

# Anaerobic Digestion and High Strength Waste Co-Digestion *Panel Discussion*

Cody Schoepke - Mike Penkwitz - Chris Shaw - Mary Frances Klimek - Ryan Giefer - Sharon Thieszen - Greg Markle



WISCONSIN WASTEWATER  
OPERATORS' ASSOCIATION

52nd Annual Conference  
Thursday, October 18<sup>th</sup> 2018  
10:00 am to 11:45 am

# Panel Discussion

- **Anaerobic Digestion (10:00am to 10:50am)**
  - Panel Member Introductions
  - Pre-Digestion
  - Digester Loadings
  - Digester Design
  - Digester Process Checks
  - Digester Mixing
  - Digester Operation
  - Digester Gas Handling
  - Digester Safety
  - Digester Equipment
  - Digester Process Analyses

# Panel Discussion

- **High Strength Waste (HSW) Receiving (10:55am to 11:45am)**
  - Panel member introductions
  - HSW receiving considerations
  - HSW characteristics
  - HSW feeding
  - HSW substrate types
  - HSW tipping fees
  - HSW haulers
  - HSW impacts
  - HSW tank design
  - HSW other considerations

# Cody Schoepke (Wastewater Superintendent) – City of Fond du Lac

## Fond du Lac Regional Wastewater Treatment and Resource Recovery Facility

- Average Daily wastewater flow to the facility: **8 MGD**
- Digestion (type): **2 Thermophilic followed by 2 Mesophilic**
- Digester Tank (shape): **Pancake**
- Digester Tank (dimensions): **4 at 65ft diameter, 30ft SWD**
- Digester Cover (type): **2 fixed covers and two gas holding spiral floating covers**
- Digester Mixing (type): **Centrifugal horizontal chopper pumps and nozzles**
- Digester Treatment Volume (gal and cu ft): **2,754,000 gal and 368,156 cu ft**
- Average daily flow to digestion:
  - Primary: 30,000 gpd
  - WAS: 40,000 gpd
  - HSW: 32,000 gpd
- Average daily loading to digestion
  - Digester 1: 0.17 Lb VS / ft<sup>3</sup> 0.27 Lb COD / ft<sup>3</sup>
  - Digester 2: 0.20 Lb VS / ft<sup>3</sup> 0.23 Lb COD / ft<sup>3</sup>
- Average daily gas production: **200,000 cubic feet**



# Ryan Giefer (Wastewater Superintendent) – City of Wisconsin Rapids

## Wisconsin Rapids Wastewater Treatment Facility

- Average Daily wastewater flow to the facility: **4 MGD**
- Digestion (type): **2 Thermophilic followed by 1 Mesophilic (Batch Class A)**
- Digester Tank (shape): **Pancake**
- Digester Tank (dimensions): **Thermophilic – 55 ft diameters, 26 ft SWD**  
**Mesophilic – 70 ft diameter, 26 ft SWD**
- Digester Cover (type): **1 fixed cover and 2 gas holding floating covers**
- Digester Mixing (type): **Compressed Gas Cannons**
- Digester Treatment Volume (gal and cu ft): **1,694,000 gal and 226,454 cu ft**
- Average daily flow to digestion:
  - Primary: **8,500 GPD**
  - WAS: **TWAS 17,000 GPD**
  - HSW: **10,000 GPD**
- Average daily loading to digestions:
  - Lb VS / 1000 cu ft: **150**
  - COD / 1000 cu ft: **xxxx**
- Average daily gas production: **135,000 cubic feet**



# Director of Utilities Chris Shaw – City of Appleton

## Appleton Wastewater Treatment Plant

- Average Daily wastewater flow to the facility: **15.5 MGD**
- Digestion (type): **2 Mesophilic**
- Digester Tank (shape): **Egg Shaped Digesters**
- Digester Tank (dimensions): **2 at 110 ft SWD, 80 ft diameter,**
- Secondary Digesters Cover (type): **2 conventional with duodeck fixed covers**
- One gas bladder
- Digester Mixing (type): **Centrifugal horizontal chopper pumps and nozzles**
- Digester Treatment Volume (gal and cu ft): **4,400,000 gal and 588,235 cu ft**
- Average daily flow to digestion:
  - Primary: **48,000 gal**
  - WAS: **60,000 gal**
  - HSW: **87,000 gal**
- Average daily loading to digestions:
  - **65 Lb VS / 1000 cu ft**
- Average daily gas production: **750,000 cubic feet**



# Mike Penkwitz (Wastewater Superintendent) – Plymouth

## Fond du Lac Regional Wastewater Treatment and Resource Recovery Facility

- Average Daily wastewater flow to the facility: **1.8 MGD**
- Digestion (type): **One Thermophilic followed by One Mesophilic**
- Digester Tank (shape): **Round**
- Digester Tank (dimensions): **One at 50 ft diameter, 26 ft SWD**
- Digester Cover (type): **One fixed cover and one gas holding floating cover**
- Digester Mixing (type): **Linear Mixer on Thermophilic, no mixing on mesophilic digester**
- Digester Treatment Volume (gal and cu ft): **450,000 gal and 60,000 cu ft**
- Average daily flow to digestion:
  - Primary: **18,720 gal (includes settled WAS)**
  - WAS: ...
  - HSW: **7,000 GPD**
- Average daily loading to digestions:
  - Lb VS / 1000 cu ft: **0.09**
  - COD / 1000 cu ft: **N/A**
- Average daily gas production: **61,000 cu ft.**



# NEW Water- Digester Overview

## NEW Water Resource Recovery Facility- Green Bay Facility

- Average Daily wastewater flow to the facility: **30 MGD**
- Digestion (type): **2- Mesophilic at 98.0°F**
- Digester Tank (shape): **Silo**
- Digester Tank (dimensions): **2- 65ft diameter, 85ft sidewall depth**
- Digester Cover (type): **Fixed steel dome covers**
- Digester Mixing (type): **Centrifugal horizontal chopper pumps (6) and nozzles**
- Digester Treatment Volume (gal and cu ft): **4,400,000 gallons & 586,666 cu ft**
- Average daily flow to digestion: (1-digester in operation, still in start-up phase)
  - Primary: **45,000 GPD- 5% Average Solids Concentration**
  - WAS: **65,000 GPD- 4.5% Average Solids Concentration**
  - HSW: **TBD- No HSW addition at this time**
- Average daily loading to digestions:
  - Daily VS Load: **33,000 lbs/day average**
  - COD / 1000 cu ft: **N/A- Performing full VFA testing**
- Average daily gas production: **235,000 cubic feet (1-digester is in operation with no HSW addition at this time)**



# Sharon Thieszen (*Former Wastewater Superintendent*) – City of Sheboygan

## Sheboygan Regional Wastewater Treatment Facility

- Average Daily wastewater flow to the facility: **10 MGD**
- Digestion (type): **Mesophilic; 3 Primary Digesters, 1 Secondary Digester**
- Digester Tank (shape): **Pancake**
- Digester Tank (dimensions): **3 at 70ft diameter, 26ft SWD; 1 at 60ft diameter, 26ft SWD**
- Digester Cover (type): **3 fixed covers (EIMCO); 1 floating-gasholder cover (EIMCO)**
- Digester Mixing (type): **Ovivo Linear Motion Mixers; 1 -10HP motor per primary digester**
- Digester Treatment Volume (gal and cu ft): **2,250,000 gal and 300,802 cu ft**
- Average daily flow to digestion:
  - Primary / WAS (2016): **59,000 gpd**
  - HSW (2016): **44,000 gpd**
  - Primary / WAS (Oct-Nov 2017): **45,000 – 50,000 gpd**
  - HSW (Oct-Nov 2017): **0 gpd**
- Average daily gas production:
  - Codigestion (2016) : **500,000 – 600,000 cu ft**
  - No Codigestion (Oct-Nov 2017) : **80,000 – 120,000 cu ft**



# Greg Markle (Process Control Supervisor) – City of Waukesha

## City of Waukesha Clean Water Plant

- Average Daily wastewater flow to the facility: **10 MGD**
- Digestion (type): **3 Mesophilic (2 Active).**
- Digester Tank (shape): **1 Egg & 2 Pancake's**
- Digester Tank (dimensions): **Egg (66ft diameter, 72 SWD),  
2 Pancake's (90ft diameter, 18ft SWD)**
- Digester Cover (type): **1 fixed cover (egg), 1 floating cover, & 1 membrane cover**
- Digester Mixing (type): **Centrifugal horizontal chopper pumps and nozzles**
- Digester Treatment Volume (gal and cu ft): **3,078,768 gal and 411,600 cu ft**
- Average daily flow to digestion:
  - Primary: **25 MGD**
  - WAS: **11 MGD**
  - HSW: **0 MGD**
- Average daily loading to digestions:
  - Lb VS / 1000 cu ft: **123 - Egg**
  - Lb VS / 1000 cu ft: **66 - Pancake**
- Average daily gas production: **160,000 cubic feet**



# Mary-Frances Klimek (Wastewater Superintendent) – City of Racine

## Racine Wastewater Treatment Facility

- Average Daily wastewater flow to the facility: **23 MGD**
- Digestion (type): **4 Mesophilic**
- Digester Tank (shape): **Pancake**
- Digester Tank (dimensions): **3 at 90 ft diameter, 1 at 60 ft diameter**
- Digester Cover (type): **3 floating covers and one gas holding covers**
- Digester Mixing (type): **Draft Tube Mixers**
- Digester Treatment Volume (gal and cu ft): **4,000,000 gal and 534,722 cu ft**
- Average daily flow to digestion:
  - Primary: **70,000 gal**
  - WAS: **35,000 gal**
  - HSW: **0 gal**
- Average daily loading to digestions:
  - Lb VS / 1000 cu ft: **36.6**
- Average daily gas production: **200,000 cubic feet**



# Anaerobic Digestion



# Conditioning/Cleaning/Removal Prior to Anaerobic Digestion

- Grit and screenings removal on wastewater
- Sludge screening on feed sludge to digestion
- Waste Activated Sludge (WAS) conditioning
  - Thermal Hydrolysis
    - Pondus
    - Cambi
  - Enzymatic Hydrolysis
  - Other

# Digester Loading

- Primary
- WAS
- Blended Sludge (Primary and WAS co-thickened)
- HSW
- Other
  
- Feed Rates
  - Continuous feed
  - Intermittent feed
  
- Lb VS / 1000 cu ft
- Lb COD / 1000 cu ft

# Digester Loading

- Percent Feed Rate of Primary vs. WAS vs. HSW
- Organic Loading (BOD/COD)
- Hydraulic Loading (Flow)
- Temperature
- % Solids and % Volatile Solids
- pH

# Digester Design

- Thermophilic
- Mesophilic
- Primary Digesters
- Secondary Digesters
- Intermediate Tankage
- Egg shaped
- Pancake
- Cylinder
- Other

# Digester Covers and Heat Exchangers/Boilers

- Floating
- Fixed
- Gas holder
  
- Heating Demand
  - Boilers
  - Heat exchangers

# Digester Process Checks

- Volatile Acids (VA) – 50 to 300 mg/L
- Alkalinity (ALK) – 1500 to 5000 mg/L
- VA/ALK ratio – 0.1 to 0.35
- Mesophilic Temperature – 95 to 98 degrees F
- Thermophilic Temperature – 122 to 140 degrees F
- Mesophilic solids retention time – 10 to 30 days (WPDES Permit Driven)
- Thermophilic solids retention time – 5 to 12 days
- Organic loading – 100 to 300 lb/1000 cu ft /day
- Gas production – 13 to 18 cu ft / lb VS destroyed
- pH
- DNA analysis

# Digester Parameters/Concentrations to Potentially Monitor

- Micronutrients
- Chlorides
- Phosphorus
- Nitrogen
- Potassium
- Sodium
- Sulfides
  
- Potential Inhibition (if not acclimated)
  - Ammonia – concentrations higher than 3000 mg/L
  - Sodium
  - Calcium

# Digester Mixing and Mixing Operation

- Pump – nozzle mix
- Draft tube
  - Internal
  - External
- LM mixer
- Gas mixing
- Other
  
- Mixing Operation
  - Continuous mixing
  - Intermittent mixing

# Digester Operation

- Series
- Parallel
- Primary and/or Secondary
- Withdrawl rates
- Percent solids in
- Percent VS solids in
- Percent solids out
- Percent VS solids out
- VS destruction
- Proper Sampling locations and techniques

# Digester Operation

- Recirculation rates of sludge
- Heat exchangers (maintenance)
- Boiler/Heat exchanger operation
- Cleaning of digesters
- Piping considerations

# Digester Potential Operational Issues

- Rags, debris, and grit accumulation
- Foaming
- Equipment failures
- Cover issues
- Struvite/Vivianite formation
- Gas handling equipment
- “Rapid Rise” phenomenon
- Corrosion

# Digester Gas Handling/Treatment

- Condensation removal
- Siloxane removal
- H<sub>2</sub>S removal
- CO<sub>2</sub>
- VOCs
- Ferric addition

# Digester Safety

- Explosive Gas (Methane)
- Pressure and Vacuum Relief
- Gas Monitoring
- Lower and upper explosive limits of Methane gas
- Emergency evacuations
- Maintenance
- Gas Leak detection


# Digester Equipment

- Pumps
- Boilers
- Heat exchangers
- Piping
- Flow meters
- Temperature Measurement

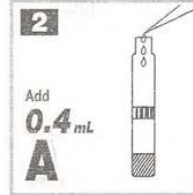
# Digester Process Analyses

- Volatile Acid / Alkalinity Ratio
- pH
- Total Solids
- Volatile Solids

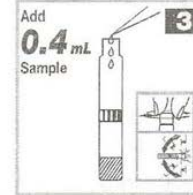
**1** Preheat **100°C**




**2** Add **0.4 mL** **A**



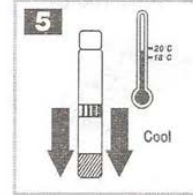
**3** Add **0.4 mL** Sample



**4** Heat **100°C** **10 min**



**5** Cool



Preheat the reactor to **100°C**.

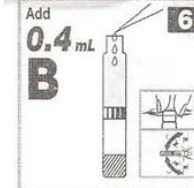
Pipet **0.4 mL** solution **A**.

Pipet **0.4 mL** of sample into the vial. Cap and invert a few times.


Heat in the reactor at **100°C** for **10 min**.

Allow to cool to room temperature.

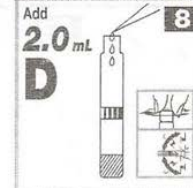
**6** Add **0.4 mL** **B**




**7** Add **0.4 mL** **C**



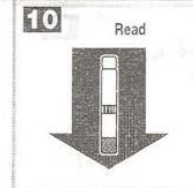
**8** Add **2.0 mL** **D**



**9** Wait **3 min**



**10** Read



Pipet **0.4 mL** solution **B**. Cap and invert a few times.

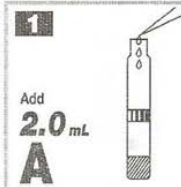
Pipet **0.4 mL** solution **C**. Cap and invert a few times.

Pipet **2.0 mL** solution **D**. Cap and invert a few times.

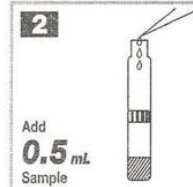
Wait **3 minutes**.

Thoroughly clean the outside of the vial and insert it into the photometer. The **barcode** is identified, and an **automatic evaluation** is carried out after the vial is inserted.

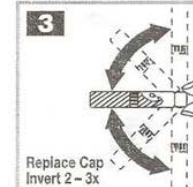
**1** Add **2.0 mL** **A**




**2** Add **0.5 mL** Sample




**3** Replace Cap Invert 2 - 3x



**4** Wait **5 min**



**5** Read



Pipet **2.0 mL** of solution **A** into the vial.

Pipet **0.5 mL** of sample into the vial.

Cap and invert 2 - 3 times until the freeze-dried contents are completely dissolved.

Wait **5 minutes**.

Thoroughly clean the outside of the vial and insert it into the photometer. The **barcode** is identified, and an **automatic evaluation** is carried out after the vial is inserted.

# Panel Discussion

- **High Strength Waste (HSW) Receiving and Co-Digestion (10:55am to 11:45am)**
  - Panel member introductions
  - HSW receiving considerations
  - HSW characteristics
  - HSW feeding
  - HSW substrate types
  - HSW tipping fees
  - HSW haulers
  - HSW impacts
  - HSW tank design
  - HSW other considerations

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- Average daily loading to digestion
  - Digester 1: 0.17 Lb VS / ft<sup>3</sup>    0.27 Lb COD / ft<sup>3</sup>
  - Digester 2: 0.20 Lb VS / ft<sup>3</sup>    0.23 Lb COD / ft<sup>3</sup>
- Average daily gas production: **200,000 cubic feet**



# Ryan Giefer (Wastewater Superintendent) – City of Wisconsin Rapids

## Wisconsin Rapids Wastewater Treatment Facility

- Average Daily wastewater flow to the facility: **4 MGD**
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## Appleton Wastewater Treatment Plant

- Average Daily wastewater flow to the facility: **15.5 MGD**
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- Digester Treatment Volume (gal and cu ft): **4,400,000 gal and 588,235 cu ft**
- Average daily flow to digestion:
  - Primary: **48,000 gal**
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  - HSW: **87,000 gal**
- Average daily loading to digestions:
  - **65 Lb VS / 1000 cu ft**
- Average daily gas production: **750,000 cubic feet**



# Mike Penkwitz (Wastewater Superintendent) – Plymouth

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# NEW Water- Digester Overview

## NEW Water Resource Recovery Facility- Green Bay Facility

- Average Daily wastewater flow to the facility: **30 MGD**
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# Greg Markle (Process Control Supervisor) – City of Waukesha

## City of Waukesha Clean Water Plant

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- Digestion (type): **3 Mesophilic (2 Active).**
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# Mary-Frances Klimek (Wastewater Superintendent) – City of Racine

## Racine Wastewater Treatment Facility

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- Average daily flow to digestion:
  - Primary: **70,000 gal**
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  - HSW: **0 gal**
- Average daily loading to digestions:
  - Lb VS / 1000 cu ft: **36.6**
- Average daily gas production: **200,000 cubic feet**



# High Strength Waste Receiving and Co-Digestion



# High Strength Waste – Receiving Tank Considerations

- Design goals and preferences based on know and potential substrates to be received
- Tank size
- Tank shape
- Tank placement
- Tank mixing
- Overflow protection/spill containment
- Piping Flushing water and cleanouts
- Sampling
- Odors
- Debris protection and removal
- Access to tankage (hauler travel route, winter operation, tight turns, pavement)

# High Strength Waste Characteristics

- Analyses
  - COD
  - BOD
  - Total Solids
  - Volatile Solids
  - Phosphorus
  - Nitrogen (TKN or Ammonia)
  - Potassium
  - Chlorides
  - Magnesium
  - Calcium
  - Sodium
  - Micronutrients

# High Strength Waste Characteristics (tests before acceptance)

- Analyses
  - COD
  - BOD
  - Total Solids
  - Volatile Solids
  - Phosphorus
  - Nitrogen (TKN or Ammonia)
  - Chlorides
  - Sodium
- Biochemical Methane Potential (BMP)
- Anaerobic Toxicity Assay (ATA)
  - Marquette – Dan Zitomer
  - Michigan State – Dana Kirk

# High Strength Waste Feeding

- % Feed to digestion (Volume and Loading)
  - Volume (gal)
    - % WAS
    - % Primary
    - % HSW
  - Loading (lbs of COD or %VS)
    - %WAS
    - %Primary
    - %HSW

# High Strength Waste - Substrates Types

- Dairy Waste
  - Cheese
  - Milk
  - Yogurt
  - Whey (Mother liquor, Permeate, etc.)
- Brewery Waste
  - Yeast bottoms
  - Retentate
- Distillery Waste
- Soda, juice, beverage Waste
- Food Waste
- FOG
- Marinade
- Potato Waste Products
- Chocolate Waste

# High Strength Waste Receiving – Tipping Fees

- Cost per gal
- Cost per concentration
- Billing

# High Strength Waste Receiving – Haulers

- Distance to travel to the WWTP
- Hours of acceptance at the WWTP
- What else is hauled in the tanks (are they cleaned out prior to hauling)
- Relationship with Haulers

# High Strength Waste – Impacts and Other Uses

- What substrate gives the most biogas production
- What substrate gives the most issues
- What substrate gives the biggest biosolids impact
  
- Biogas concentration impacts
  - Methane
  - CO<sub>2</sub>
  - H<sub>2</sub>S
  
- Potential Other uses for substrates
  - Food source (carbon) for Bio-P

# High Strength Waste – Impacts to the Wastewater process

- Bio-P
  - High N and P in the recycle streams
- Solids Handling – increase in biosolids
- Effluent Quality
- UV transmissivity
- Increase to the nutrients in the activated sludge system
- Increase in nutrients in the biosolids
- Potential to increase Struvite or Vivianite (if dosing Ferric) formation
- Chemical feed for phosphorus, struvite, and H<sub>2</sub>S control
- Thickening / Dewatering changes
- Accumulation / Increase in chlorides

# High Strength Waste – Activated Sludge / BNR Impacts

- Potential to increase energy costs due to more ammonia recycle
- Potential need for extra carbon for BNR facilities if large ammonia recycle
- Potential increase in phosphorus chemical usage

# High Strength Waste – Biosolids / Solids Handling Impacts

- Potential to increase volume of biosolids to handle (thicken, dewater, and haul)
- Potential to increase polymer usage and heat requirement to heat the digesters
- Potential impact to percent solids coming off dewatering equipment
- Potential to increase Struvite or Vivianite formation
- Potential increase in chemical costs (for example – Ferric Chloride)
- Potential increase in nutrients along with other parameters such as chlorides and sodium

# High Strength Waste – Biogas Impacts

- Biogas storage and conveyance sizing
- Biogas cleaning system size and operation
- Biogas characteristics changing (potential lower methane values)
- Biogas engine/microturbine sizing and runtimes
- Potential it increase maintenance of biogas utilization equipment

# High Strength Waste Receiving – Potential Overall Impacts

- Odor generation
- Increased truck traffic
- Increased manpower hours
- Potential increase for digester foaming

# High Strength Waste Receiving – Tank Design

- Consideration to WWTP loading design limits
- Tank design goal for volume
- Tank design shape
- Tank mixing preferences
- Tank materials of construction (Concrete, Stainless Steel, etc.)
- Tank placement (below grade or exposed)
- Filling of the tank (gravity flow or pumped)
- Types of pumps used to pump into and out of the HSW tank
- Tank and piping coatings/lining
- Flow metering of the HSW

# High Strength Waste Receiving – Considerations

- Overflow protection
- Spill containment (offloading of tankers)
- Odor control
- Debris removal prior to tank (rock trap, coarse bar rack)
- Debris removal from the tank (Vac truck access)
- Access for the trucks/tankers (hauler road, turning radius, fencing, hours of access, cleanup of the area, snow removal)
- Sampling of the high strength waste
- Monitoring of the impacts of the HSW to digestion and the WWTP
- Billing of the high strength waste

# High Strength Waste Receiving – Other Impacts and Considerations

- Biogas Utilization System
  - Microturbine
  - Internal Combustion Engine
  - Biosolids Dryer
- Biogas Treatment System
  - Moisture removal
  - H<sub>2</sub>S removal
    - Media
    - Biological
  - Siloxane removal

# High Strength Waste Receiving – Other Impacts and Considerations

- Biogas Treatment System and Maintenance (H<sub>2</sub>S and Siloxanes)
  - Media types
    - What are the options
    - Where to purchase
  - Frequency of cleaning / media change out
    - What is the basis for determining the change out or cleaning
  - How to sample and confirm H<sub>2</sub>S and Siloxane treatment
  - Where are siloxane samples sent for analysis
    - What are the levels of siloxanes that are important to watch for
    - Oil analysis

# High Strength Waste Receiving – Other Impacts and Considerations

- Microturbine Equipment
  - Heat exchangers
  - Wiring harness
  - Inlet cooling fans
  - Water flow meter
  - Combustion Chamber
  - Ignitor
  - Inlet filters
- Internal Combustion Engine
  - Oil changes
  - Spark plugs
  - Valve lash or valve clearance (gap between rocker arms and valve tappet)
  - Air flow

# High Strength Waste Receiving – Other Impacts and Considerations

- Heat exchanger maintenance
- Condensate traps and drains
- Service Contracts
- Air Emissions
- When doing maintenance on biogas utilization equipment important to consider potential impacts to peak demand