IT'S ALL IN THE MIX – DESIGN OF NEW MIXERS FOR ANAEROBIC SLUDGE DIGESTION FACILITIES AT ST. JOHNSBURY WWTF

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NEBRA ANNUAL CONFERENCE
OCTOBER 26, 2017

Image Source: Google Maps, 2012

PRESENTATION OUTLINE

1 - Introduction to St. Johnsbury WWTF
2 – Existing Digester Facilities
3 – 2013 Digester Mixer Evaluation Study
4 – Energy Evaluation of Digestion Process
5 – Digester Mixer Design Considerations
6 – Current Status

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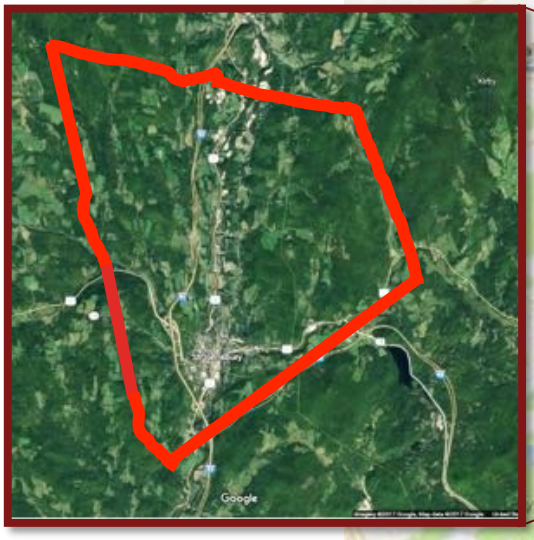
1 - INTRODUCTION TO ST. JOHNSBURY WWTF

Image Source: Google Maps, 2017

TOWN OF ST. JOHNSBURY, VT

Pop. 7,600 2010 Census



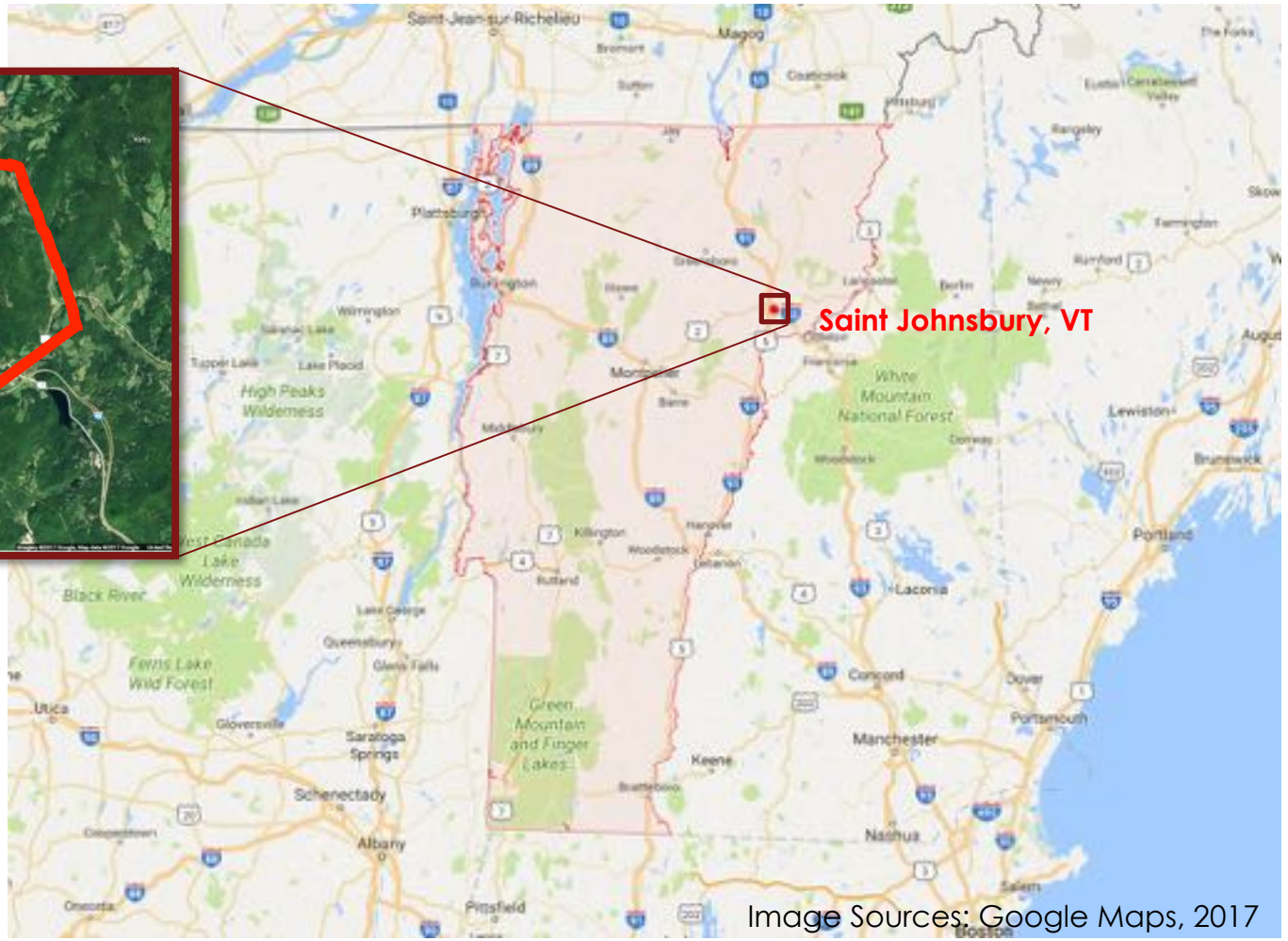


Image Sources: Google Maps, 2017

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PLANT CHARACTERISTICS

- Secondary Treatment Plant
- Owned by Town of St. Johnsbury
- Operated by Utility Partners
- Treats St. Johnsbury, VT Wastewater
- Handles Water Trt. Plant Residuals
- Last Major Upgrade 1988-1990
- Discharges to Passumpsic River

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TREATMENT PROCESS COMPONENTS – LIQUID TRAIN

1. Influent Lift Pumps
2. Preliminary Treatment
3. Primary Settling
4. Rotating Biological Contactors
5. Final Settling
6. Chlorination / Dechlorination

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TREATMENT PROCESS COMPONENTS – SOLIDS TRAIN

1. Primary and Secondary Sludge, Scum, and Septage
2. Primary Digester
   - Anaerobic Digestion
3. Secondary Digester
   - Settling
   - Gas Holder Tank
4. Sludge Storage Tank
5. Land Application

Image Source: Google Maps, 2017

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INFLUENT PARAMETERS

	2008 Design	2016
Average Daily Flow (MGD)	1.6	0.74
Peak Daily Flow (MGD)	6.9	6.9
BOD (mg/L)	251	271
TSS (mg/L)	296	298

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2 – EXISTING DIGESTER FACILITIES

PRIMARY DIGESTER

- 45’ Diameter Dual-Deck Steel Structure
- Dome Surface Fixed to Concrete Tank Walls
- Gas Mixing System Converts Volatile Organic Solids to Methane Gas
- Gas Mixing System in Constant Use

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SECONDARY DIGESTER

- 45’ Diameter Floating Steel Cover
- Cover Rides Up & Down on Gas Bubble
- Steel Rollers & Spiral Guides Align Cover
- Digester Serves as Settling and Gas Holding Tank
- Gas Mixing System Used Infrequently

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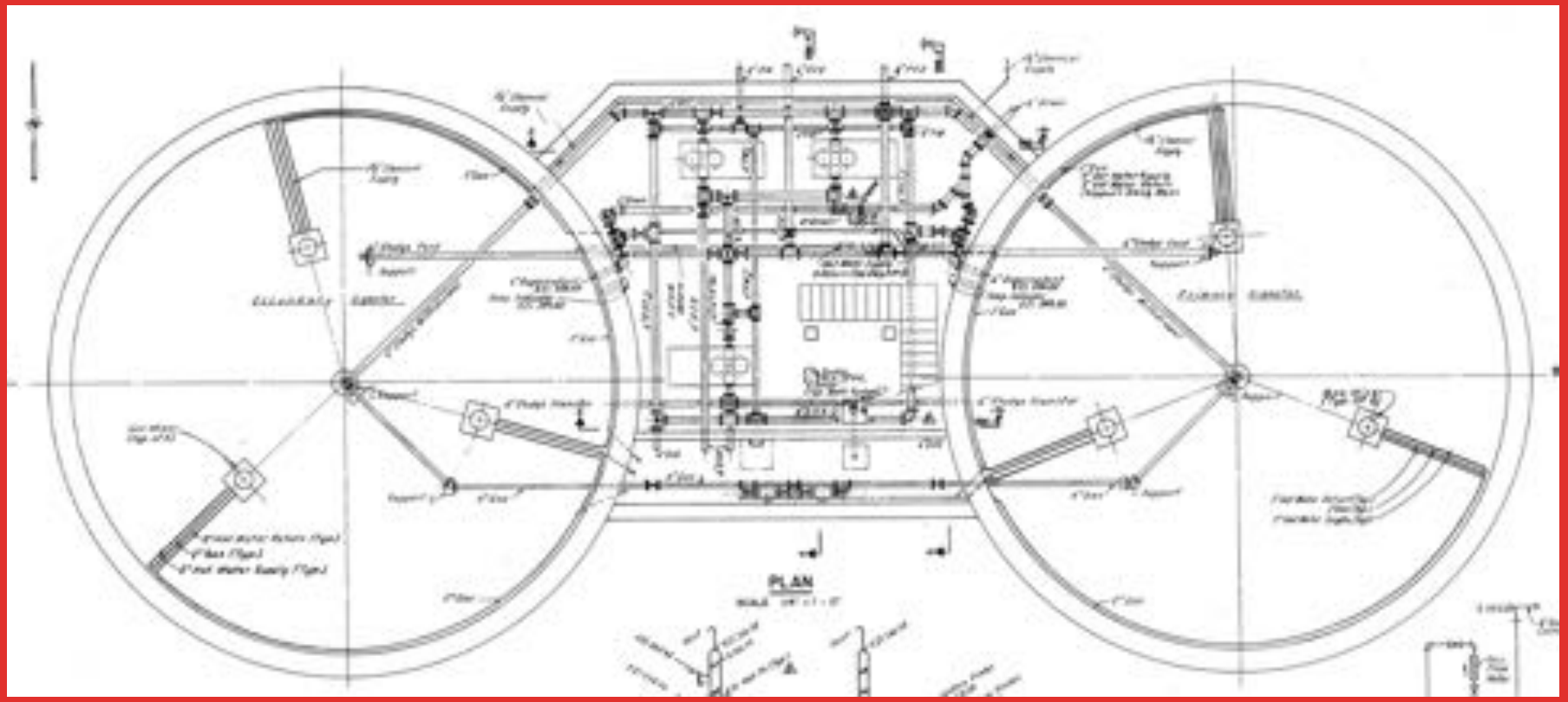
EXISTING GAS MIXING/ HEATING SYSTEM



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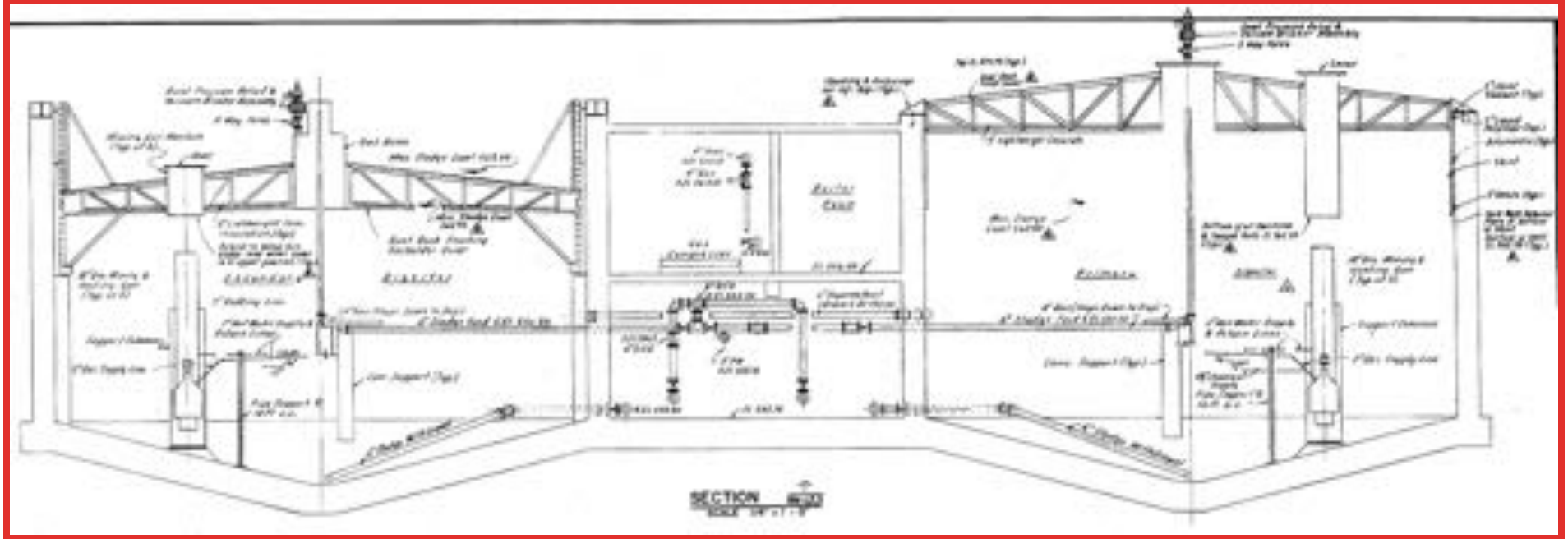
EXISTING GAS MIXING/ HEATING SYSTEM

Large Gas Bubble Mixing System	Gas Drawn Off Center Well of Secondary Digester	Gas Cleaned, Compressed, & Returned to Three, 24" Diameter Open-Ended Heating/Mixing Tubes	Heat Exchanger Mounted on Inside of Tubes



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DIGESTER SIZE & OPERATION

- Digester Tank Dimensions, Diam X Ht — 45' x 21'
- Tank Volume, Each, cf — 31,620
- Type of Operation — Mesophilic
- Internal Temperature, °F — 95

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DIGESTER OPERATING CONDITIONS

	Design	2014 Avg.
• Sludge Loading, lbs/day	3,846	1,874
• Volatile Solids (VS) In, %	70	62
• VS Loading to Primary Digester, lbs VS/1000 cf/day	85	38
• Tank Detention Time, Days	16	37
• Estimated VS Reduction, %	55	60

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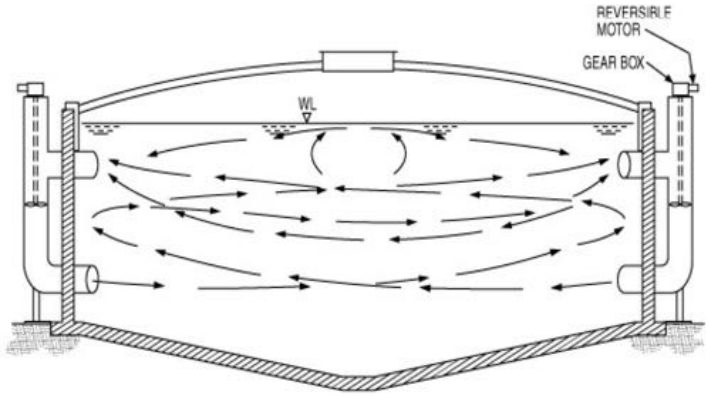
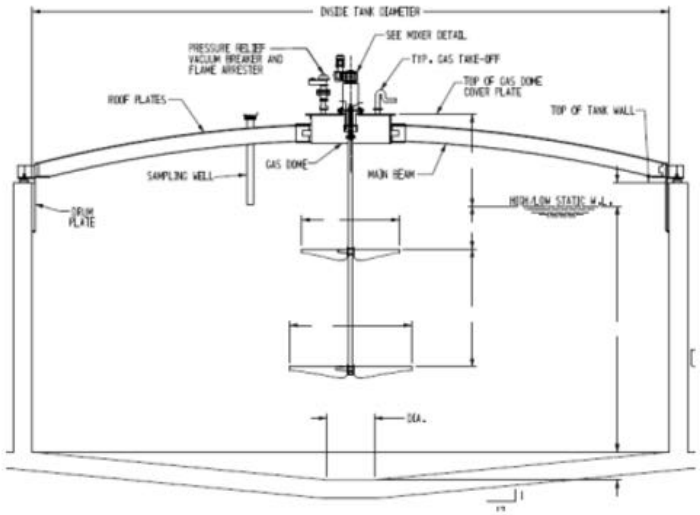
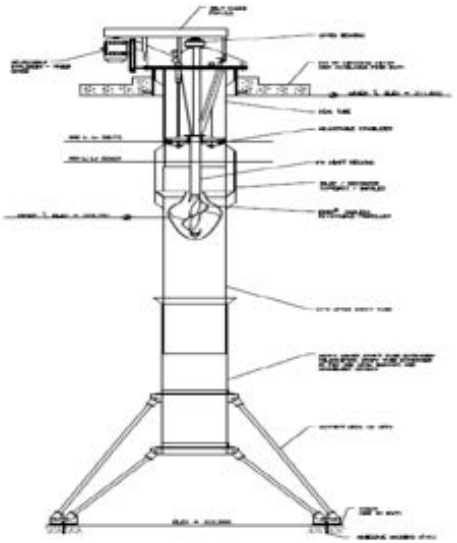
3 – 2013 DIGESTER MIXER EVALUATION STUDY







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Reasons for Evaluation Study

- Mixing Equipment >22 Years Old
- Poor Mixing Characteristics
- Solids Build-up in Tank
- Water Residuals Impact
- Tanks Taken Out of Service Frequently
- Gas Mixing Not Comparable to Current Mixing Systems

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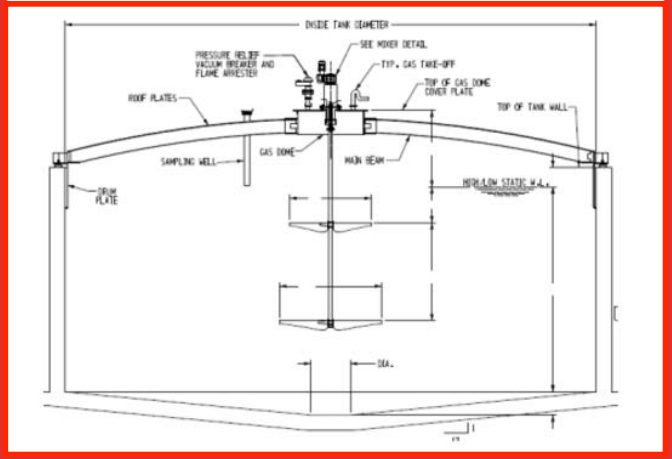
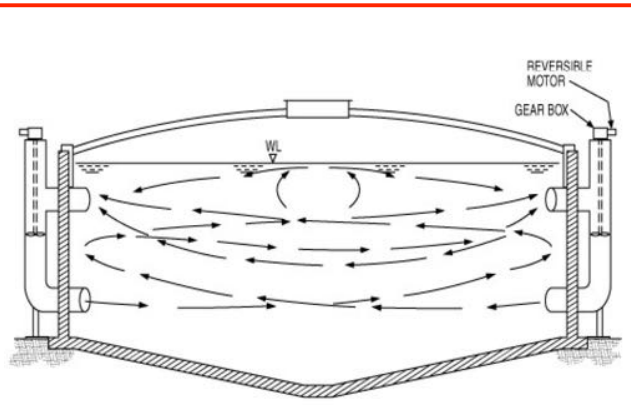
Mixers Evaluated

Linear Motion Mixer

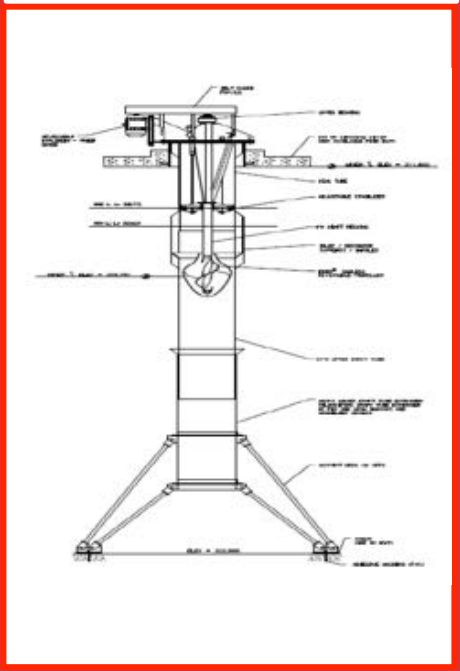
Low Speed Mechanical Mixer



External Draft Tube Mixer, With and Without Sludge Heat Exchanger



Rooftop Mounted Internal Draft Tube Mixer, With and Without Sludge Heat Exchanger



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Mixer Cost Summary

ALTERNATIVE	CONSTRUCTION COST	ANNUAL O & M COST	PRESENT WORTH COST
LINEAR MOTION MIXER	$1,344,800	$20,300	$1,598,000
LOW SPEED MIXER	$1,234,400	$22,500	$1,515,000
INTERNAL DRAFT TUBE MIXER	$1,179,800	$21,900	$1,453,000
INTERNAL ROOFTOP DRAFT TUBE MIXER WITH INTEGRAL HEAT EXCHANGER	$526,500	$15,200	$716,000
EXTERNAL DRAFT TUBE MIXER	$1,569,800	$29,100	$1,932,000
EXTERNAL DRAFT TUBE MIXER WITH INTEGRAL HEAT EXCHANGER	$1,003,500	$23,300	$1,294,000

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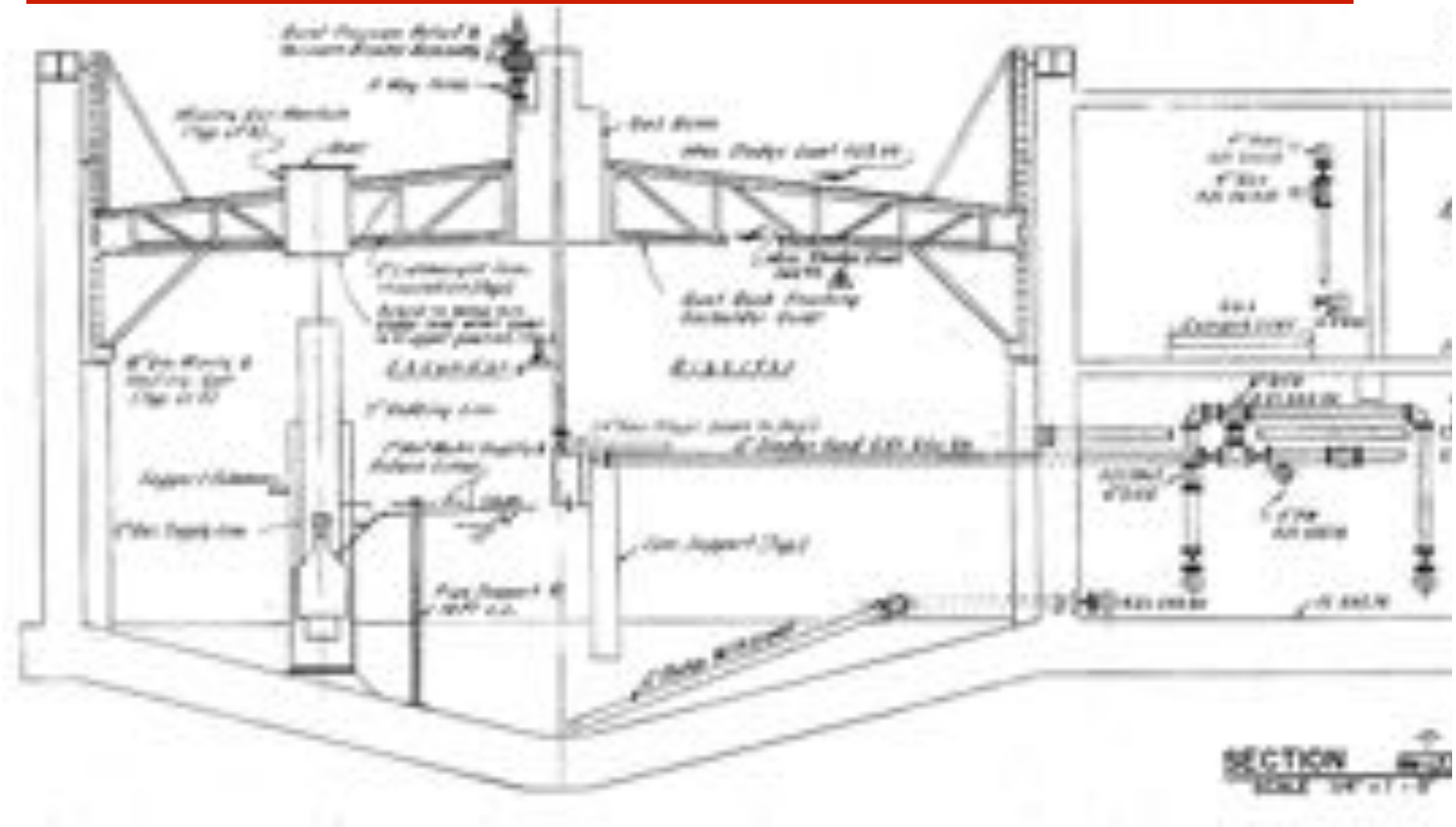
4 – Energy Evaluation of Digestion Process



2015 Digestion Energy Evaluation Report

Investigated

- Digester Gas Production/Use
- Increased Digester Gas Production Alternatives
- Additional Energy Efficiency Improvement Alternatives
- Digester Gas Use for Energy Production

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DIGESTER OPERATIONS - 2014

	%TS (in)	%VS (in)	%VS (out)	%VSR	Sludge In (gal)	Sludge Loading (lb/day)	SRT (days)	VS Destroyed (lbs)	VS Loading (lbs/10³ ft³)	Gas Production (ft³/day)
January	2.5	60	43	50	5849	1196	40	367	23	5694
February	2.9	70	41	70	6265	1516	38	768	35	11898
March	4.6	64	37	67	4533	1721	52	760	36	11776
April	1.9	54	39	46	11067	1709	21	433	30	6707
May	3.2	53	40	41	5559	1461	43	326	25	5055
June	3.2	51	39	39	6730	1769	35	358	29	5556
July	3.2	62	42	56	7150	1880	33	668	38	10347
August	4.4	57	37	56	6347	2304	37	753	43	11677
September	3.8	69	38	72	7893	2470	30	1272	56	19717
October	4.1	68	38	71	9006	3044	26	1517	67	23513
November	2.2	71	39	74	6239	1119	38	605	26	9375
December	6.5	69	37	74	4239	2299	56	1203	52	18646
Average	3.5	62	39	60	6740	1874	37	752	38	11663
Minimum	1.9	51	37	39	4239	1119	21	326	23	5055
Maximum	6.5	71	43	74	11067	3044	56	1517	67	23513

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Increased Gas Production Alternatives

- Improve Mixing
- Add More Septage, Food Waste, Oil & Grease
- Maintain 4 – 6% TS Feed Daily
- Add/Withdraw Daily Similar Amount of Sludge

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Energy Efficiency Improvements

- Improve Digester Insulation
- Replace Digester Boiler
- Install Dual-Fuel Burner in Boiler for Domestic Heating/Hot Water

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Digester Gas Use for Energy Production

- Use Digester Gas to Generate Electricity via Combined Heat & Power System
- Essex Junction, VT, & Fairhaven, MA
- Possible Future Option for St. Johnsbury

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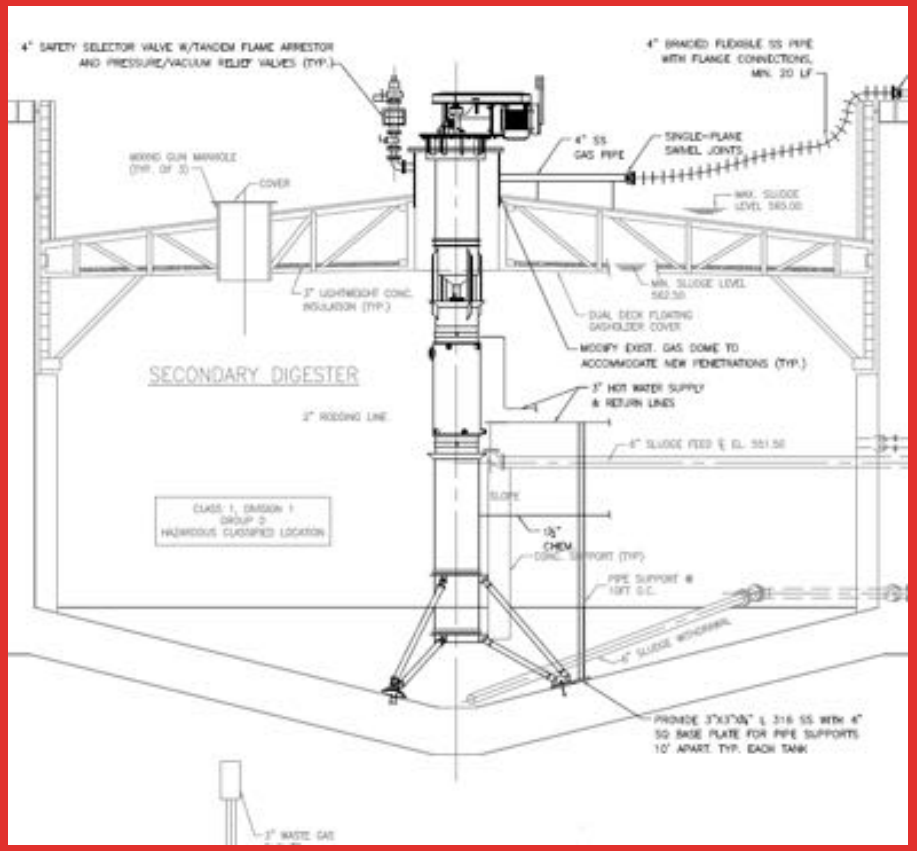
5 – Digester Mixer Design Considerations

Digester Mixer Design Considerations

- Mixer Components
- Mixer Design Criteria
- Structural Analysis of Covers
- Heat Exchanger Size on Mixer
- Digester Cover Modifications
- Internal Piping/Piping Support Modifications
- Taking Digesters Offline



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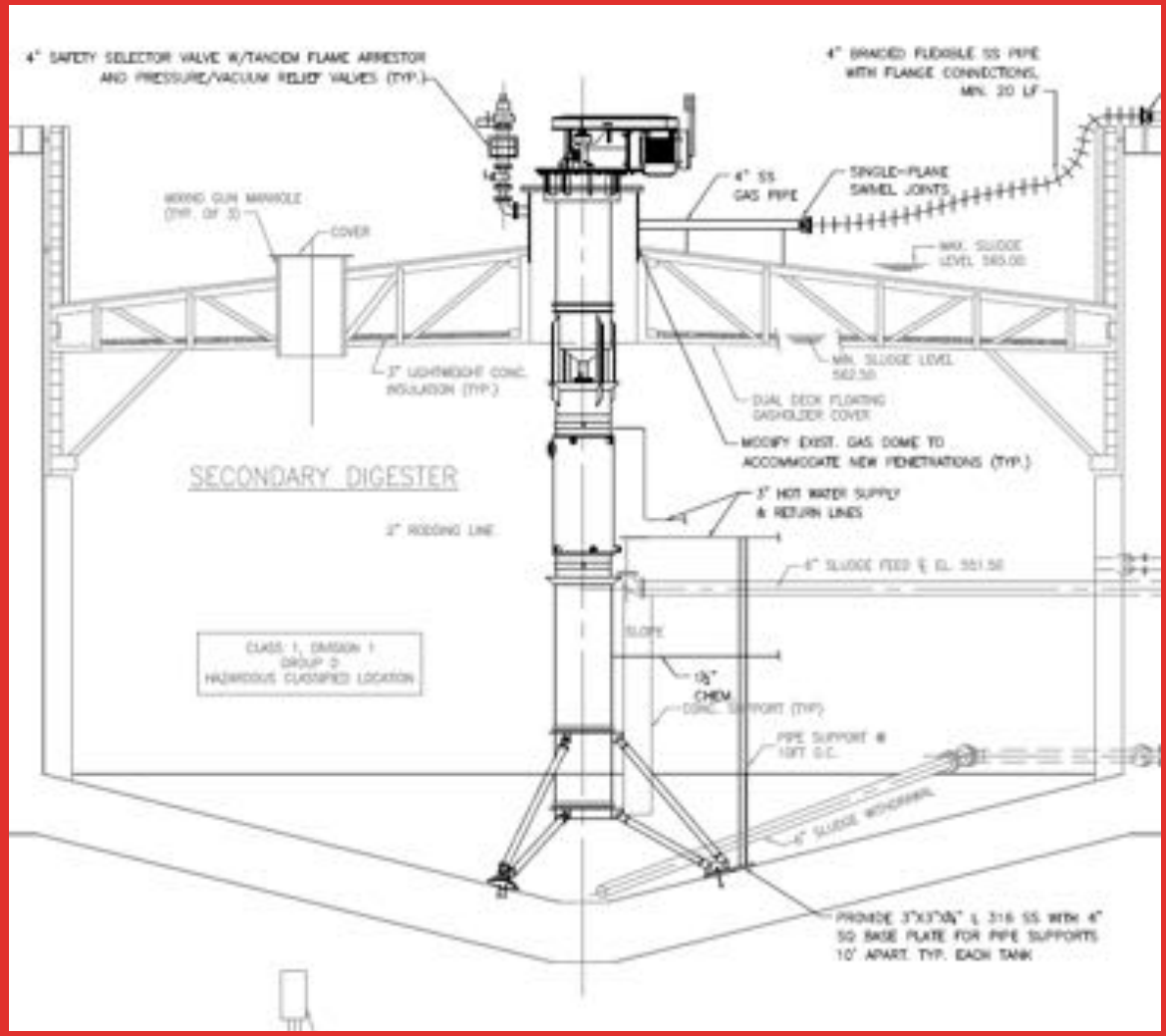
Mixer Components



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Mixer Design Criteria

• Propeller Diameter	24"
• Motor Size	7.5 hp
• Pumping Capacity	
– Up/Down	9,000 gpm
• Draft Tube Diameters	27" & 28.5"
• Digester Turnover Time	30 minutes
• Heat Exchange Transfer	360,000 BTU/hr
• Warranty	5 yrs.

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Structural Analysis of Covers

- Support Added Weight of Mixer
- Complete Structural Analysis of Covers for Added Load

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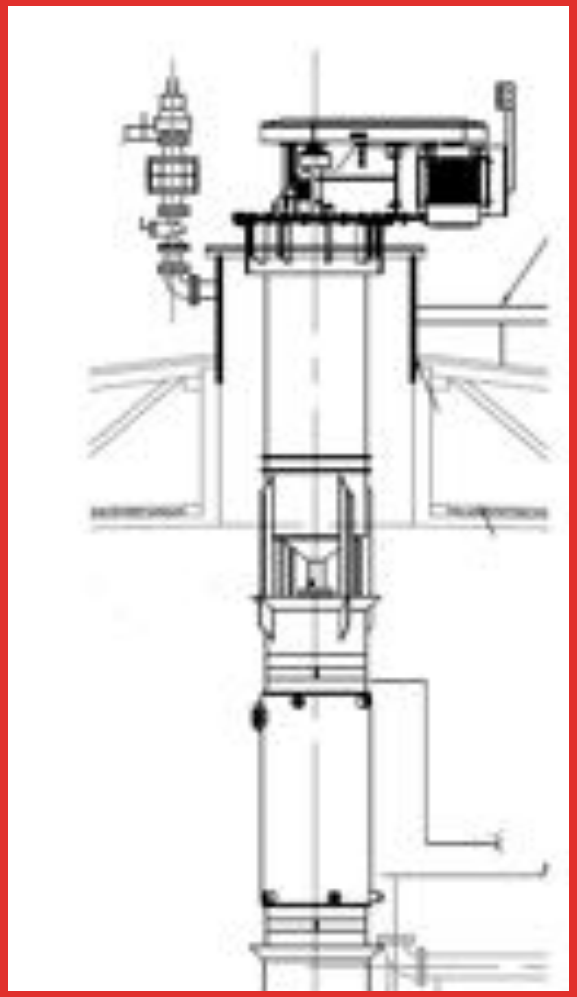
Heat Exchanger Size

- Larger Heat Exchanger
  - More Capital Cost
  - More Efficient Heat Transfer



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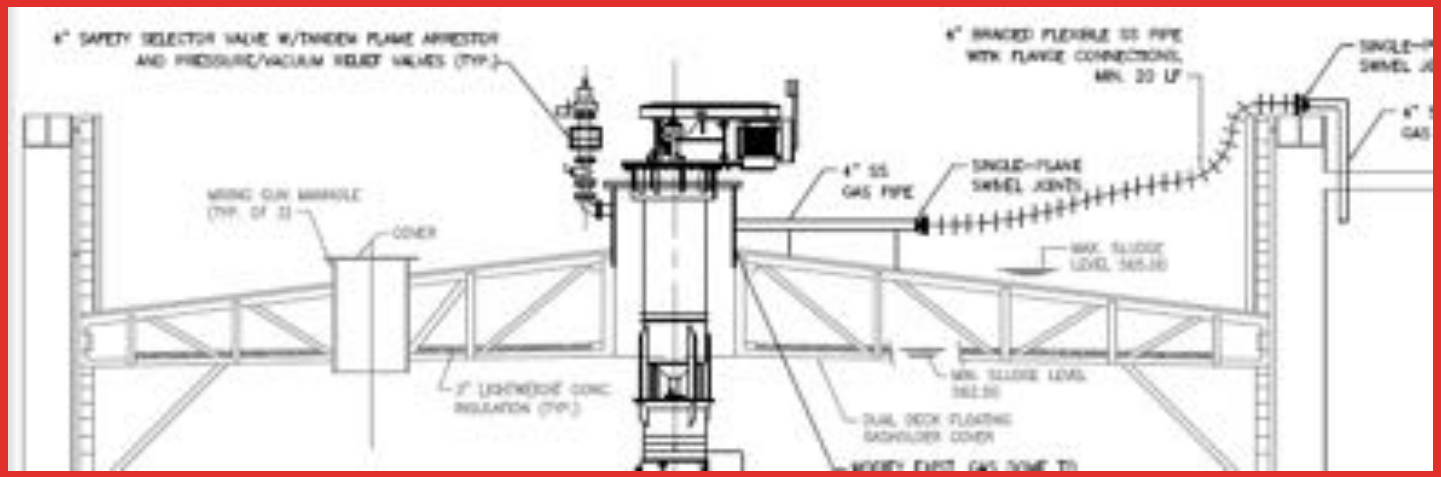
Cover Modifications



- New Pipe Penetrations
- New Cover Mounting Plates for Mixers
- Attic Insulation
- Floating Cover Ballast Adjustment

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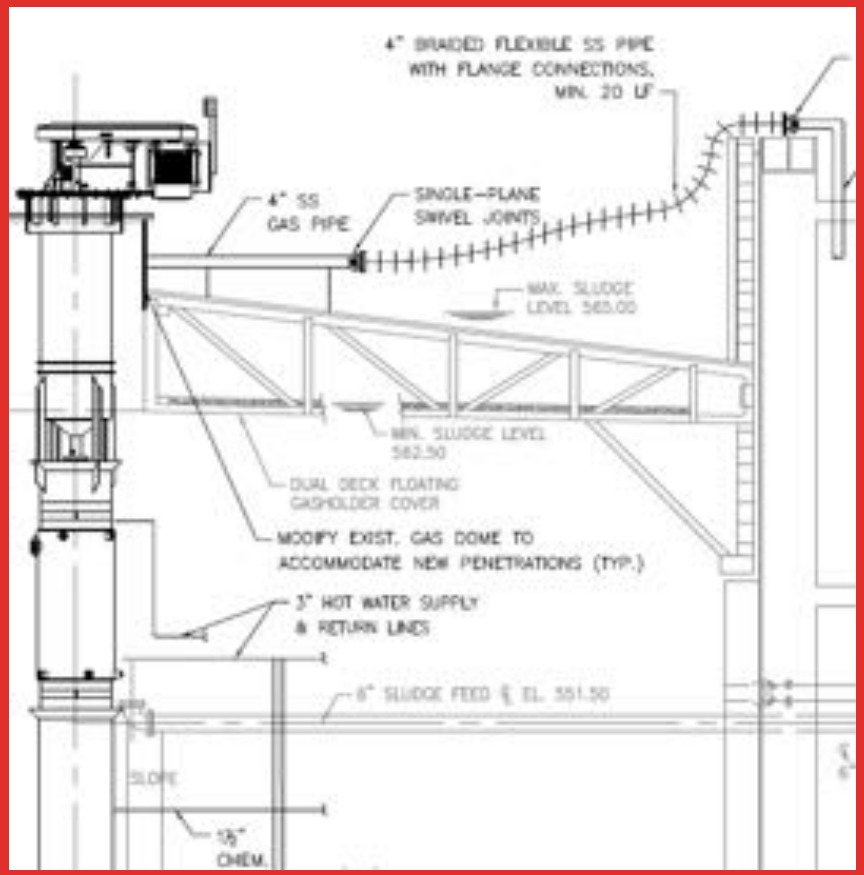
Piping Changes

- Hot Water Piping & Pipe Supports
- Gas Piping, Including Flexible Piping



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Taking Digesters Off-Line

- Work Plan to Take Down 1 Digester at a Time
- Clean Digester
- Remove Equipment
- Install Equipment
- Start Up Digester
- Repeat Sequence for 2nd Digester

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6 – Current Status

- Design/Bidding Complete
- Construction Start Date – 9/5/17
- Construction End Date – 9/30/18
- Engineer's Estimate for Digester Mixer-Related Improvements - $1,290,000

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QUESTIONS?

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