Joining together. Growing together.

Ryan Breese

Product Development Engineer

Lyondell Chemical Company

The Wonderful World of Pneumatic Conveying

It Will Blow You Away…..

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Goals for Today!

- **Develop:**
  - ***General understanding of pneumatic conveying systems and equipment***
  - ***Understanding of a typical plant's transfer system***
  - ***Troubleshooting skills for fines and streamers issues***

"We create sustainable business value by being a preferred solutions provider to our customers."

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Agenda

- Types of Flow: Dilute vs. Dense Phase
- How fines and streamers are generated
- System components
- System design best practices

What is Pneumatic Conveying?

- **Moving objects with air**
  - ***Vacuum - Pulls***
    - System pressure is less than atmospheric
      - *Vacuum Cleaner*
      - *Drinking Straw*
  - ***Pressure - Push***
    - System pressure is greater than atmospheric
      - *Leaf Blower*
      - *Garden Hose*

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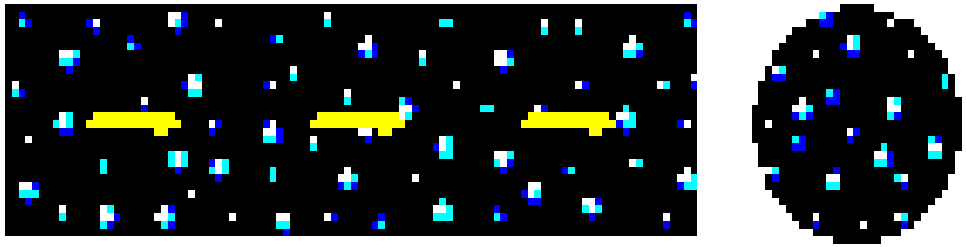
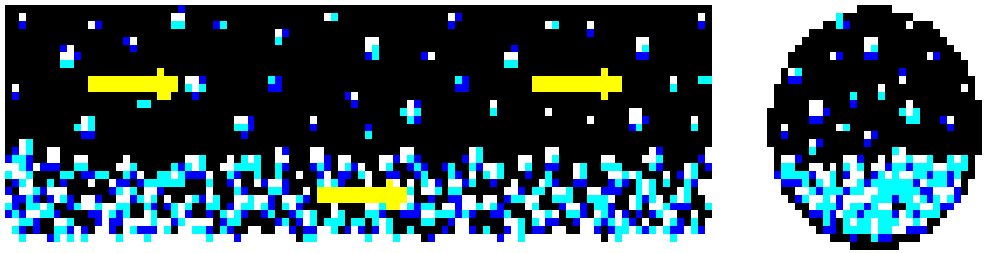
Dilute vs. Dense Phase…

- ***Stream Flow (Dilute)***
  - air/solids > 2.25



- ***Two Phase Flow***
  - 2.25 < air/solids < 0.2



- ***Pulsed Piston Flow***
  - air/solids < 0.2

***loadings ratio in units of scf of air/lbs of pellets**

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Dilute Phase Conveying

- Object are suspended in the conveying air
- The transfer velocity is greater than the “saltation” velocity
- Low system pressures (< 14 psig)
- High air to solids loading ratios (> 2.25)
- High linear velocities (4,200 – 6,500 ft/min)
- More destructive - mostly due to the high velocities
- Lower capital costs at startup
  - *Lower cost equipment / not rated for pressure system*
- Easier to operate
  - *Wider Δv range on phase diagram*

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Dense Phase Conveying

- Anything that is not Dilute Phase
- The transfer velocity is less than the “saltation” velocity at some point in the system (< 4,200 ft/min)
- High system pressures (14 – 90 psig)
- Low air to solids loading ratios (< 0.2)
- Low velocities but high pounds capacity (10^1 – 10^2 ft/min)
- Less destructive – a result of lower velocity
- Higher capital costs at startup
  - *Pressure rated lines, airlocks, valves, etc.*
- More difficult to operate (easier to plug)
  - *Narrower Δv range on phase diagram*

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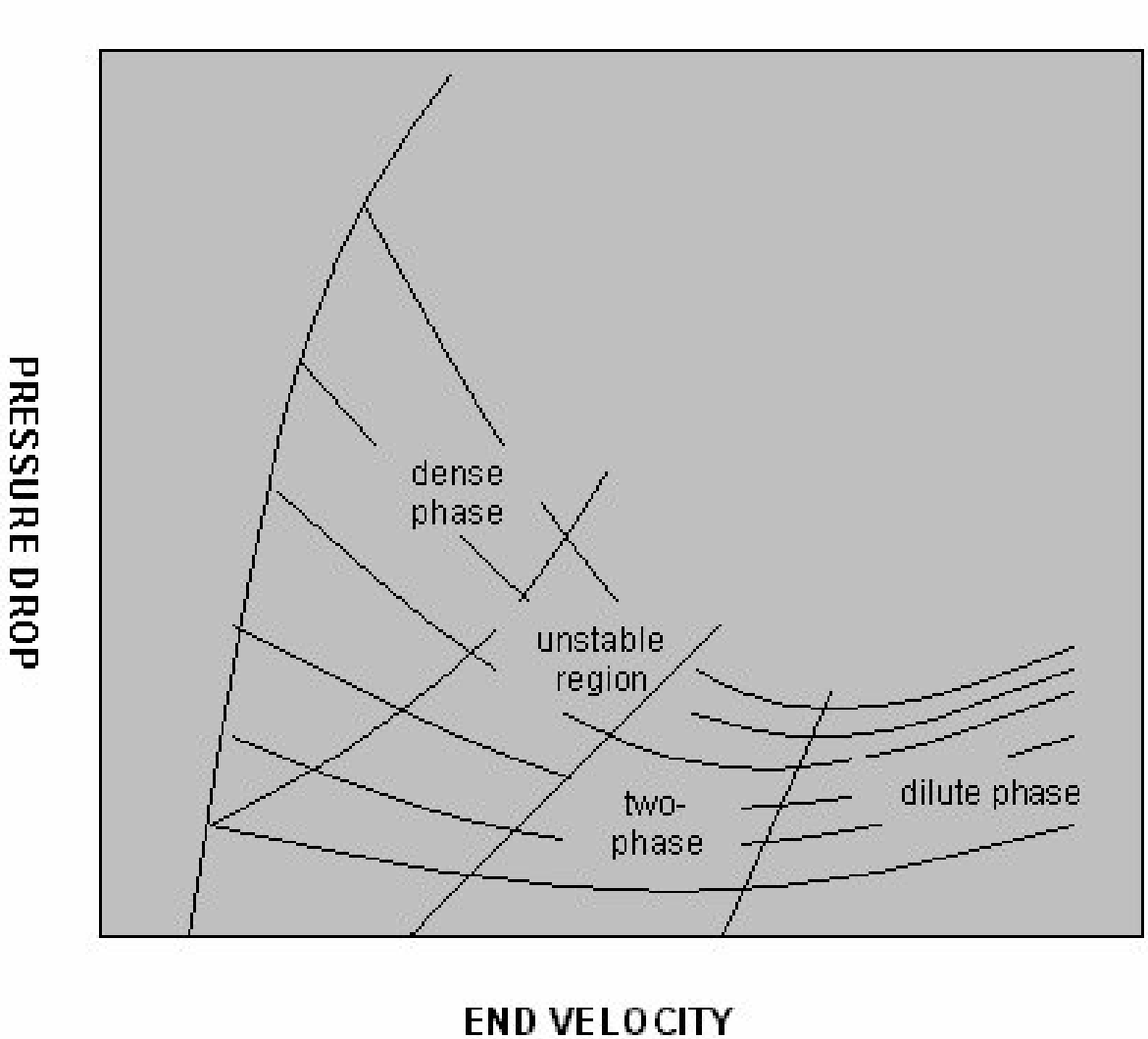
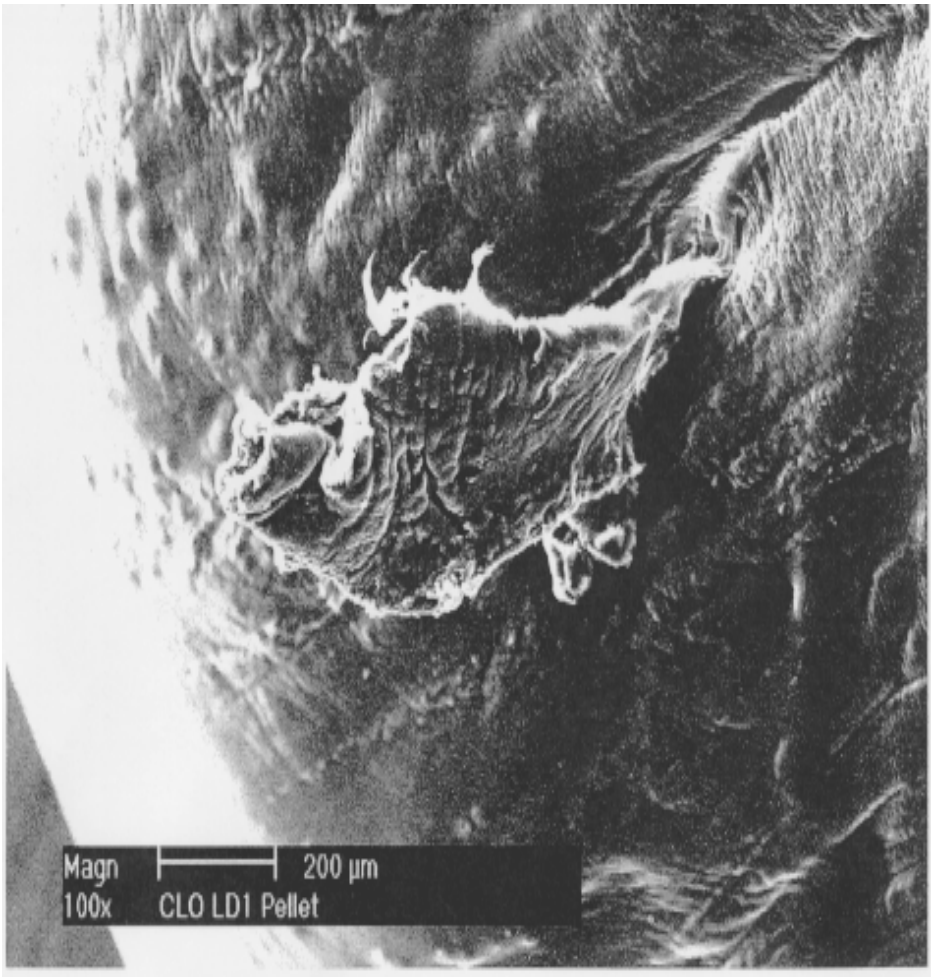
Pneumatic Conveying Phase Diagram



The Origin of Fines and Streamers

- A coating of plastic formed by smearing pellets against the pipe wall
- Skin peels off in strips and becomes streamers, angel hair, and/or fines

Pellet Tail Can Form Fines



- Tails are small stubs of polymer that are the result of poor pellet cut
- Pellet tails can break off and generate fines
- Small percentage of fines studied looked like pellet tails (<7%)

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Fines Are “Mini-Streamers”

- Most fines look like “mini-streamers” under a microscope
- Most fines are generated by “smearing” and not tails.
- Breaking up of snakeskins forms angel hair and fines

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Typical Conveying System

- **Feed Vessel**
- **Feed Point**
  - ***Pressure System: Air Lock (rotary valve)***
  - ***Vacuum System: Gate Valve***
- **Air Mover (Blower)**
  - ***Pressure: Mover at the solids pickup***
  - ***Vacuum: Mover at discharge vessel***
- **Air Cooler**
  - ***Located at the blower discharge***
  - ***Especially a concern with pressure systems due to temperature rise induced by the blower***

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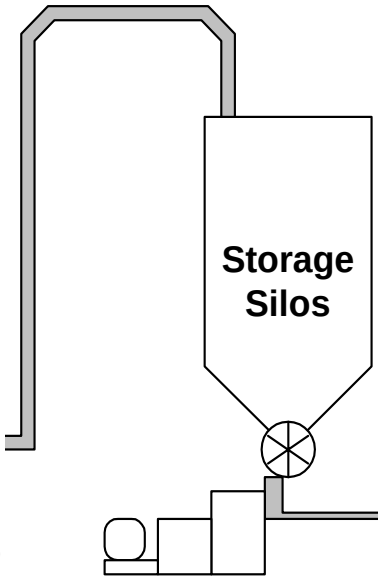
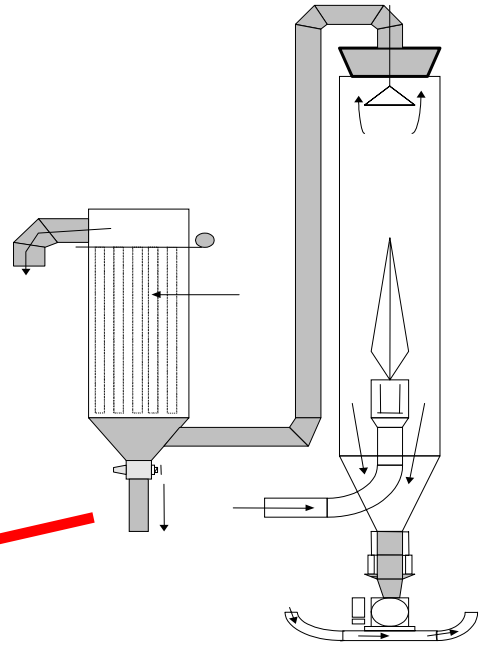
Typical Conveying System-Continued

- **Transfer line**
  - ***including piping, elbows, and divert valves***
- **Discharge vessel**
  - ***Feed hopper at the extruder***
- **Particulate removal equipment**
  - Bag filters (suction of vacuum blowers)
  - Dedusters-fines
  - Elutriators-some fines and streamers
  - Scalperators-streamers
  - Cyclones
    - ***tangential entry vessels can be conducive to streamers generation***

Typical Pellet Transfer System



Blower/Cooler



Elutriator

Scalperator

Deduster

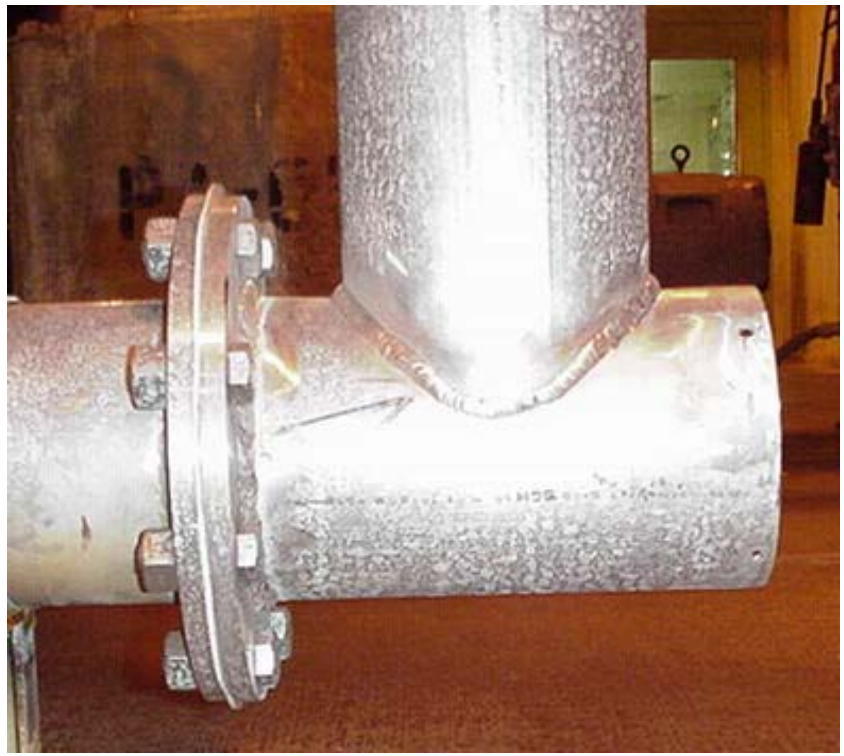
The Common Elbow

- **Long Radius Bends**
  - ***Lowest –ΔP***

    among all bends
    - ~20 ft of straight pipe
  - ***Generates Streamers***
    - Pellets “smear” against the outermost wall of the elbow
    - Frictional heat generated by this rubbing causes the outer portion of the pellet to melt and leave a skin
    - This skin peels off as snakeskins and could potentially be broken into angel hair/fines

Dead End Tees

- Largest –ΔP among all bends
  - *~70 ft. of straight pipe*
- Minimizes streamers
  - *Semi-static bed of pellets forms in dead end and acts as a cushion*
- Vortex in bed provides for self cleaning
  - *Tee wears out if pocket is not formed due to low solids/air ratio*
- Least expensive of specialty bends
- Easy to fabricate



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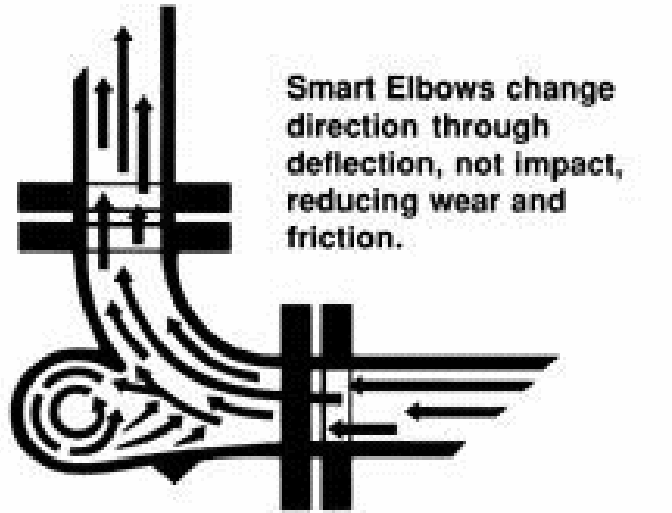
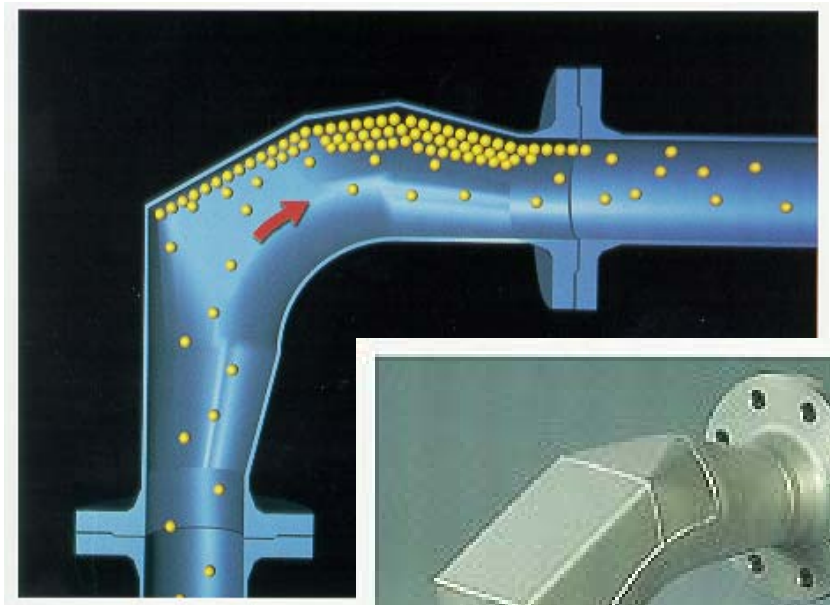
Hammertek Smart Elbow

- ***–ΔP similar to long radius***
- ***Minimizes wear***
- ***Minimizes streamers***
  - Circulating bulb of pellets deflects the solids



Specialty Elbows

- **Coperion Gamma Bend**
  - ***–ΔP is less than DET but greater than LR***
  - ***Minimizes streamers***
    - Moving bed of pellets minimizes impact



Specialty Elbows

- **Diamond Cut**
  - ***–ΔP similar to short radius***
    - greater than long radius bends
    - similar/slightly less than DET
  - ***Minimizes streamers***
  - ***Streamers prevented from Diamond Cut on inner wall***
    - Fines generation is still an issue- smearing mechanism of pellets to metal is still present

Specialty Piping

- **Shot Peened**
  - ***Shot is used to roughen the inside of the transfer pipe***
  - ***The roughening of the pipe prevents the formation of snakeskins***
  - ***More fines are generated due to abrasion***
  - ***Helps with reducing large snakeskins but generates more fines***
  - ***Inexpensive initial cost, but has a short life span***

Specialty Piping

- **Spiral Grooved**
  - ***A lip is machined into the inner wall of the pipe***
  - ***Groove acts as a “speed bump” and prevents the pellets from smearing***
  - ***Expensive initial cost***
  - ***Has a substantially longer lifespan than peening***

Ideal Pneumatic Conveying Conditions For Pellet Conveying

- **Some Heuristics…**
  - ***Velocities***
    - Pickup = 4,200 ft/min for pressure

      = 4,400 ft/min for vacuum
    - Terminal (exit) should be less than 6,000 ft/min
  - ***Temperature***
    - As cold as possible!
    - Temperatures above 100 °F are excessive

Designing Line Layout

- **Avoid inclined lines**
  - ***Keep lines horizontal and vertical***
- **Avoid installing elbows within close distances to each other**
  - ***Have straight stretch between elbows***
- **Avoid bends and use direct paths**
- **Avoid bends within 20-30 pipe diameters from the pickup point**
- **Never use more than 2 bends in a series**
- **Downward conveying design**
  - ***Treat as horizontal when doing pressure calculations***

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Designs Which Cause Line Plugs

- **Line configurations**
  - ***Avoid bends at the pickup***
    - First bend at ~ 20-30 pipe diameters
  - ***Minimize the changes in direction***
  - ***Do not use upward sloping lines***
- **Conveying air conditions**
  - ***If a loss of air volume occurs, check…***
    - Blower: dirty filters, leakage through rotary feeders, valves, couplings, holes, non-seating RV, opening of RV due to over pressuring
  - ***Dirty filter on resin vessel***

Designs Which Cause Line Plugs

- **Miscellaneous**
  - ***Resin vessel***
    - Improperly sized feeder
    - bridging in cone
  - ***Material buildup in line***
    - result of fine materials and moisture
    - Additives, etc.

A line plug will typically be found about 40' downstream of a leak!!!

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Ways To Increase Capacity

- Minimize flex hose length and eliminate where possible
- Increase pressure to system's maximum by optimizing solids/air ratio
- Check sloping lines for recycling of material
- Minimize the number of bends
- Shorten the total conveying distance
- Increase/decrease the system's air supply
  - *Install a larger/smaller blower, change rpm, etc*
  - *Must take into consideration pressure limitations*
- Step up the line diameter near the end of the system
  - *Doing so decreases the total system pressure*

Ways To Minimize Wear in Conveying Lines

- **Wear:**

$$Time\ to\ Failure \propto (linear\ velocity)^{-4}$$

- **Reduce conveying velocities**
- **Use wear resistant materials**
  - ***More prevalent for abrasive materials***
    - Sand, carbon black, etc.
- **Minimize line length and number of bends**
  - ***Lower velocities and fewer changes in direction***

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Ways To Minimize Wear in Vessels

- Enter the vessel radially, not tangentially
- Hang a flapper in the middle of the bin to allow the material to contact it instead of the vessel wall
- Step up the line diameter 40’ before the vessel entrance to reduce conveying velocities

Top 5 Reasons for Fines/Streamers Issues…

1. **High transfer velocities**
2. **High conveying temperatures**
   - ***No cooler on pressure system***
3. **Long Radius Bends in service**
   - ***Especially near the end of a conveying system***
4. **No fines/streamers removal device**
   - ***Bag filter on vacuum suction***
5. **No preventative maintenance for silo washing**
   - ***Rinse out silos at least semi-annually***

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Resources

- **Transfer System Engineering Companies**
  - ***MAC***
  - ***Hammertek***
  - ***Fuller Bulk Handling***
  - ***Coperion Waeschle***
- **Consultants**
  - ***Pneumatic conveying consultants: Paul Solt***
    - http://www.powderandbulk.com/pcc/index.html
    - Phone: (610) 437-3220 (pccsolt@itw.com)
  - ***PSRI (Particulate Solid Research, Inc.): Ted Knowlton***
    - http://psrichicago.com/
    - Phone: (773) 523-7227 (tmkspri@ix.netcom.com)
- **www.powderandbulk.com**
  - ***"Pneumatics Points to Ponder" Articles by Paul Solt***

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Questions?

Ryan Breese

Product Development Engineer

Ryan.Breese@Equistar.com