PENNSTATE
Department of Agricultural
and Biological Engineering

Reinfold Farm

Type of farm: Dairy
Name of farm: Reinford Farm
County: Juniata
Anaerobic digester operator: Drew Reinford
Digester designer: RCM Digesters Berkeley, CA
Digester Installer: Reinford Farm acted as the general contractor
Construction start date: August 2007
Date Digester became operational: February 2008
Number of animals contributing to the digester: 470, milking and dry
Type of Barn: freestall
Manure handling system: continuous alley scraped
Type of Bedding: separated, digested manure solids
Type of digester: Complete Mix
Digester cover: flexible
Digester temperature: mesophilic 100°F
Biogas uses: operate the CHP unit to produce electricity and heat
Biogas utilization equipment: Caterpillar 342 engine with a 130kW single phase 220 volt generator, auto flare
Recovered heat utilization: engine generator water and exhaust jackets to heat digester,
hot water for milking parlor, heat to milking parlor, calf milk pasteurizer, house, domestic hot water and shop floor heat; engine radiator hot air provides supplemental heat for grain drying.
Power Purchase Agreement: Yes
2009 July Status of Digester: operational

Introduction:

Reinford Farm is located in Juniata County, Pennsylvania. The dairy farm was purchased in 1991, starting out with 57 dairy cows and 144 acres. Currently the farm consists of 440 milking cows, 30 dry cows and 180 acres. A total of 900 acres are farmed and heifers are raised on another farm. Plans are in motion to bring all the heifers to the main farm. In 2003 the family thought about putting in an anaerobic digester; mainly for odor control, but also for a planned farm expansion and power production to reduce or totally eliminate the purchase of electrical power from the local utility, Pennsylvania Power and Light (PPL). Son, Brett led the way in gathering anaerobic digester information. The Reinford's visited other farms with anaerobic digesters and attended various meetings on the topic. One such meeting was The Dairy Summit, at which they found the designer for their digester project. The Reinford's are very innovative and progressive in how they upgrade and operate their farm. They have not only put in the anaerobic digester for odor reduction and power production, but also have installed a calf milk pasteurizer and grain drier that utilizes rejected heat from the gen-set. The Reinford Farm was the first farm East of the Mississippi to have a Westfalia Carousel milking parlor and the first anaerobic digester on the East Coast to have a RCM, Inc. H2S scrubber installed. Expansion is planned, for a new 500 cow freestall barn, but has been temporarily placed on hold. The family farm has received the Dairy of Distinction Award and Dairy Quality Award.

The digester currently receives manure from 470 cows of which 440 are milking and 30 dry cows. The manure from the dry cows, heifers and calves on another farm just down the road does not enter the digester. Drew Reinford is the digester operator.

Digester Information:

RCM Digesters from Berkeley, CA designed the Reinford digester. Team Ag Inc. from Ephrata, Pennsylvania provided the Professional Engineering services for the project. Reinford Farm acted as the General Contractor and hired a Project Manager to oversee all construction. Construction for the complete mix digester started the first week of August 2007 with a February 2008 start-up. The digester is designed for 1000 cows and an operating mesophilic temperature of 100oF. Currently the digester is operating at the designed 100oF, with the manure from 470 cows. Continuous alley scrapers are used to remove the manure from the freestall barn and daily scrape from the dry cow barn to a concrete holding tank, where gravity flow moves the manure through a 30 inch pipe to the 20' L x 20' W x 12' D influent tank. Reinford's received additional feedstock, spent brewers yeast, during the first few months of operation; 6,000 gallon loads were put into the manure influent tank with each yeast delivery. A Houle 10 hp mixer is used in the influent tank to mix the manure. The total amount of manure introduced into the digester each day is 11,000 gallons. The influent pump to the digester is a 5 hp Houle piston pump which starts and runs 12 minutes every 4 hours. Three Houle 20 hp (two 10 hp motors) mixers are used to mix the digester tank. The complete mix digester is a m circular, heated, mostly below ground tank sized at 80' in diameter x 16' deep and has a non-expanding flexible cover. The manure capacity of the digester is 526,000 gallons (70,370ft3) when two feet of freeboard is maintained. Recovered hot water from the CHP unit is circulated through internal heating pipes inside the digester. Two inches of insulation surrounds the outside of the digester with four inches of insulation covering the top to help maintain the 100oF temperature. The heated, complete mix digester is designed for a hydraulic retention time (HRT) of 21 - 24 days at 10 – 12% solids, and is currently operating at about 48 day HRT with about 14% solids. Biogas is produced and collected under the non-expanding flexible cover. The digester cover is a black plastic 60 mil thick material. All milking parlor waste water and copper sulfate foot bath waste by-pass the digester.

Complete Mix digester with non-expandable flexible cover.

Manure influent, effluent and digester temperatures are recorded daily from probes within the digester. Influent and effluent, manure total and volatile solids and nutrients are analyzed twice per year. In the summer of 2008, with yeast waste added to the digester influent, the total solids reduction was 10.3% with volatile solids reduction of 9.6%.

Biogas System:

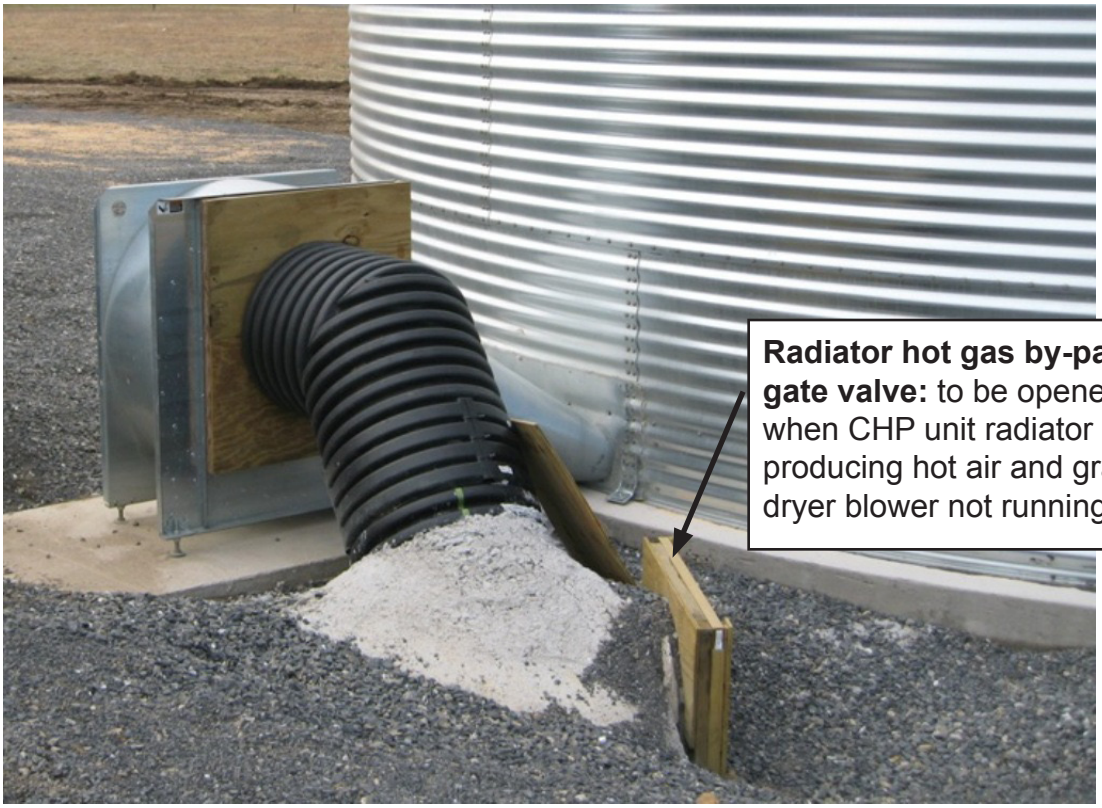
Biogas is piped underground through PVC pipe to the engine generator set. A hydrogen sulfide removal system is also used to pre-treat the biogas before it enters the engine. Biogas production measured on the Fox Thermal Instrument gas meter averages 50,000 to 60,000 ft3/day. An auto flare burns any excess biogas not consumed by the engine generator set. A Bacharach Fyrite® Gas Analyzer is used to manually measure the CO2 concentration in the biogas and is typically 36%; the calculated methane concentration is 64%. The hydrogen sulfide content in the untreated biogas measures in the range of 2500 ppm.

Combined heat and power unit (CHP):

The biogas is piped to a reconditioned, 1200 rpm Caterpillar G342 engine coupled to a 250 volt AC, 60 hertz, single phase 130kW generator purchased from Martin Machinery Inc. of Ephrata, PA. Heat recovered from the engine water jacket heats water for the digester, milking parlor, a calf milk pasteurizer, farmhouse heat and domestic hot water. This hot water is also used as radiant heat in the floor of the work shed and office space. A grain bin installed in November 2008 uses the waste heat from the radiator of the engine to dry the grain. The CHP unit runs 24/7/365 days a year except during maintenance. All power is sold to the local utility. Brad Penn engine lubrication oil is being used and changed every 400 hours of operation. Engine oil analysis is performed after each oil change and the results are reviewed by Martin Machinery Inc.

Waste heat recovered from the engine water jacket heats hot water to pasteurize milk for the new born calves in this pasteurizer.

Capturing and sending the heat from the engine radiator over to the grain drier.



Waste heat from the engine radiator entering the circulating fan for the grain drier.

G342 Caterpillar, 1200 rpm engine with 250 Volt, 1 phase generator.

Power purchase agreement:

Reinford Farm has a power purchase agreement with Pennsylvania Power & Light (PPL) Electric Utilities Corporation. Daily power production averages 95 kWh/day. The farm has a commercial electric service with all power produced being sold to the grid at 13.0 cent per kWh. Electricity used on the farm is bought back at a residential rate of 8.9 cent per kWh. Use of rejected heat from the CHP unit to heat the farmhouse has saved $3,000.00 in electric heating cost when compared to 2007 electric rates.

Digester effluent:

The nearly odorless digested manure flows to an effluent storage pit measuring 20' L x 20' W x 12' D. A Houle (Baldor Farm Duty Motor) 7.5 hp pump directs the effluent to the solids separation building. The solid/liquid separation room is above the separated solids storage bay. A Cri Man manure separator, distributed by Alpha Bio Systems, Inc., with a 5 hp motor is used. The solids fall directly into the digested solids storage bay. These separated solids are then used as bedding for the cows. Only half of the separated solids are needed for use on the farm, the remaining 50% is sold to nearby farms. The herd somatic cell count has had a continuous lowering trend since the use of separated solids for bedding. Counts now range between 120,000 – 150,000. The separated liquid effluent gravity flows to the 2.5 million gallon storage pond. The effluent is stored and applied by both drag hose and tanker haul twice a year to crop fields.

Cri-Man solid/liquid manure separator distributed by Alpha-Bio Systems, Inc.

Appling separated solids as bedding.

Project costs:

The digester project cost $1.1 million. A feasibility study was first preformed for the farm at a cost of $12,000. RCM Digesters helped the Reinford Farm apply for grants for the anaerobic digester system. The Reinford's received funding for the project from the Pennsylvania Department of Environmental Protection (PADEP), receiving an Energy Harvest Grant of $285,000, a Pennsylvania Department of Agriculture's Machinery and Equipment Loan Fund (MELF) for $135,000, Resource Enhancement and Protection Tax Credit Program (REAP) $90,000, a United States Department of Agriculture (USDA) Grant for $203,600 and the USDA Environmental Quality Incentives Program (EQUIP) provided $40,000. The farm borrowed the remaining amount needed for the project. The carbon credits generated by the destruction of the methane are banked through the Chicago Climate Exchange through a broker.

Lessons learned:

A knowledgeable project manager is essential and must be on the construction site everyday during the digester project.

Specific items:

- ensure piping is configured to direct raw manure away from the digester during maintenance
- configure the digester effluent piping to allow by-pass of the solids/liquid separation system and go directly into the lagoon
- add manways to allow access to cleanouts where manure solids may cause piping obstructions Note: ensure manways have the proper signage: "Confined Space: entry requirements must be followed".
- since biogas bypasses the biogas flow meter when using the flare – either a separate biogas flow meter needs to be installed or the flare needs to be moved. Currently if biogas is destroyed by the flare the biogas cannot be measured for carbon credit calculations.

Would you install a digester again? Yes

*Please see the digester system schematic and log sheet on the following two pages.

The information obtained in this case study was collected by Penn State researchers, Deborah Topper and Patrick Topper during farm tours, observations, farmer completed questionnaire and interviews at the Reinford Farm in 2008 & 2009.

The content of this case study is not meant to be all inclusive or intended to delete any entity, or constitute an endorsement of a company or individual or to be a product endorsement of a company.

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Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture

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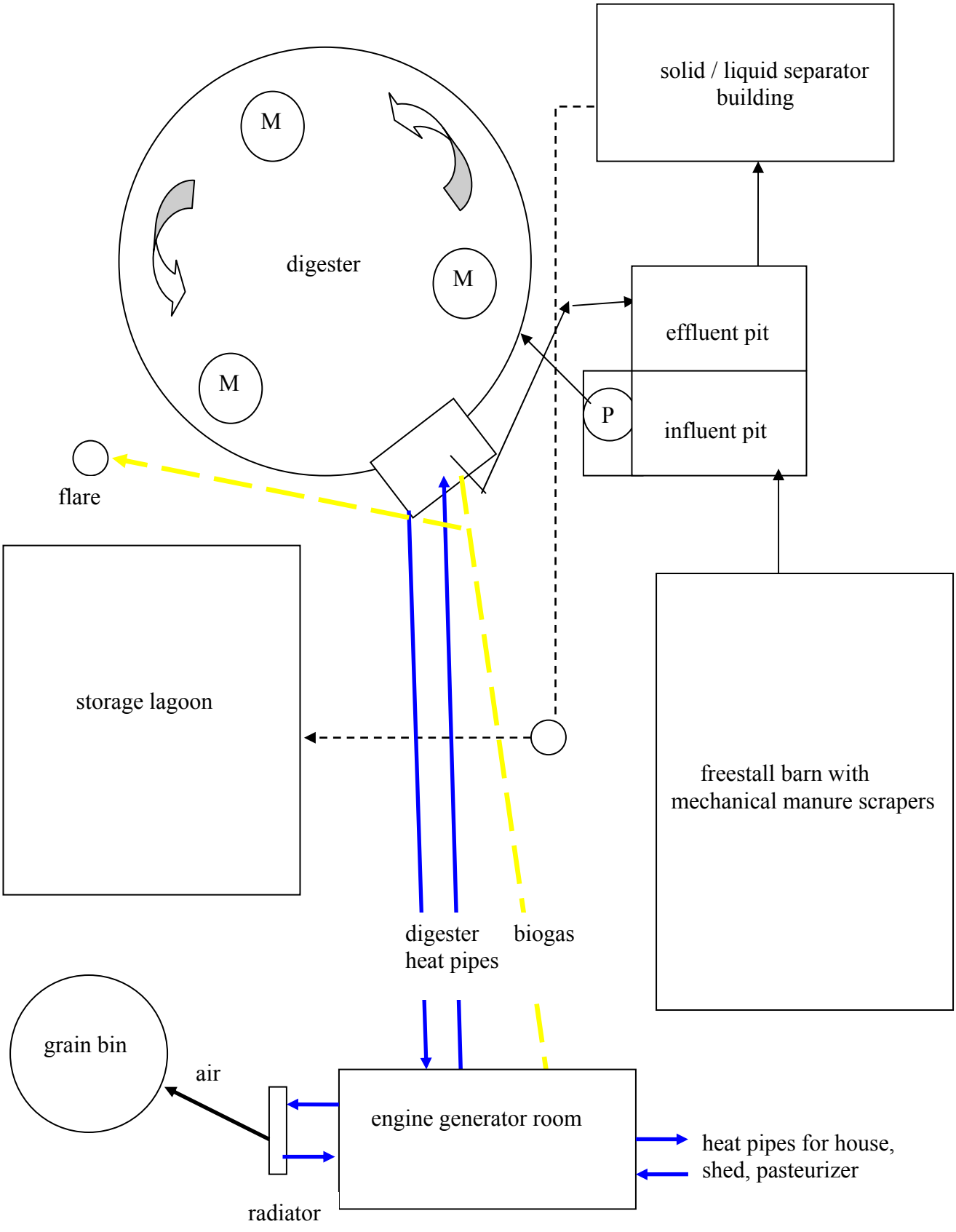
Reinford digester system schematic



DIGESTER DAILY LOG

Next Oil Change _____ hrs

		MON	TUE	WED	THUR	FRI	SAT	SUN
Date								
Time								
Who								
Feed	Fed Manure, gal							
	Fed Other, gal							
Panel	Volts 1,2,3	/ /	/ /	/ /	/ /	/ /	/ /	/ /
	Amps 1,2,3	/ /	/ /	/ /	/ /	/ /	/ /	/ /
	KW output							
	kWh reading							
	KWh output 24 hr							
	Eng Hour Meter							
	Eng hrs operated							
	Oil Press							
	Oil Temp							
	Exhaust Temp							
	Gas pressure							
Gas	Meter reading							
	Calc 24 hr output							
Efficiency	Calc CF/kWh							
	Pressure to eng							
	CO2							
	Bag Pressure							
Engine	~~GEP~~ Avg kw							
	Oil level in tank							
	Calc Oil used/day							
	Charger Amps							
	Wat temp to Digest							
	Wat temp fm Digest							
Flare	~~Wat temp to~~							
Water in	~~Wat temp fm~~							
	Wat temp to Eng							
	Wat temp fm Eng							
	Wat temp to Boiler							
	Wat temp fm Boiler							
Electric Meter	Read buy							
	Calc 24 hr buy							
	Read sell							
	Calc 24 hr sell							
Digester	Water Temp in							
	Water Temp out							
	Internal Temp 1							
	Internal Temp 2							
	Internal Temp 3							
	Internal Temp 4							
	Effluent Temp							
	pH							
	Dig. Temp							