# Coarse & Fine Solids Separation

## Process Overview For Operators

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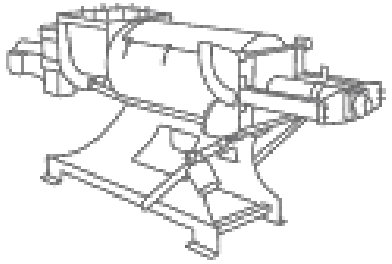
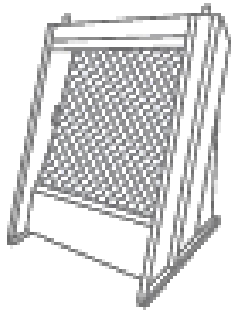
# Coarse Solids Separation

Although pre-digester treatment can include rags, grit, and sand separation using lanes, clarifiers, and screens, the focus of this review is on separation post-digestion.

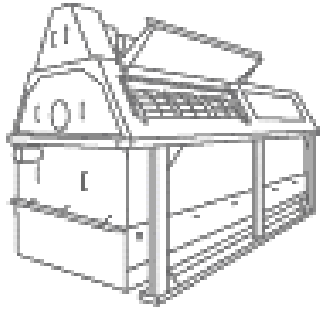
Screw Press



Slope Screen



Rotary Screen



Essentially, three general classes of screens are utilized for post-digestion, coarse solids separation: Screw presses, slope/inclined screens, and rotary screens. Each has their own set of ideal application conditions, plusses/minuses, and unique operational concerns.

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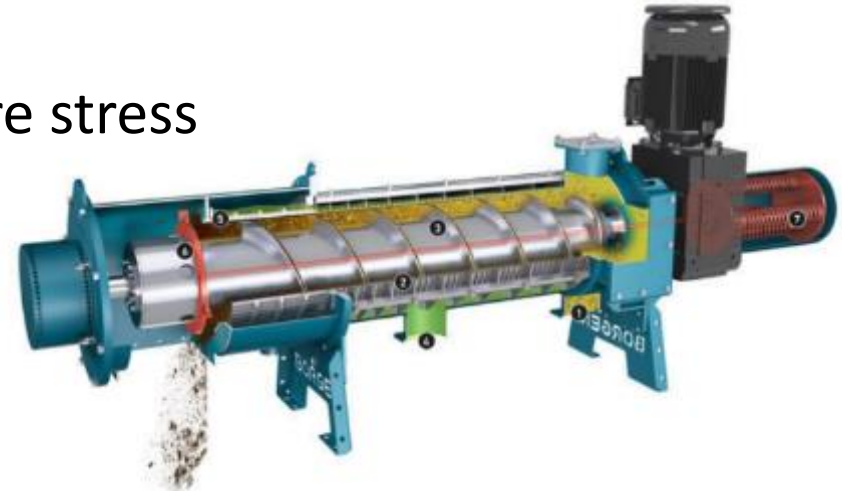
# Screw Press

A type of pressurized filtration, screw presses are in essence a wedge-wire screen cylinder. Digestate is forced to pass axially through the cylinder by an auger, while back pressure is maintained by means of single or multiple gates at the discharge of the cylinder. The pressure expels water through the screen.

- Treat digestate with 3% TS or greater
- Can produce dry cake at 20-40% TS—higher operating cost incurred
- Replacement parts: screens, augers, gearbox motor, seals, rails/guides
- Regular upkeep—oil, grease, screens
- Attempt higher output TS, by increasing pressure—more stress
- Periodic pulling screens, pressure wash of inner system



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# Slope Screen

A slope screen consists of a wedge-wire screen having various pore size openings that is set at an angle and includes a dewatering system, such as sets of rollers and/or presses, to aid in removing moisture. Various additional components such as automatic washers, timers and/or vibrating screens can be added to ensure more steady operation.

- Treat digestate with 4% TS or less
- Limited somewhat in cake dryness (20-30%)
- Can involve in-series, settling pits, mesh sizes
- Replacement parts: roller/press motors, rollers
- Regular upkeep: pressure/acid washes, oil, grease, rock trap, washers/timers setting, flow control, TS consistency

# Rotary Screen

The rotary screen works by injecting digestate within a rotating screen. The screen bar allows liquids to fall through the screen while separated solids are conveyed by flighting affixed to the screen to a designated discharge location. Water washes and/or brushes are often included. Additional dewatering in form of presses are added for thickening of solids.

- Treat digestate with 8% TS or less
- Limited somewhat in cake dryness (20-30%)
- Replacement parts: roller/press motors, wash system
- Regular upkeep: pressure/acid washes, grease/oil

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# Auxiliary, Conveyance, & Solids Handling

Whatever the choice of equipment for coarse solids separation, operation involves not just maintenance of separation equipment but often pre-post auxiliary systems, conveyance, and handling of produced solids.

- **Piping**—flow control, pumps, freezing weather, struvite, clean-outs, pipe sizing
- **Pits**—agitators, mixers, odor control systems, periodic clean-out
- **Conveyance**—grease, belt replacement, motors, bearings/rollers/splicing, washings
- **Electrical**—drives, timers, sensors, flow meters
- **Handling**—front-end loader certification/skill
- **Post**—drying, compost, bagging, etc.

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# Expectations of the Job

- **Walk-through**—inspection of all pieces of equipment, daily tasks such as grease/oil, recording of flows/data, sampling, time sheets/job numbers, observe difference between normal and abnormal working conditions, timely/critical response, pricing/ordering/deliveries, stop-gap solutions, and critical thinking/skill sets.

- **SOP**—daily tasks within proscribed standard operating procedures (SOP) for equipment. What is to be done daily, weekly, monthly, and annually. What is good to have on hand vs. ordered.

- **Periodic Scheduled Maintenance**—replacement maintenance of parts (motors, gearboxes, screens, seals, belts, augers, sensors). Proper scheduling/ordering.

- **Unscheduled Maintenance**—critical thinking, stop-gap solutions, timely response.

# Final Thoughts—Coarse Solids

Interviewed operational team regarding years of coarse solids/liquid separation and their list of common themes.

1. Cleanliness of screens—keep them clean, they will be your friend
2. Flow consistency—designed for steady input/throughput—strive for this.
3. Struvite/drainage—digestate will lead to struvite, and mostly at separator.
4. Expected vs. unexpected maintenance—you can prepare for expected maintenance, and even unexpected if you have a watchful eye/ear.

**Know how your equipment works—can't critically think and resolve problems unless you are well vetted in how the technology works and is integrated into larger system**

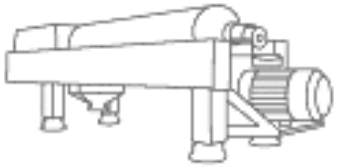
# Fine Solids Separation

After coarse solids separation, is the potential for further solids treatment, specifically the separation of suspended, fine solids—solids which are often associated with significant levels of nutrients.

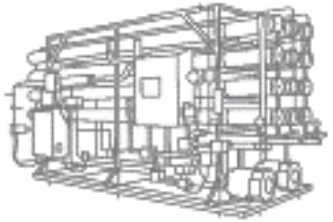
Suspended, fine solids can be removed through settling/clarification, but typical technologies for post-digestion involve various methods for chemical flocculation—or if chemicals are to be avoided, decanting centrifuge or membrane separation.

Chemical Flocculation

Decanting Centrifuge



UF Membrane



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# Chemical Flocculation

Chemical flocculation systems are a class of technologies whereby chemicals are added to the digestate so that small suspended solids can be aggregated into larger flocs so that separation, dewatering, and removal of solids into a stackable pile can occur.

The process involves adding coagulants (metallic ions, i.e. Fe+3) and/or co-polymers (long-chain carbon with charged species, i.e. PAM) of specific form, quantity and charge so that with proper mixing energy, flocs can form. The process steps are:

- **Chemical make-down**: convert solid/concentrated chemical to appropriate solution
- **Reaction**: adding all ingredients and mixing for appropriate energy/time
- **Bulk-liquid Separation**: removal of clarified liquid from flocs
- **Solids Dewatering**: use of dewatering apparatus to dewater flocs to stackable pile.

# Chemical Flocculation

Various approaches differ primarily in the manner which they separate bulk liquid and dewater the solids. The most common approaches are:

**Bulk Liquid Separation**

- **Dissolved Air Flotation (DAF)**: micro-air bubbles to induce flocs to rise, allowing for skimming off of solids
- **Inclined Screens**: micro-screens to allow bulk liquid removal out of bottom
- **Moving Discs**: rotating discs with micro-spacing, self cleaning

Moving Disc

DAF

Inclined Screen

# Chemical Flocculation

Various approaches differ primarily in the manner which they separate bulk liquid and dewater the solids. The most common approaches are:

**Solids Dewatering**

- **Moving Disc**: rotating discs alongside angled auger, with pressure plate
- **Belt Press**: Belt movement of solids against sequence of squeeze rollers
- **Rotary Press**: channeled solids in between two rotating screens with pressure plate against solids

Moving Disc

Rotary Press

Belt Press

# Chemical Flocculation

Fine solids separation involves added mechanical/chemical complexity and as such operational expectations are more complex. An incomplete listing is below.

- **Chemical Make-Down**: while polymer expert will help identify correct chemical mixture, day-to-day operations involve chemical ordering/storage/safety, periodic re-testing, maintenance on solid augers, mixers, flow meters, pumps, variable speed drives, mathematical dilution equations, spill clean-up.
- **Reaction**: dosing pumps, agitation, recycle feeds, flow meters, flow modulators, air generators, pressure gauges, feedback controls.
- **Dewatering**: Pumps, agitators, augers, disc/screen/press maintenance, wash cycles, variable speed drives.
- **Auxiliary**: Pits, agitators, pumps, clean-outs, struvite, conveyance, exhaust, solids handling, electrical controls/panel, meters.

# Final Thoughts—Chemical Flocculation

Interviewed operational team regarding years of chemical flocculation separation and their list of common themes.

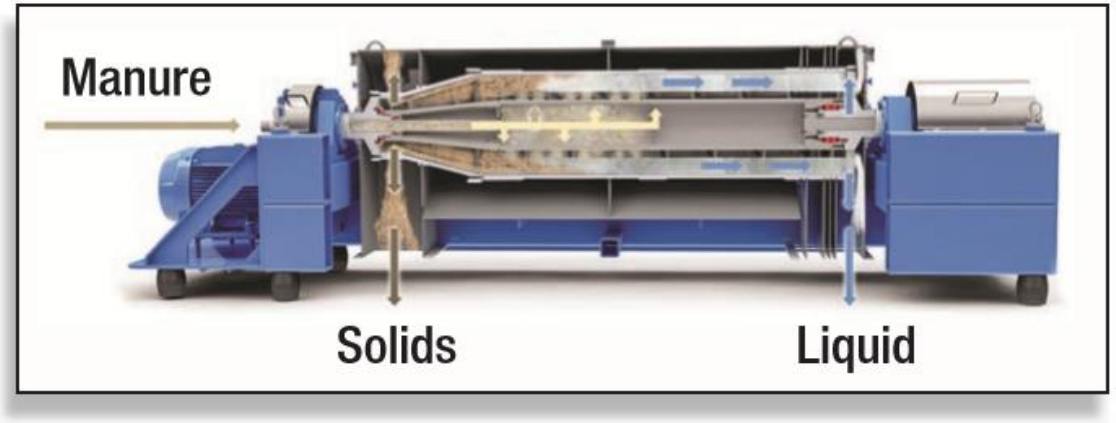
1. Polymer—it gets everywhere, spills/clean up, impact on pumps, equipment, etc.
2. Struvite/drainage—digestate will lead to struvite, and mostly at separators
3. Flow consistency—designed for steady input/throughput—strive for this.
4. Expected vs. unexpected maintenance—you can prepare for expected maintenance, and even unexpected if you have a watchful eye/ear.

**Know how your equipment works—can't critically think and resolve problems unless you are well vetted in how the technology works and is integrated into larger system**

# Decanting Centrifuge

Centrifugation uses high-speed g-forces (2000-4000 G) to spin and separate solids and liquids by density. It's somewhat comparative to the spin cycle of a washing machine where the spinning of the washer drum forces water out of the clothes.

Centrifuges can also utilize chemical flocculation as a pretreatment and then using the centrifuge as a bulk-water removal and solids dewatering apparatus. Greater solids and nutrient capture can be accomplished, but at a higher cost.

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# Decanting Centrifuge

While effective at removing solids and producing a dry product, drawbacks do exist with operations. Specifically, analyses comparing a typical chemical flocculation process against polymer centrifugation for treatment of biosolids showed:

- Nearly **5x** the cost of **electricity** to operate the centrifuge with its high G-forces.
- Nearly **2x** the cost of **polymer/chemical dosage** due to short residence time/shear forces of centrifuge negatively impacting flocculation efficiency.
- Similar labor and maintenance costs, however
  - Centrifuge required **more extensive operator training** and there was higher **potential for large replacement maintenance costs** with centrifuge.
- **Dryer product** is achieved which impacts downstream costs.
- Still **significant fine solids separation without polymer.**

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# Ultrafiltration Membrane

High pressure membranes use electrical inputs to induce high pressure suitable for forcing digestate through porous membrane. Depending on the pore-size, certain sized particles will be rejected by the membrane and shunted out of the system as a concentrate while other particles are allowed to pass through as a permeate.

Ultra-filtration (UF) systems are of a suitable size to remove all suspended solids, bacteria/virus, and considerable fraction of N/P nutrients, leaving behind salts, ammonia and other smaller chemicals.

- **High electricity, pressure systems, pumps**
- **Membrane cleaning, control systems**

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