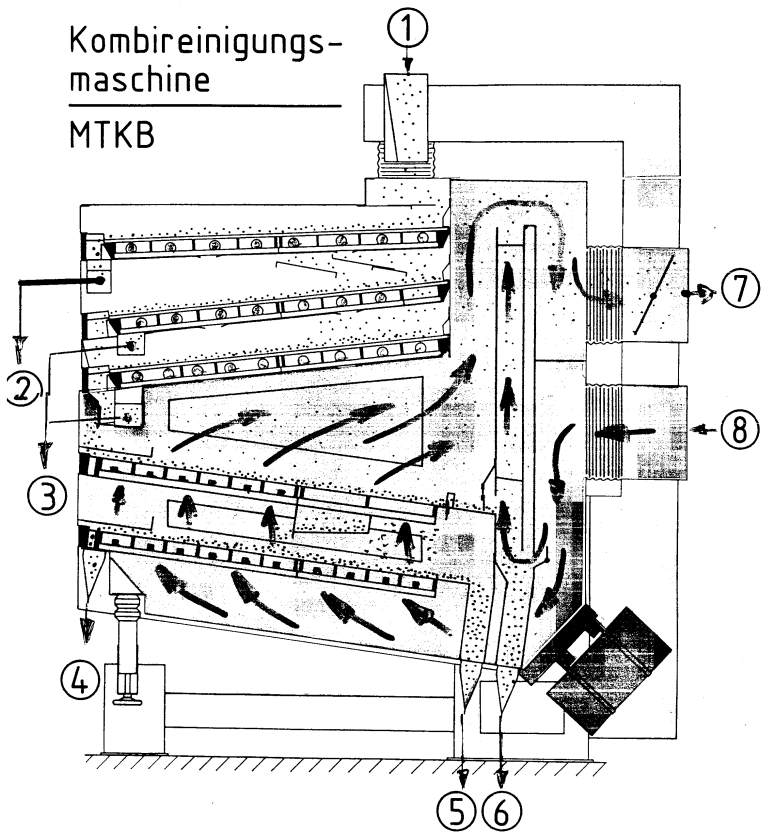
Combi-Cleaner

- The combi-cleaner combines several cleaning principles into one machine.
- The top screener portion removes impurities by size.
- The middle deck separates wheat by density into two fractions (high and low density).
- The bottom deck removes stones and mud.
- The tail end aspirator removes light impurities with air currents.

Generic Cleaning Flow Principle



Combination Machine Combi-Cleaner

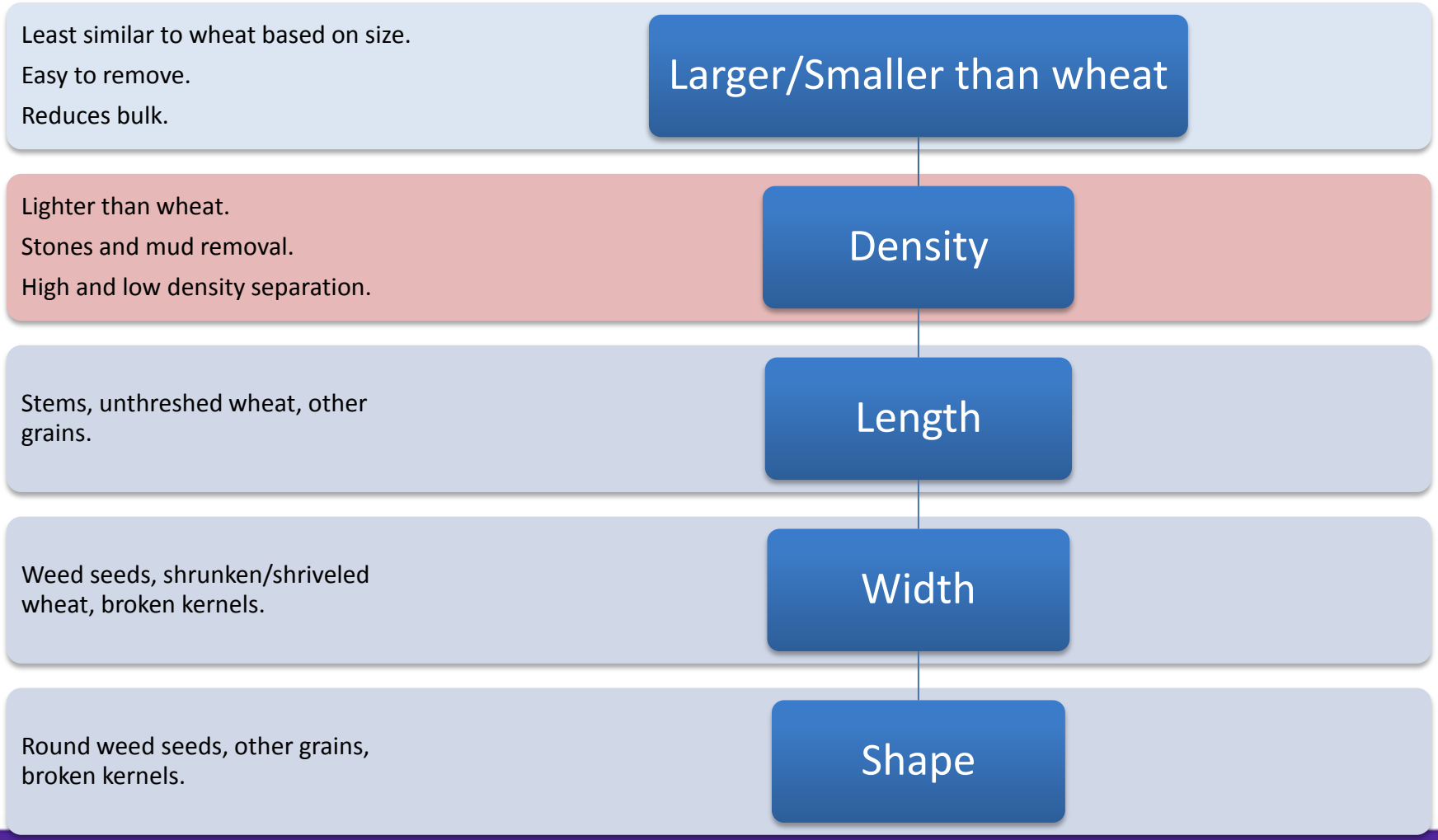


1 – Inlet
2 – Coarse imp.
3 – Sand
4 – Stones
5 – Heavy product
6 – Mixed product
7 – Light product
8 – Recycling air

Combi-Cleaner: Top Screener – Larger than Wheat

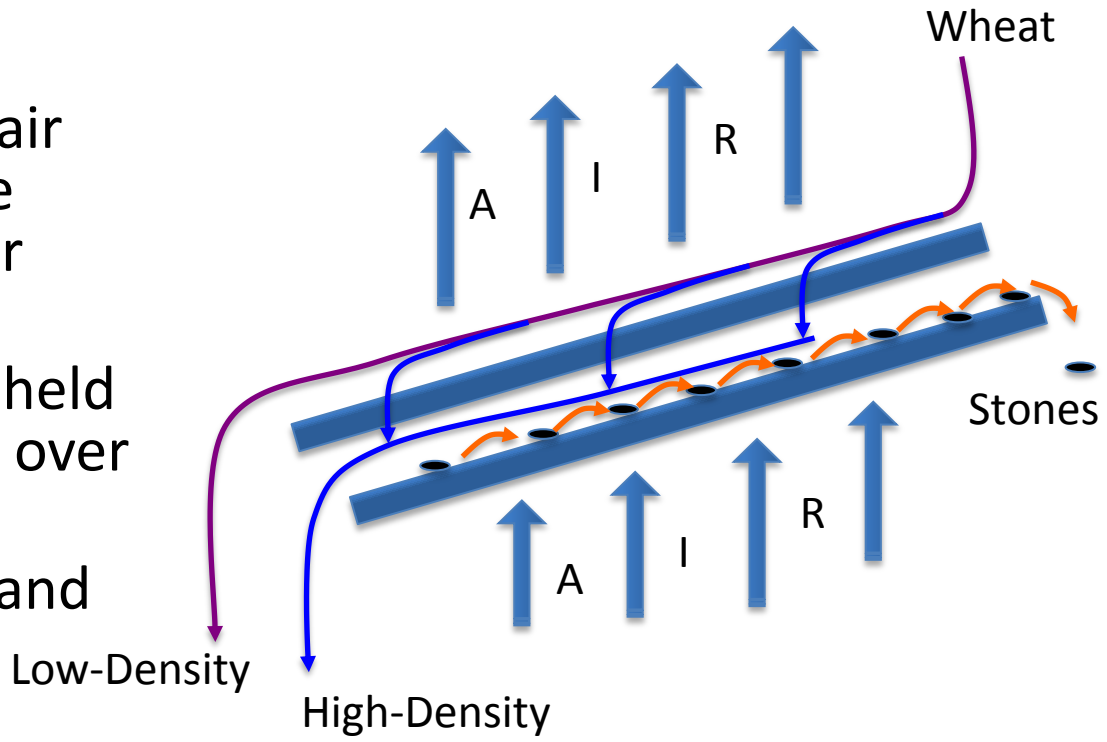
Combi-Cleaner: Top Screener - Smaller than Wheat

Generic Cleaning Flow Principle



Separation by Density

- Density separators use air currents to differentiate materials based on their density.
- Lower density wheat is held afloat by air and passes over the deck or screen.
- Stones are not held up and make contact with the screen.
- Stones are conveyed upward by the motion of the destoner.



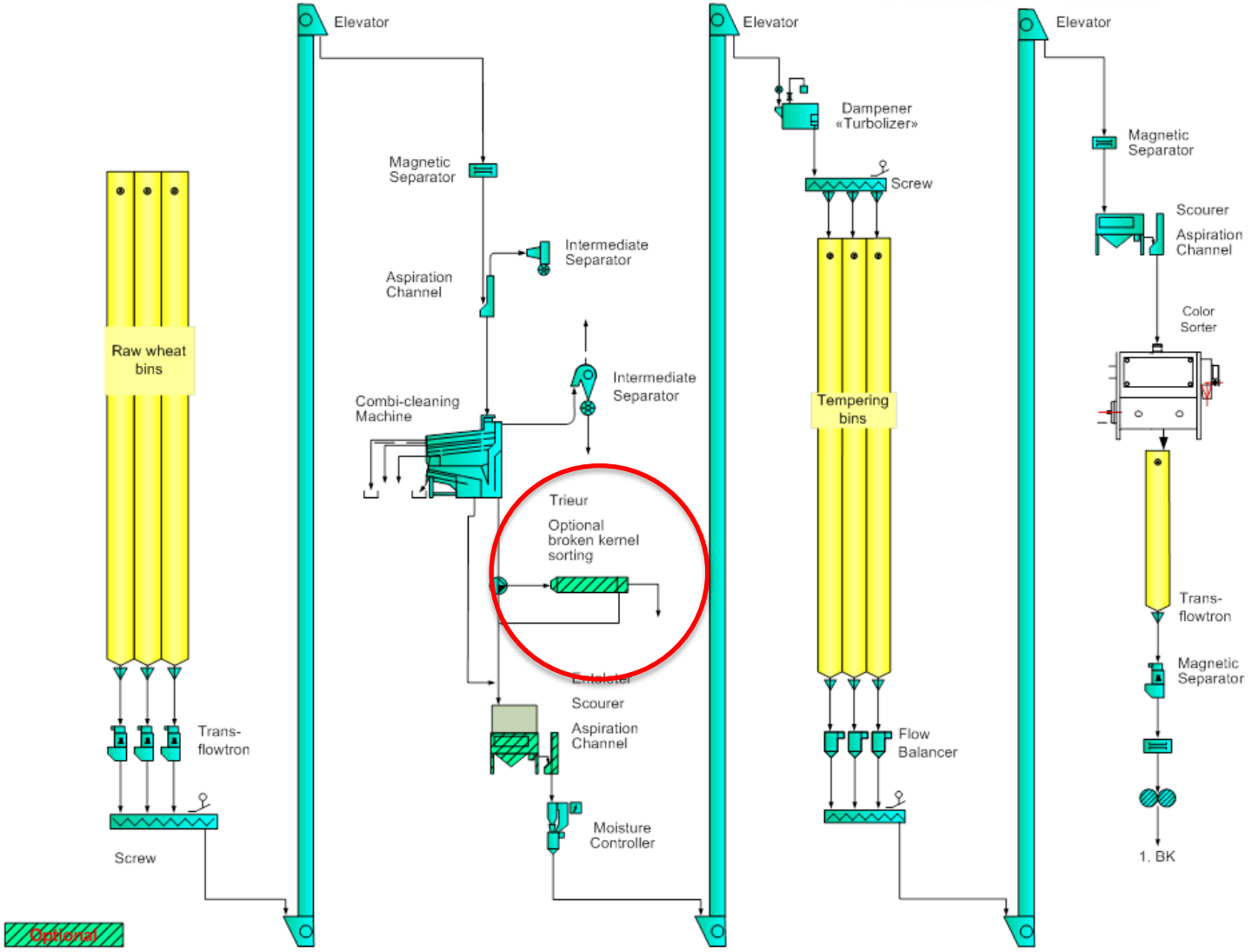
Combi-Cleaner: Stones and Mud

Combi-Cleaner: Aspirator Channel

Combi-Cleaner: High and Low Density Wheat

Low Density ~30% High Density ~70%

Low Density Fraction

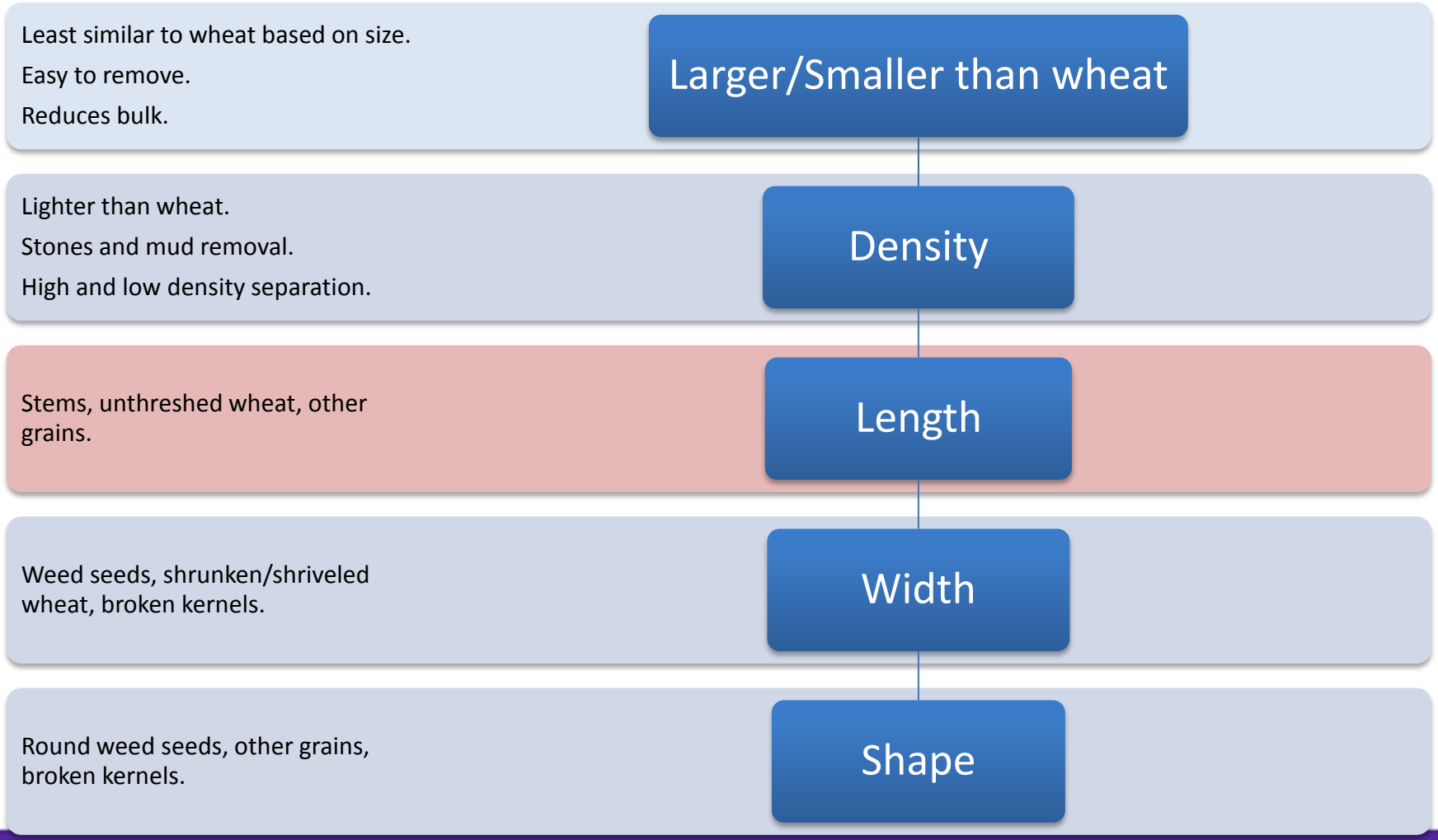


Separation by Shape

- All materials can be described by both their size and shape.
- Size alone can't differentiate impurities near the size of wheat.
- Shape is a property that can generally be described by the length and width.

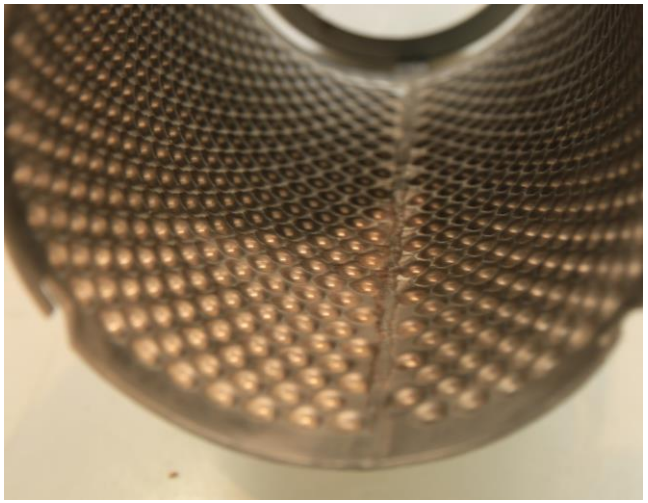
Separation by Shape

Generic Cleaning Flow Principle



Separation by Length

- The Indented cylinder contains several round tubular shells with indentations on the inner surface
- Material fitting in the pockets (determined by length) are removed as the cylinder rotates



Indented Cylinder Separator (longer)

- Longer-than-wheat impurities are separated by lifting wheat out of the longer foreign material.
- Pocket diameter is chosen to contain the entire wheat kernel, but nothing longer than wheat.

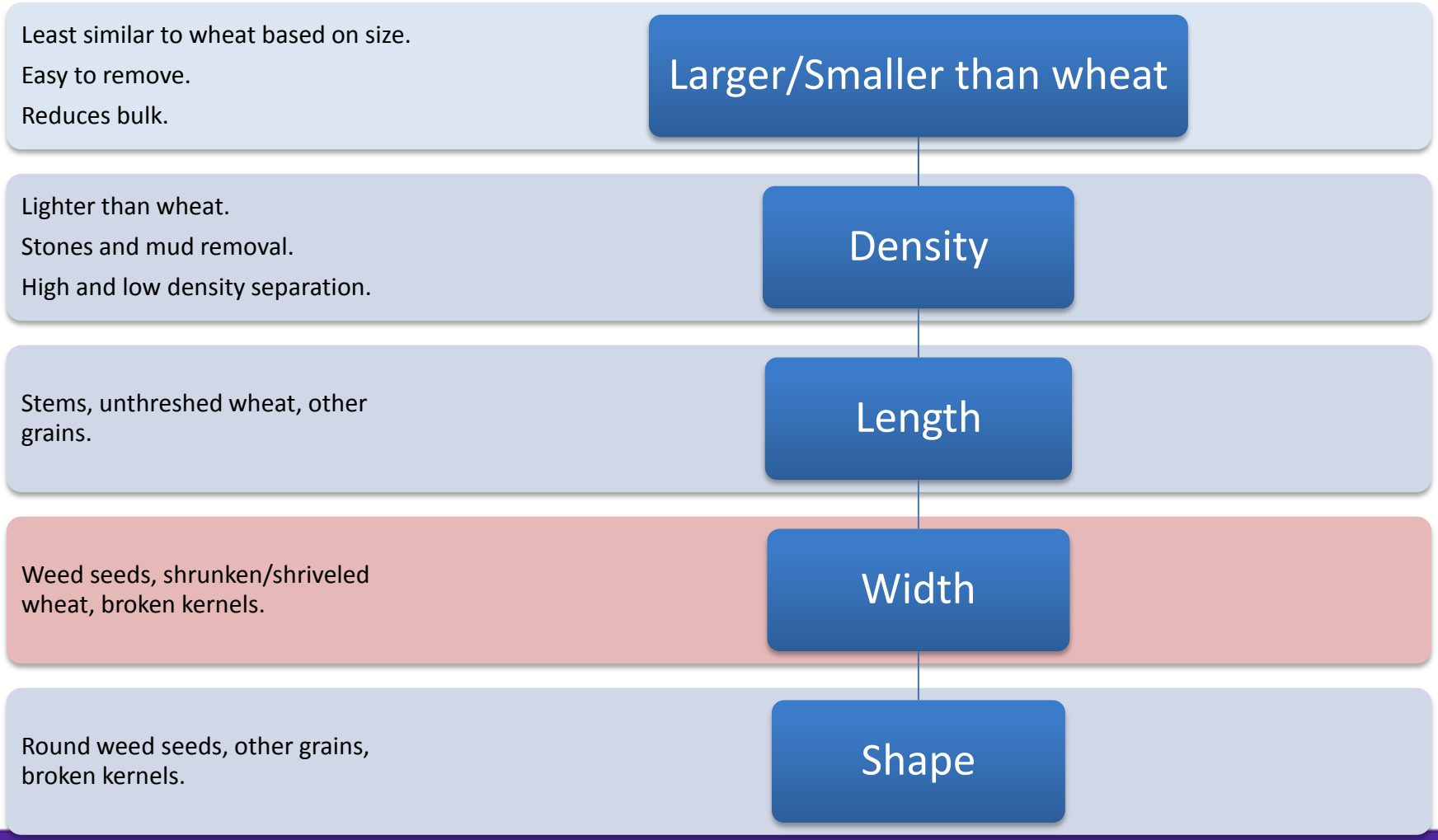
Length Separation (shorter)

- Materials shorter than wheat (including broken wheat) are removed using a pocket that cannot contain a wheat kernel.
- Small round weed seeds and sorghum are common impurities removed.

Separation by Length


1
BÜHLER
Tristar
2

Generic Cleaning Flow Principle



Separation by Width

- The slotted cylinder or grader separates materials based on their width dimension.
- Slot width is chosen to to select materials either wider or narrower than wheat.

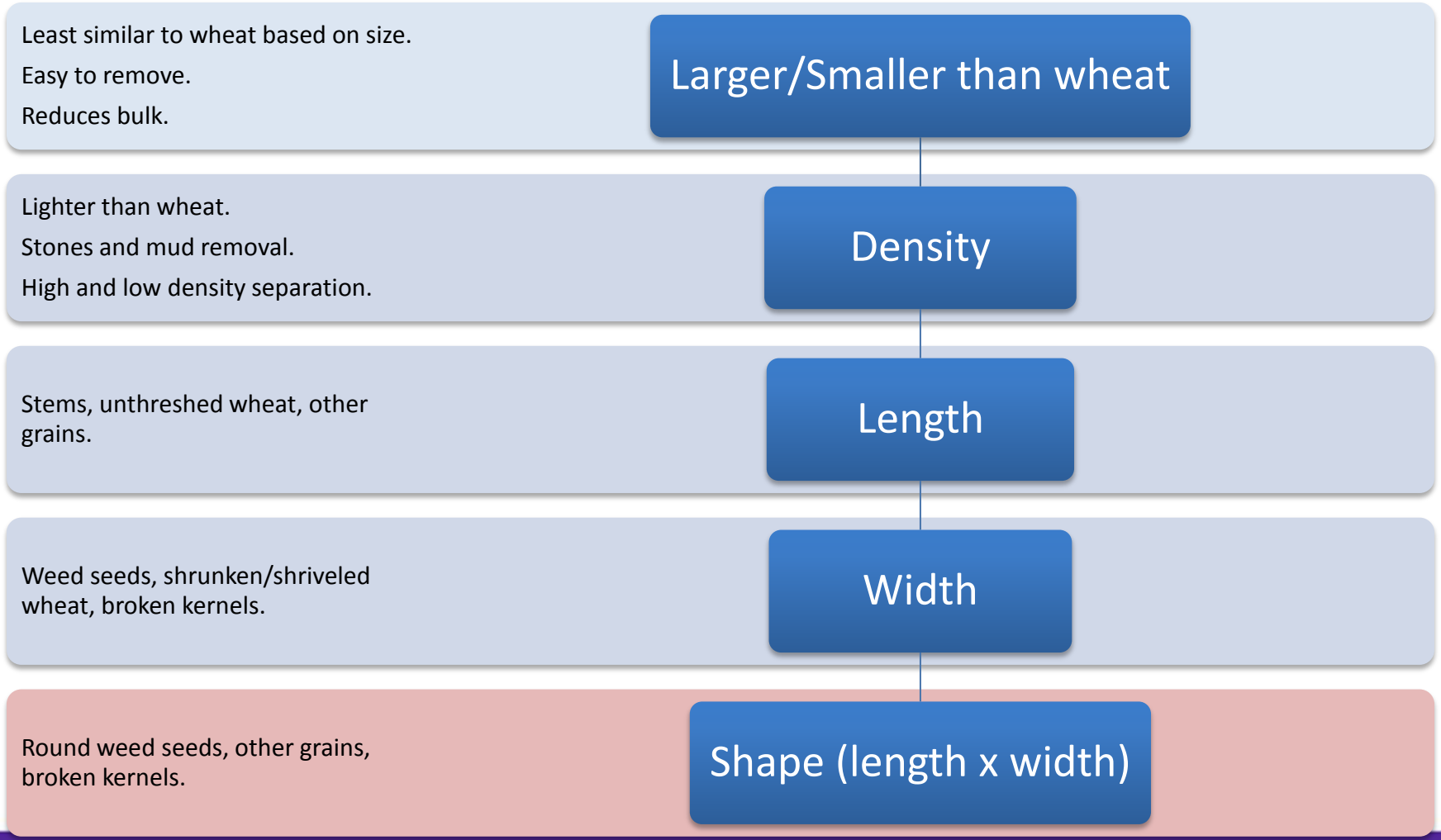
Slotted Cylinder/Grader (wide)

- To separate wide materials such as corn and soybeans, the slot width allows wheat to pass through the screen.

Slotted Cylinder/Grader (narrow)

- To separate narrow materials shrunken/shriveled wheat kernels a slot is chosen that will not allow wheat to pass through the screen.

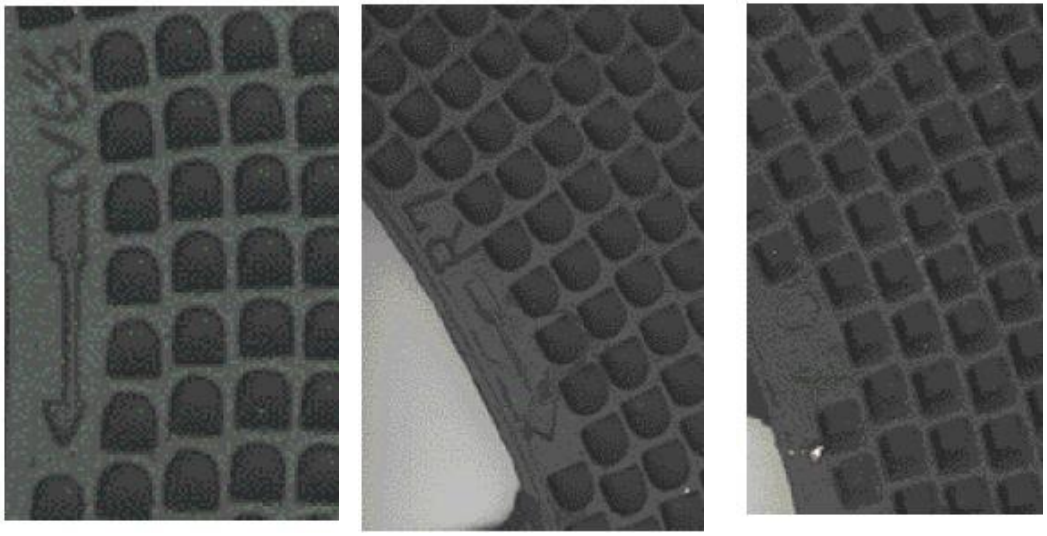
Generic Cleaning Flow Principle



Separation by Shape

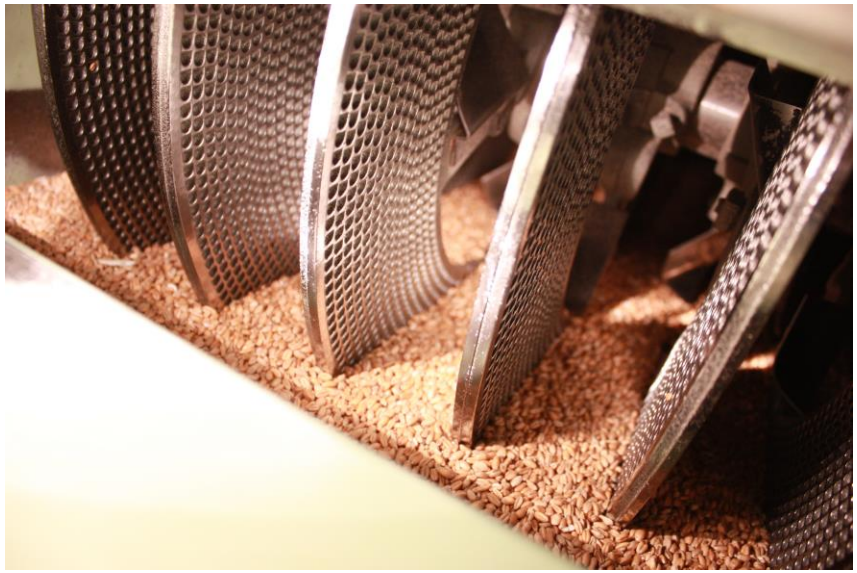
- Certain materials can be separated by their unique three-dimensional shape.
- The Carter Disk Machine has pockets forged to allow optimal separation by shape.
- V-Style for Round Seed Removal.
- R-Style for Long Seed Removal.
- Square/Rectangular Style for load splitting to be re-sized.

"V" "R" "AC"



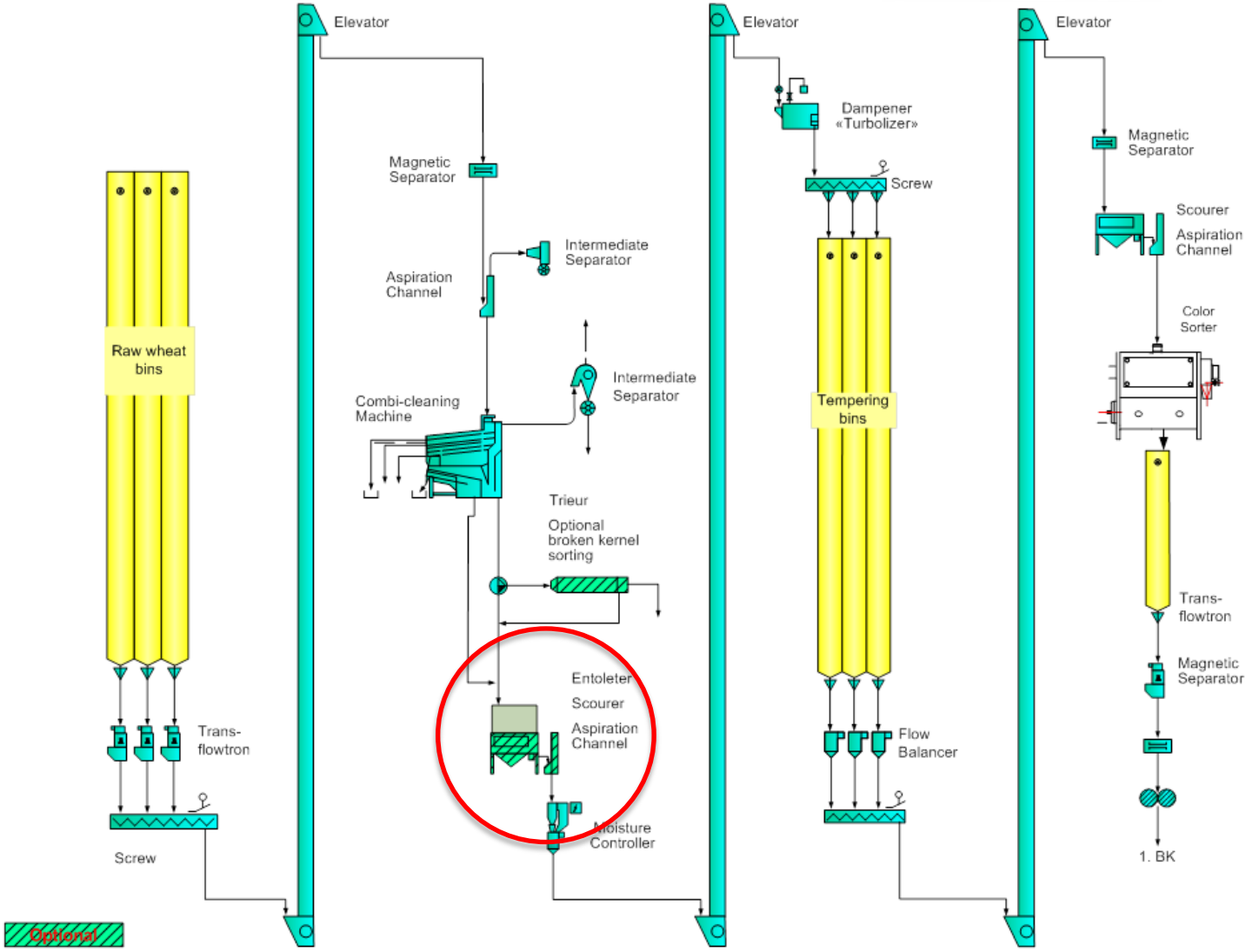
Carter Disk (round seed removal)

- Disk pockets with a rounded bottom and semi-circle design are used to remove sorghum. A common impurity found in the mid-western United States.

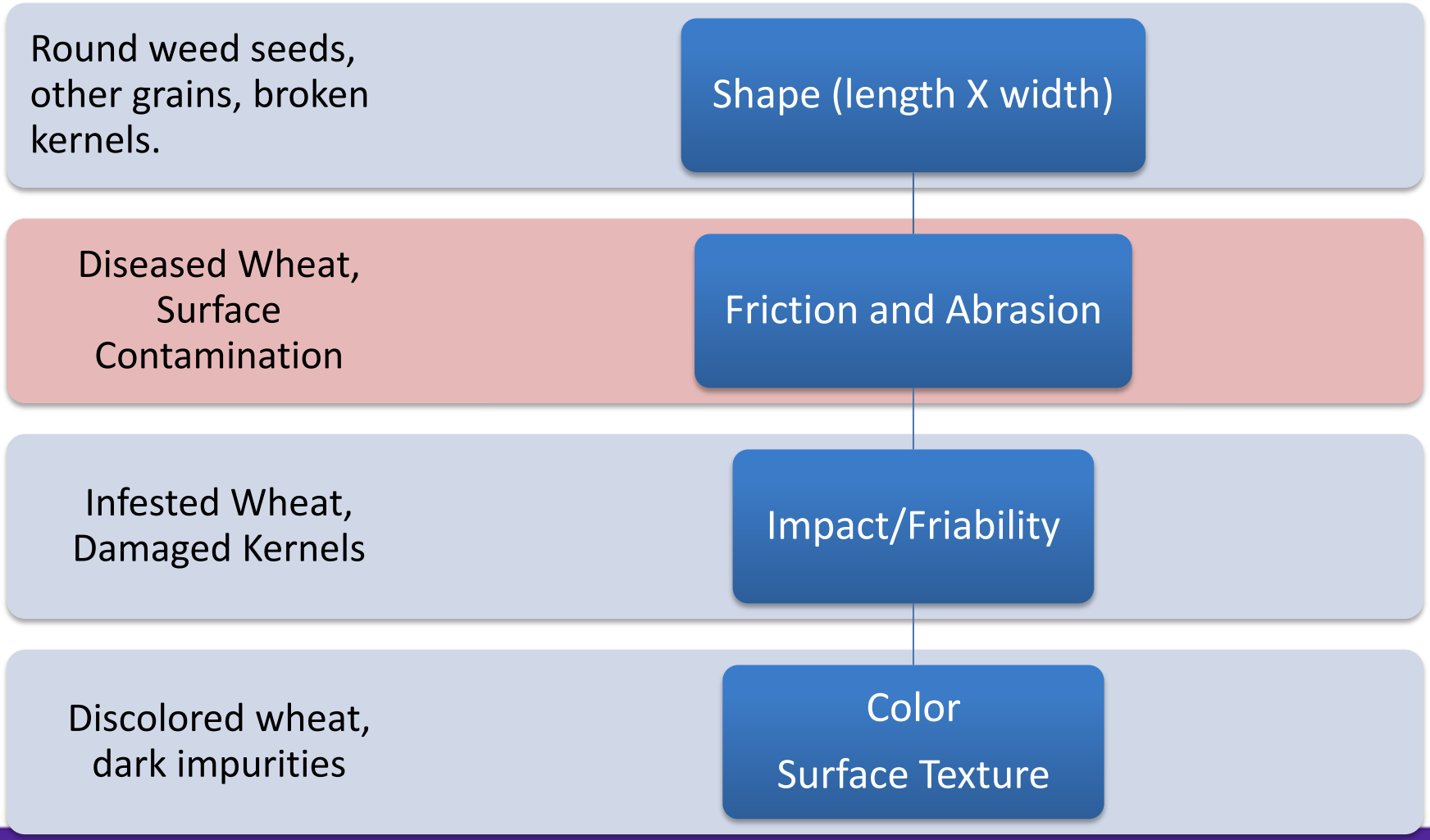


Carter Disk

High & Low Density Combined

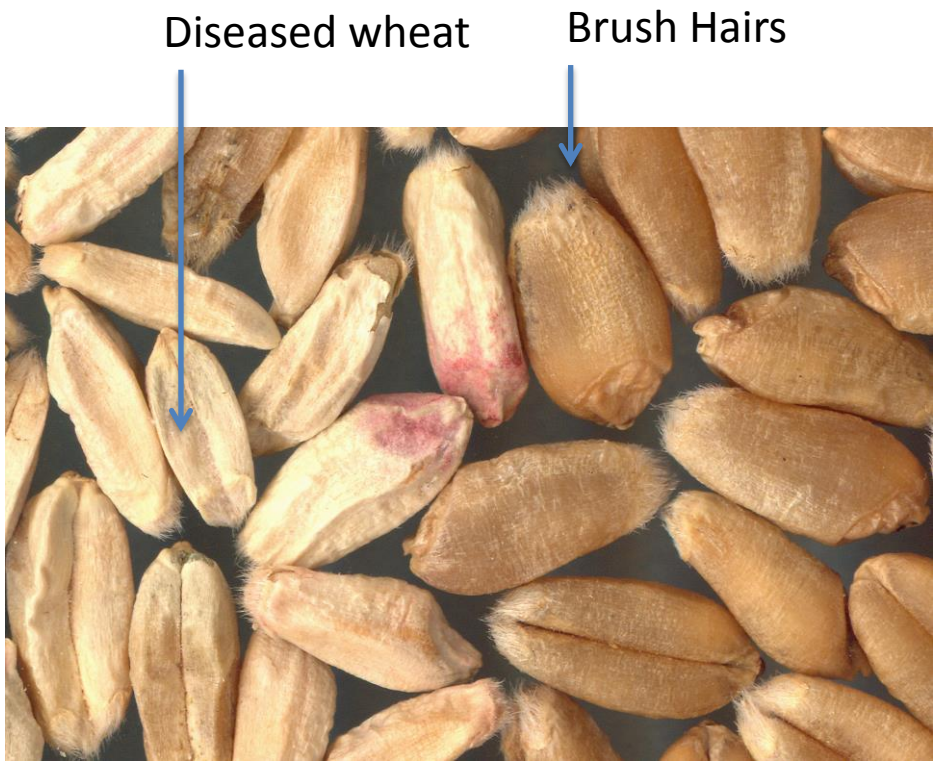


Generic Cleaning Flow Principle



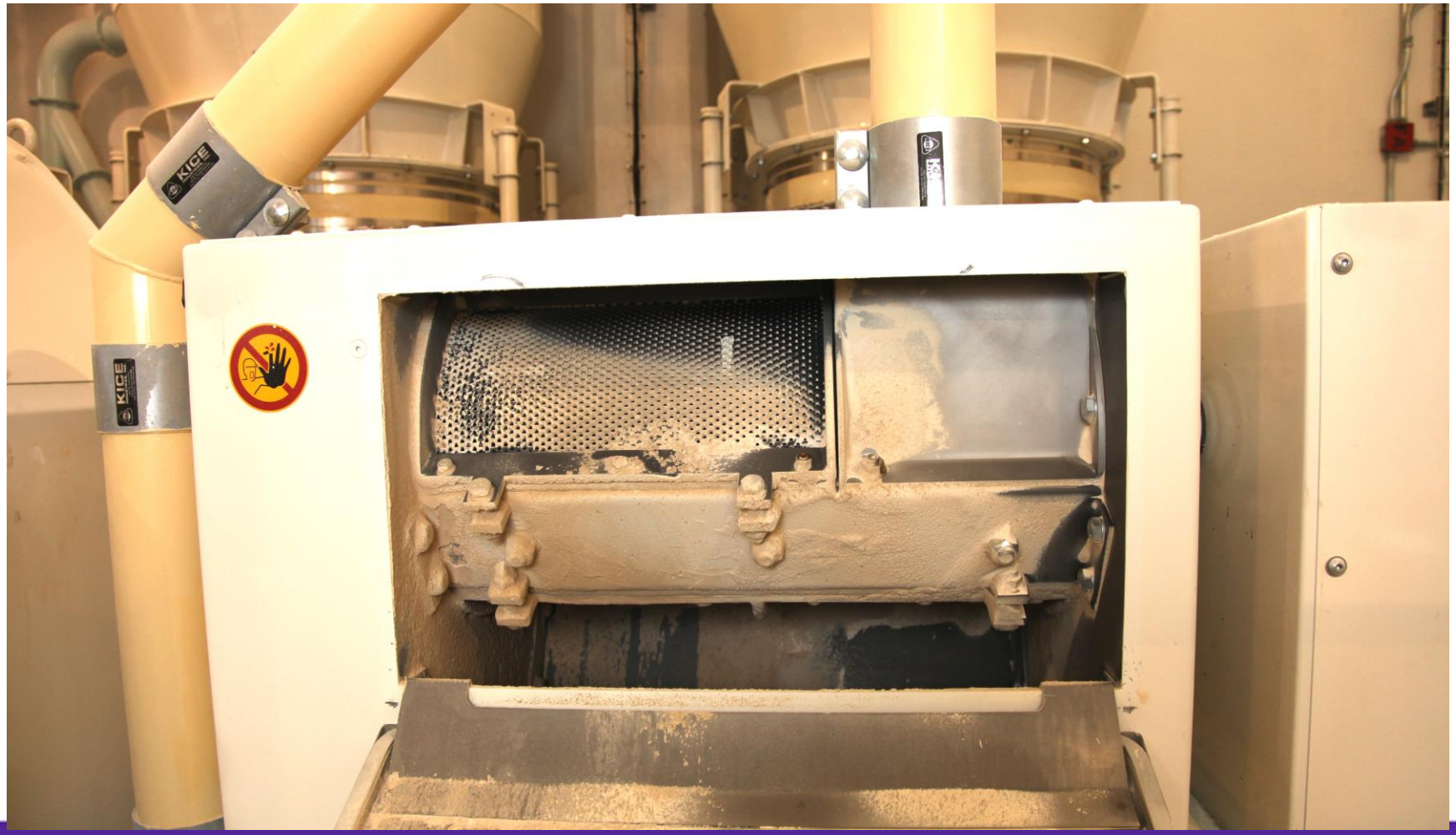
Friction and Abrasion

- One final step in wheat cleaning uses surface abrasion to remove trichomes (wheat brush hairs) and surface contamination (dirt).
- Diseased kernels are easily broken apart using the scourer.
- Surface contaminants are then separated using aspiration following the scouring step.



Scourer and Aspirator

Scourer



Scourer Aspirator

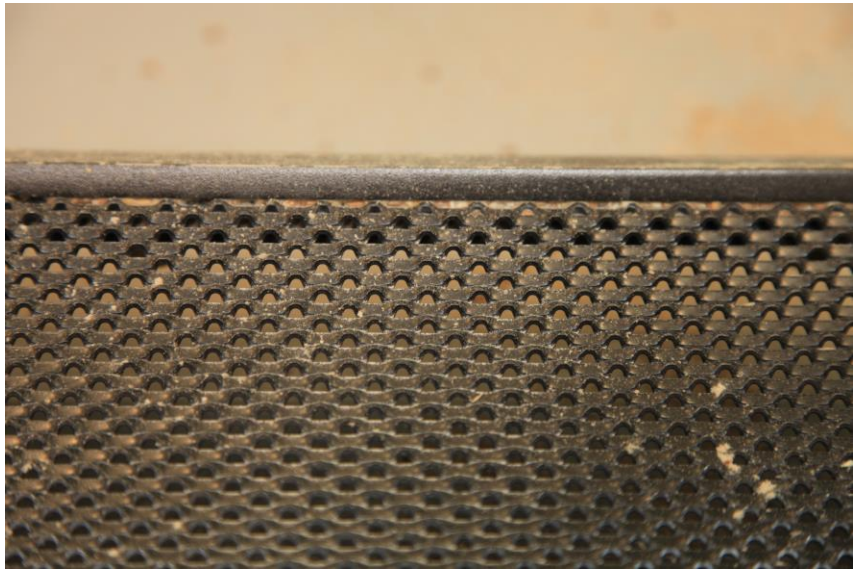
- The scourer operates by passing wheat through a narrow passage between a specially designed inner rotor and the outer abrasive screen.

Scourer Rotor Design

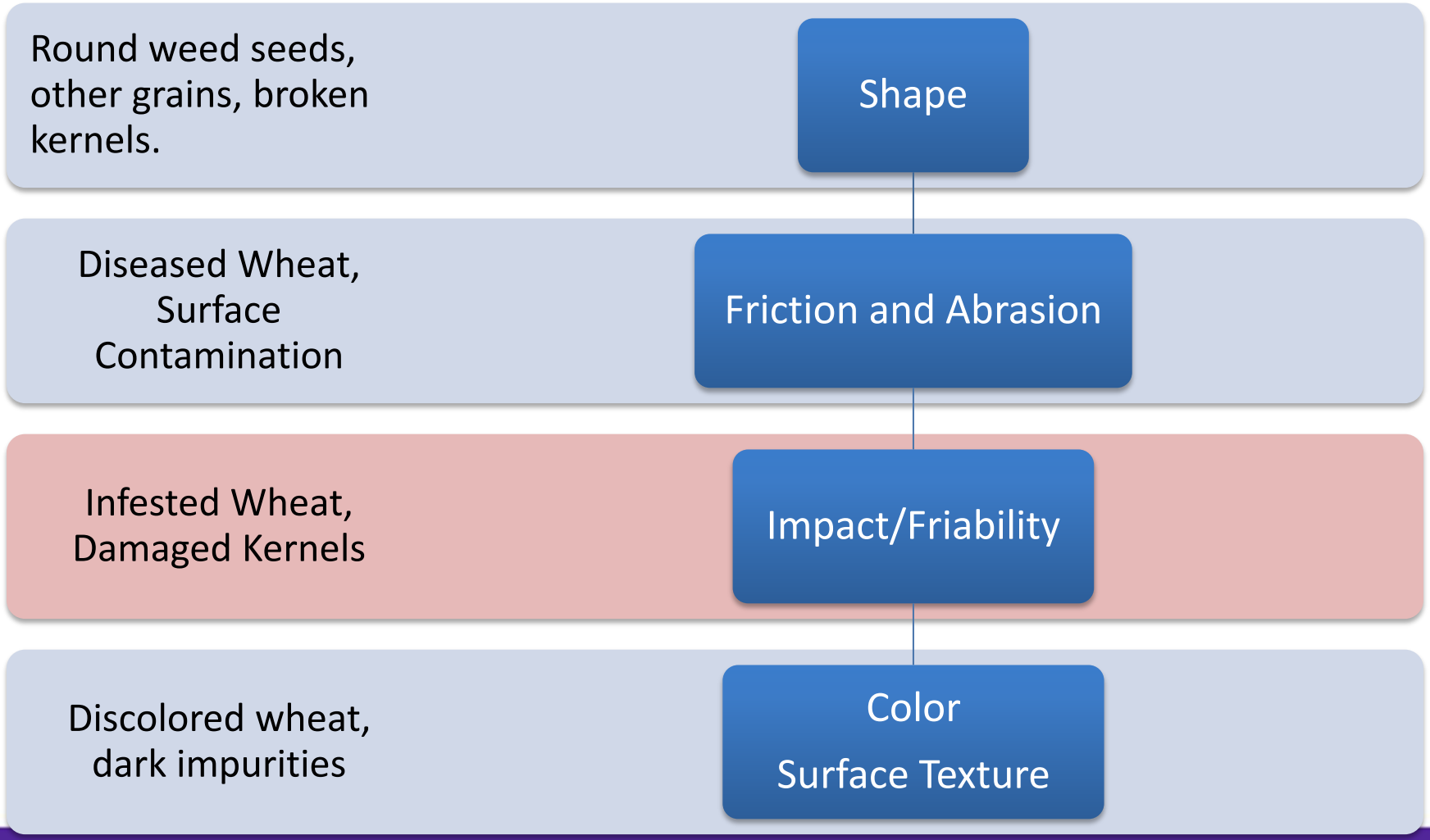
Abrasive Plates

Conveying Plates

Scourer- Abrasive Outer Screen

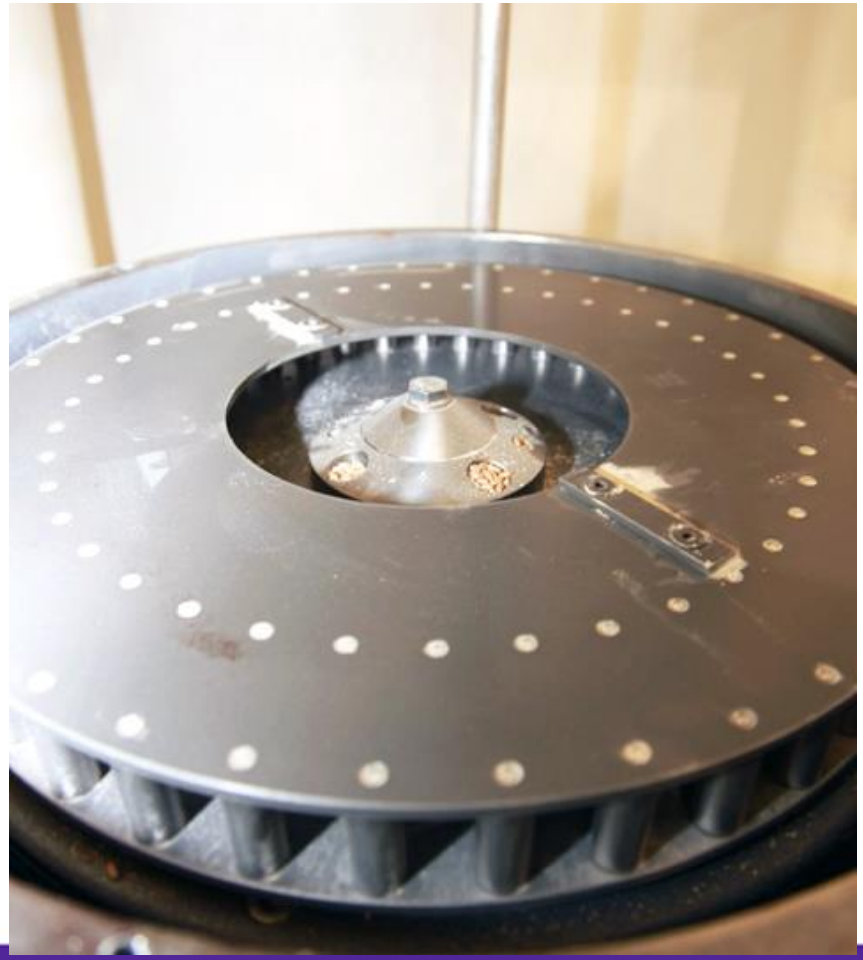


Generic Cleaning Flow Principle



Separation by Impact (friability)

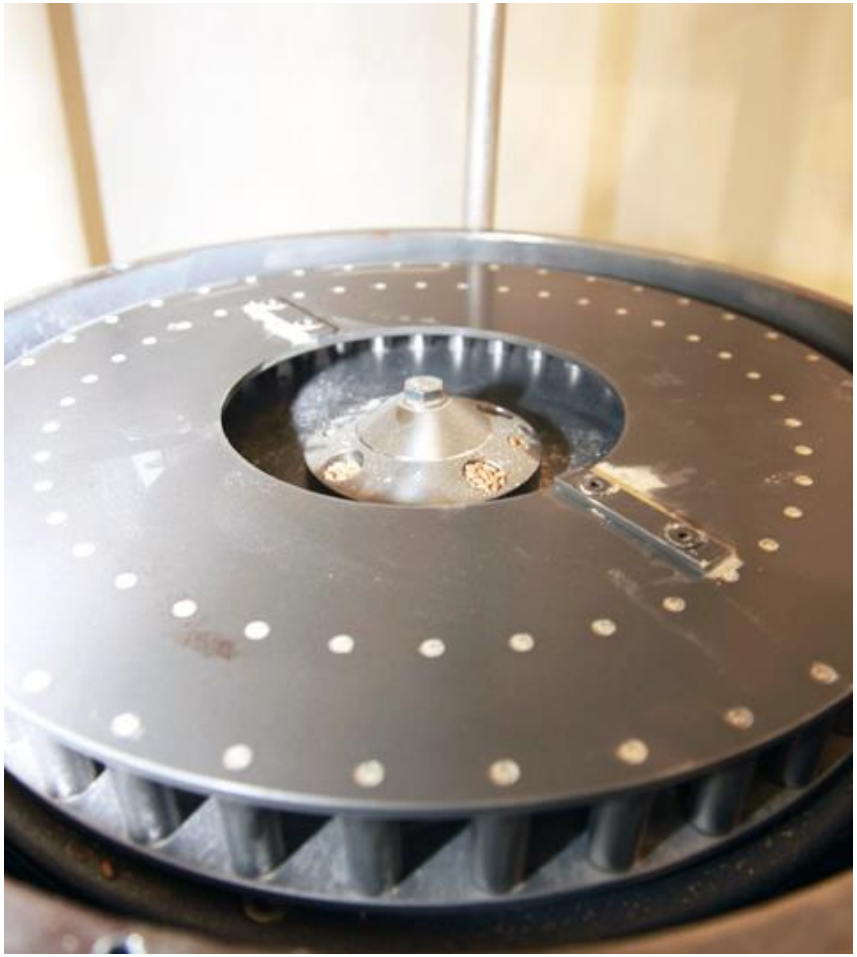
- Insect damaged wheat and other impurities such as mud balls can be destroyed and separated by impact.
- Wheat is impacted by pins attached to the surface of a spinning rotor.

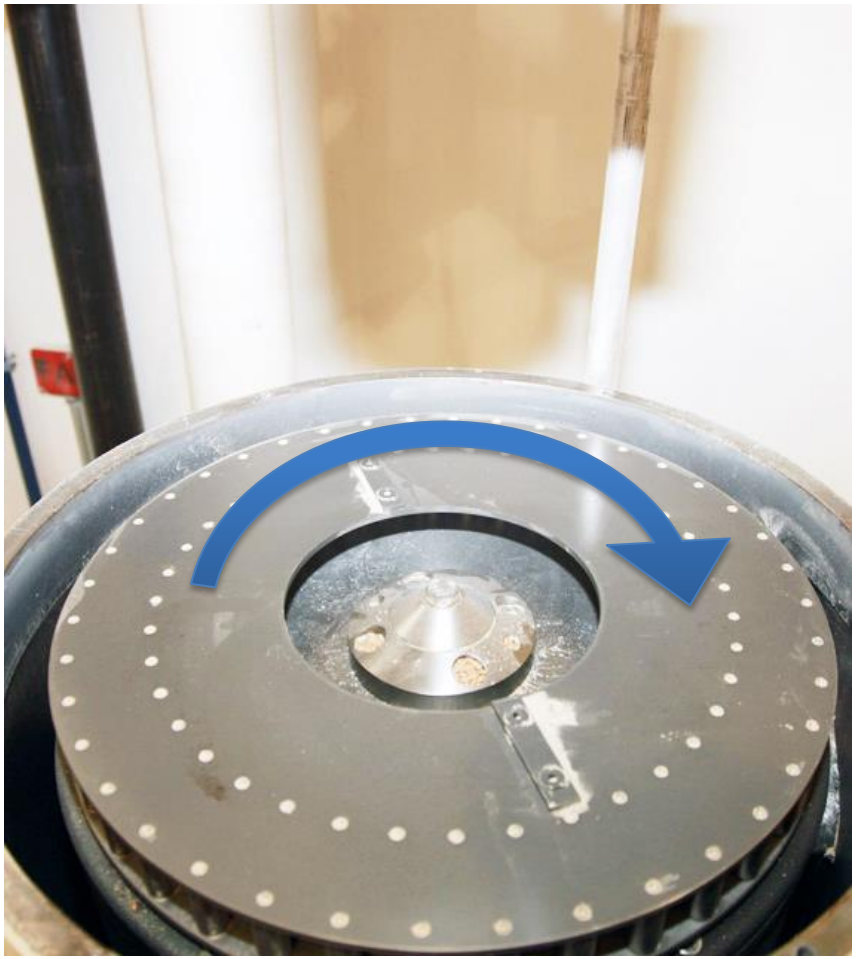


Entoleter Aspirator

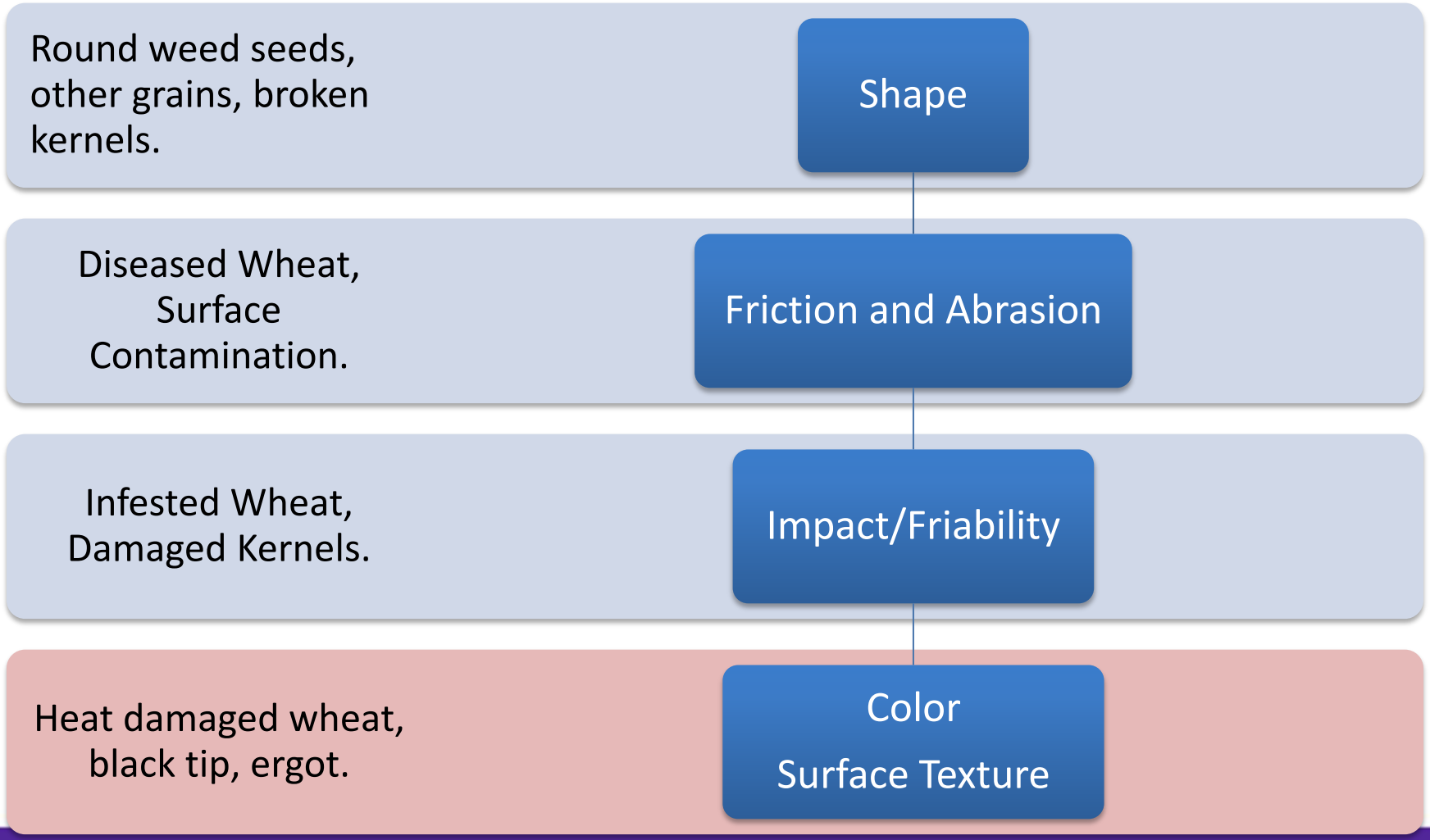
- Infested kernels are more friable that intact wheat kernels and can easily be broken apart in the entoleter.
- Aspiration is used to lift the broken materials away from the clean wheat.

Entoleter





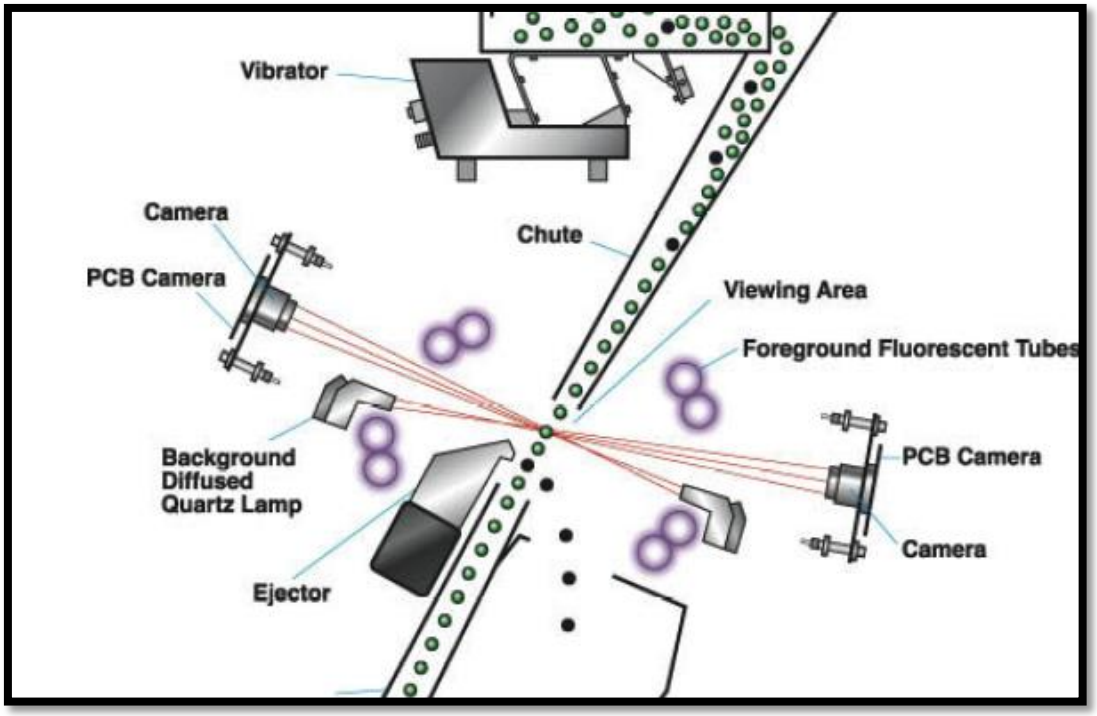
Generic Cleaning Flow Principle



Digital Optical Color Sorting

- Helps remove color impurities from wheat.
- Heat damaged kernels, black tip fungus, ergot, and any remaining mud or stones.
- Common in durum wheat cleaning for high purity semolina production.
- Also used in corn, rice and oat milling.

Color Sorter Working Principle



Color sorter removes dark impurities from healthy wheat

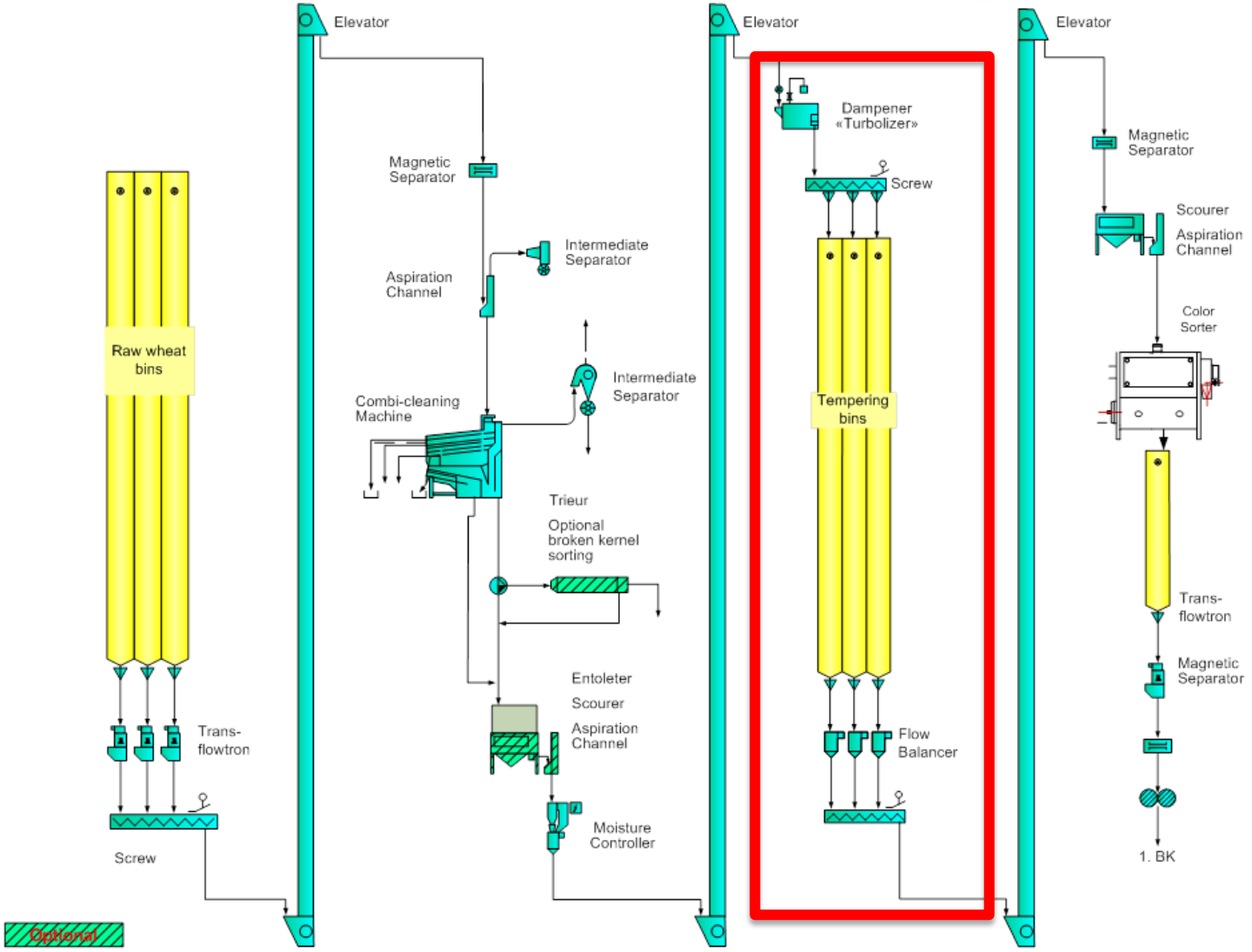
Discolored wheat

Cleaned Wheat

Dark Kernels Removed from Wheat

Cleaned Wheat

Low Density Fraction



Summary

- Wheat cleaning uses equipment to separate materials based on their physical properties.
- Rule of thumb for cleaning system design
  - First remove impurities that pose a safety risk.
  - Next remove materials that may limit equipment efficiency (dust and chaff).
  - The most difficult separation is removing wheat from wheat.
  - Try to concentrate these into a small stream to improve equipment efficiency.

Thank You!