Hidden Threats:

Inefficiencies and Vulnerabilities in Anaerobic Digestion and Combined Heat & Power Systems

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Agenda

- Overview
- At the Digester:
  - Feeding
  - Pumping
  - Heating
  - Mixing
- Support Facilities:
  - Thickening
  - Gas Storage
  - Gas Treatment & CHP
- Safety

Challenges with “Lessons Learned”

- “Eating Crow”
- Sharing the good, bad and ugly.
- Really Learning from our collective Mistakes & Challenges
- Skewed Perception of Risk
- Lack of Data

Source: firmex.com

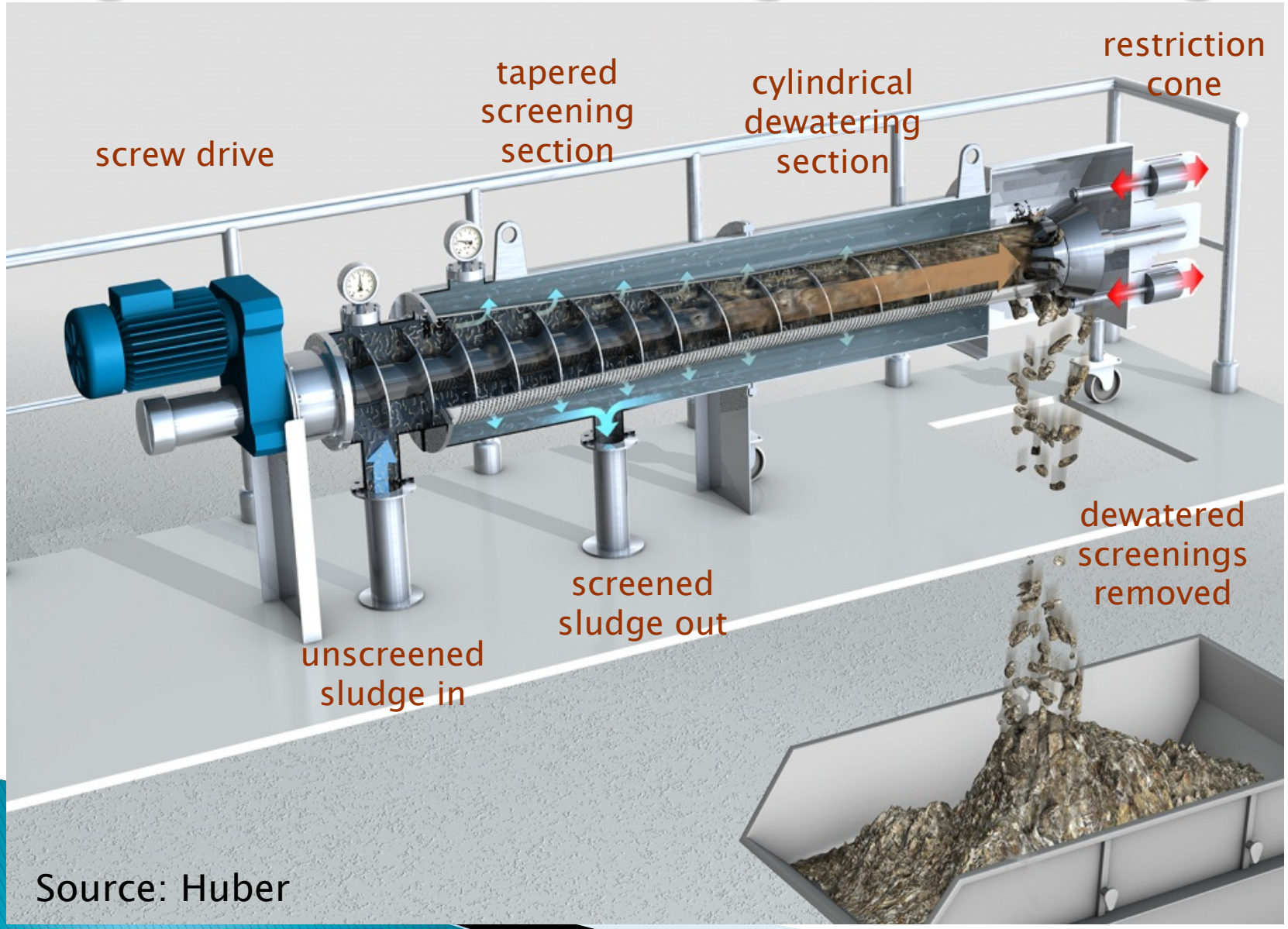
Threats Defined

- Inefficiencies
- Design Pitfalls
- Operational Issues
- Potential for Catastrophic Failure

Digester Feed Considerations

- Consistent, even feeding to each digester
  - No “slug” feeding
  - Beware of uneven pump wear
  - Use caution when blending WAS and Primary (odor)
- High Strength Waste
  - Rocks, utensils, toxic chemicals
- Waste Receiving & Screening

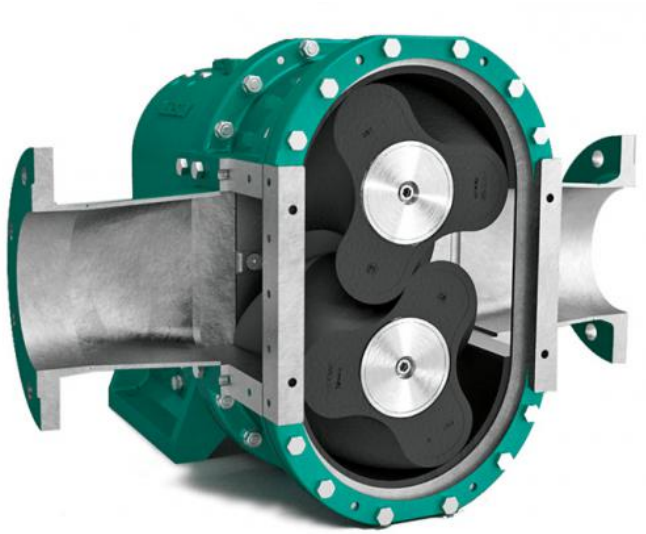
Digester Feed– Sludge Screening



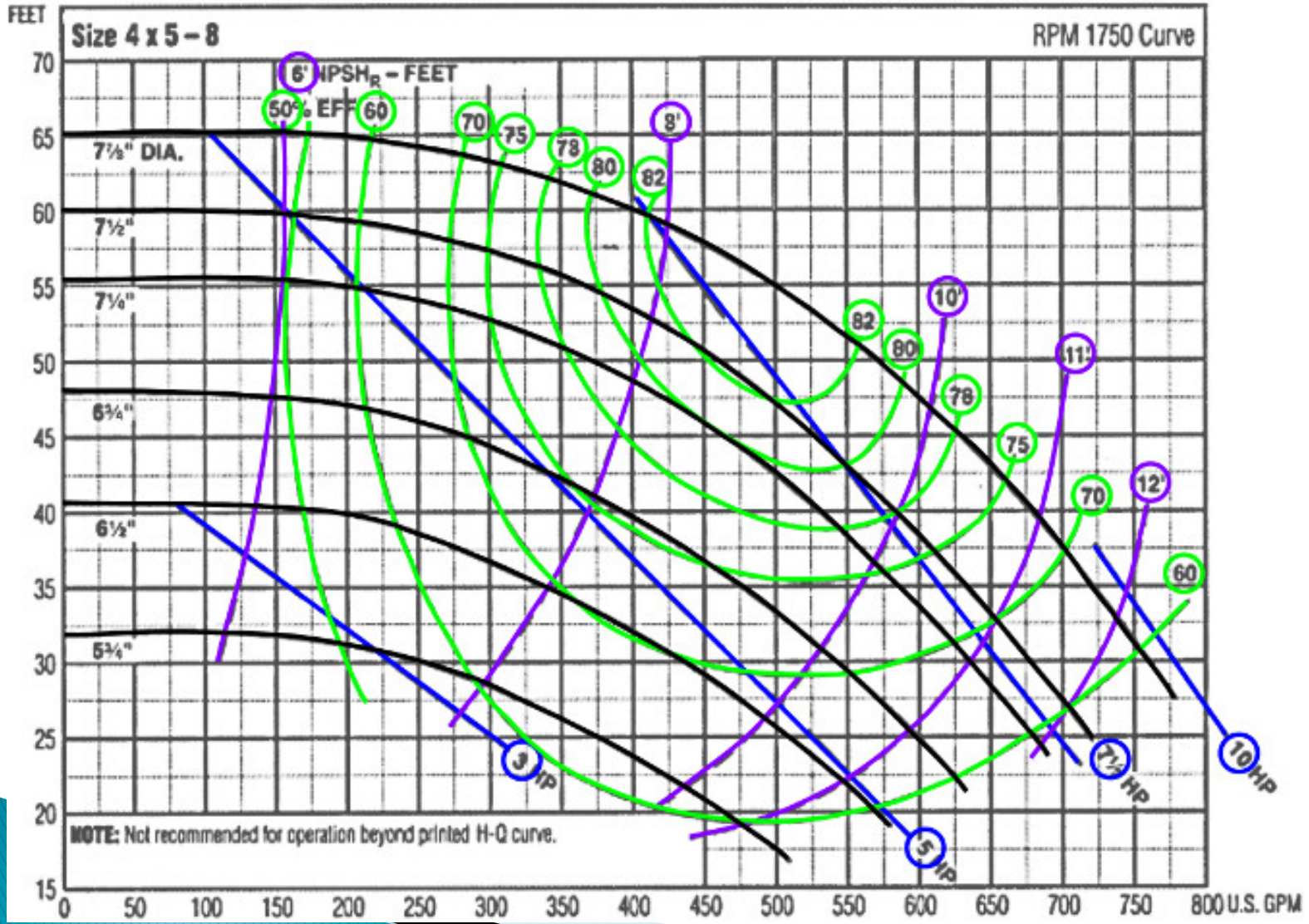
Source: Huber

Pumping Considerations

- Inefficiency and Operational Threats
- Pump Type
- Pump Performance

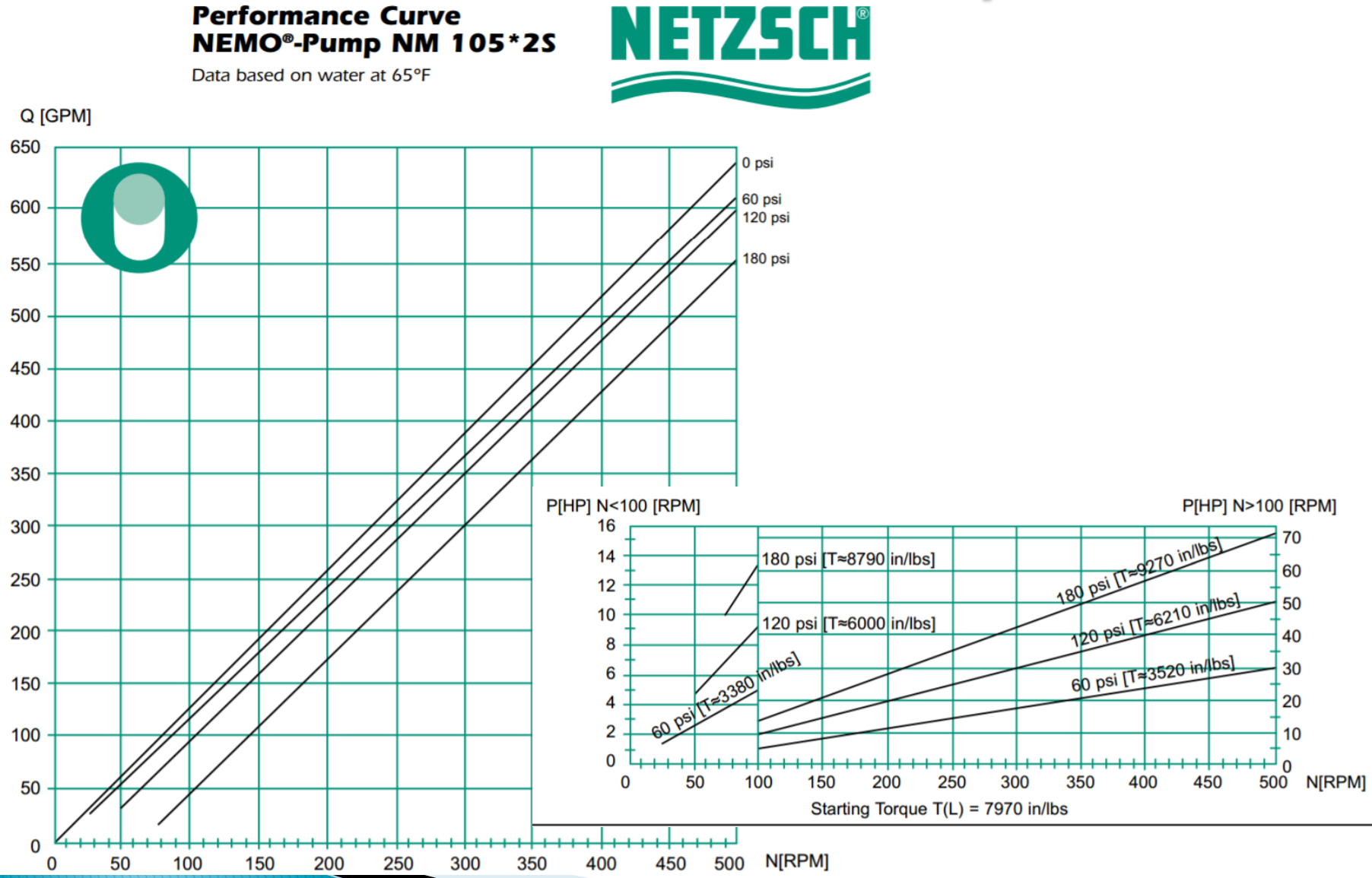


Centrifugal Pump Curve



Source: Flow Control Network

Positive Displacement Pump"Curve"



Pumping Summary

- Centrifugal
  - Flow can vary widely with small head variation.
  - Uses less energy than PD Pumps
  - Low-medium pressure applications (Recirculation, Transfer)
  - Chopper or non-clog pumps must be used.

- Positive Displacement
  - Flow consistent despite pressure variation.
  - High Flows need significant HP.
  - Medium-High pressure and precision flow applications (Feed, Transfer).
  - Good for solids but debris will cause maintenance problems.

Digester Mixing Approaches

- Gas Mixing
  - Compressors & Tubes/Lances
- Pump Mixing
  - Pump(s) and nozzles
- Linear Motion Mixer (LMM)
  - Vertically-moving disk
- Draft Tube Mixer
  - Motor, shaft and propeller

Gas Mixing Pros & Cons

- Pros:
  - One Compressor
  - No moving parts in sludge
  - Reliability
- Cons:
  - No Redundancy
  - Ragging
  - Ineffective
  - One direction of flow
  - Maintenance Hazards

Pump Mixing Pros & Cons

- Pros
  - Familiar Equipment
  - Redundancy (second pump)
  - Simple & inexpensive
- Cons
  - High energy usage (pipes and nozzles)
  - One direction of flow
  - Low Flow Rates
  - Foaming potential
  - Pump Maintenance
  - Large piping inside tank & building

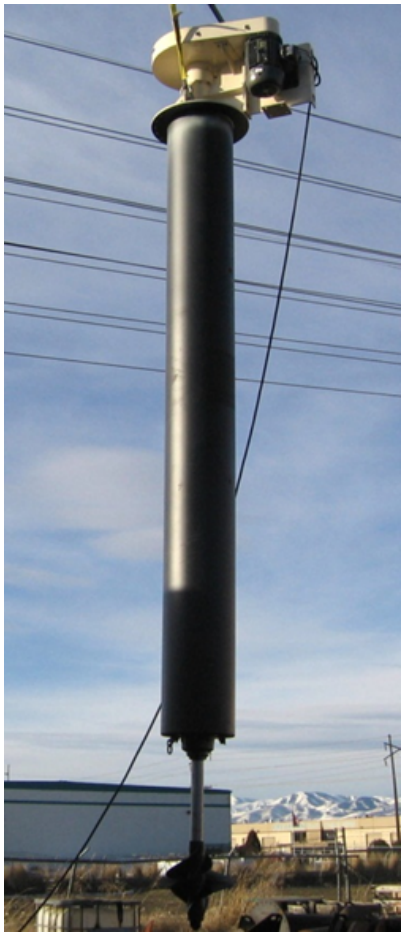
http://www.chopperpumps.com

Linear Motion Mixer

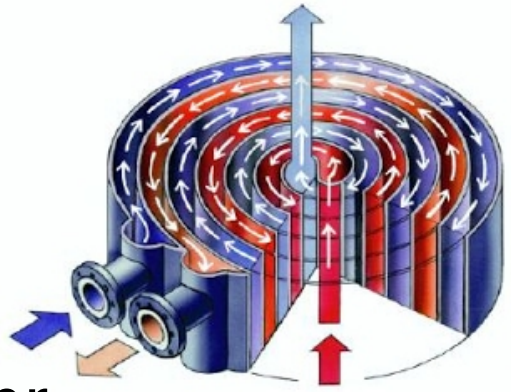
- Pros
  - No rotating parts in tank
  - Low energy claims
- Cons
  - Sole-sourced, proprietary, expensive.
  - Cam Mechanism
  - Long-term reliability & mixing performance unknown.

Draft Tube Mixing Pros & Cons

- Pros
  - Redundancy
  - Reversible Flow
  - Very high flows
  - Reliability (10+ years)
  - Mitigates foam (pump down)
- Cons
  - Crane required for repairs
  - Moving parts in sludge
  - Not compatible with low sludge levels



Digester Heating



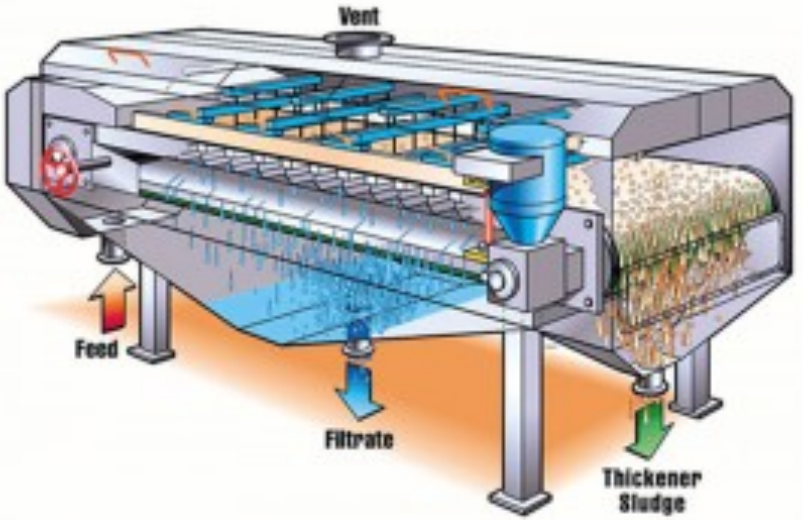
- Proper Sizing
  - Fouling Factor (+47%) by manufacturer
  - 10 States Standards (+30%) by consultant
  - = 190% larger than required for heat transfer
- Heat Source < Heat Exchanger
  - Variable Flow Rates
  - Oversizing
- Recirculation pumping may be costly and problematic.
- Pumps and HXs take up space in cramped digester buildings.

Mixer Heat Exchanger Jacket

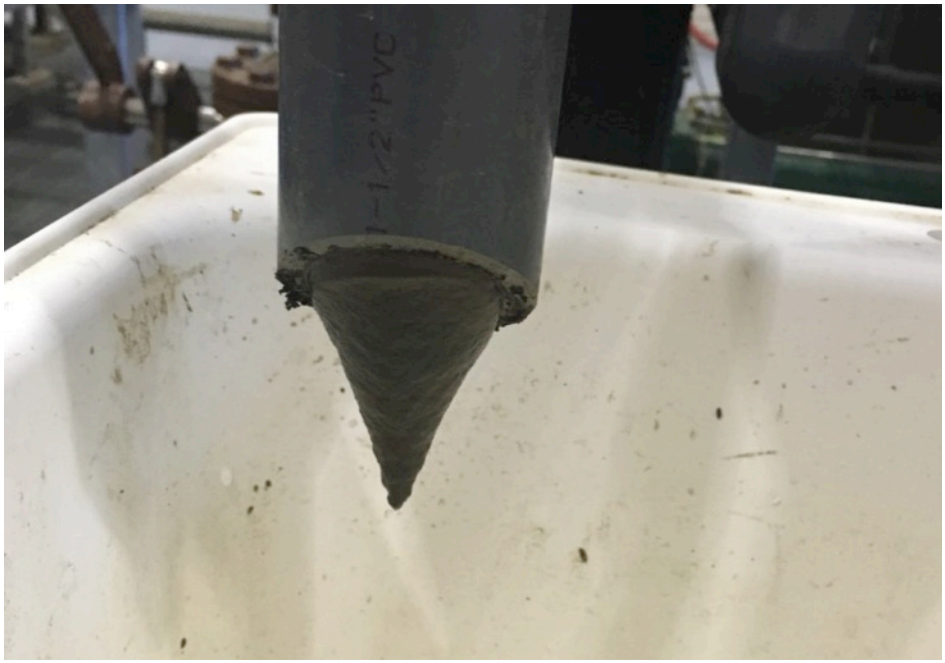
- Hot water piped to mixer
- No extra sludge pumps or piping
- Reduced electricity usage
- Saves room in digester building

Thickening

- Too Little(<2-3%)
  - Excessive heat demand.
  - Volatile loading rates too low.
- Too Much (>6-8%)
  - Difficult to Pump & Mix
- Hydrolysis/THP
  - Allows Digester feeds from 7-16.5%
  - Viscosity drastically decreased.



Source: BDP



Biogas Storage

- Beware of “Rules of Thumb” for sizing”.
- Displacement not compression (low pressure)
- Level indication is essential.

Cogen/Combined Heat & Power (CHP)

- Secure contracts for grease & high-strength waste supply.
- Ensure there are automatic controls to protect digesters, scrubbers & CHP equipment.
- Design and size for operational flexibility.
- System supplier should have strong local support.

Other Digester Issues

CAUSE	RESULT	PREVENTION
1. Process Upset	Foaming	1. Even Feeding 2. Proper Mixing 3. Freeboard 4. Oversized Overflows 5. Unobstructed Relief
1. Mixer Outage 2. High Gas Production/ Holdup	Rapid Rise/Volume Expansion	
1. Liquid Withdrawal 2. Utilization equipment 3. Undersized/closed safety valves	Under Pressurization (Vacuum)	1. Clean Flame Arrestors 2. Freeze Protection 3. Level sensors 4. Pressure sensors/ controls 5. Sloped Pipes & Condensate removal
1. Blocked Pipes/Valves 2. Liquid Level too high 3. Foam/Rapid Rise	Over Pressurization	

Basic Digester Safety

- No smoking, electric equipment, open flames
- Ensure relief valves are working properly
- Use only non-sparking tools
- Only properly trained personnel should work around the cover

Questions?

Additional Questions or Comments:

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Problems in Paradise