

2019 Audit of Operations and Maintenance Millersville LFGE Facility

Anne Arundel County Department of Public Works
Waste Management Services
Millersville Landfill and Resource Recovery Facility
389 Burns Crossing Road
Severn, Maryland 21144

SCS ENGINEERS

02211047.13 | November 5, 2019

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1 INTRODUCTION

SCS Engineers has prepared this report to present the results of the 2019 annual audit of the operations and maintenance (O&M) at the Millersville Landfill Gas-to-Energy (LFGE) facility, conducted on September 25, 2019. The Millersville LFGE facility is owned by the Anne Arundel County Department of Public Works (County) and is operated by the Northeast Maryland Waste Disposal Authority (Authority). The Authority currently contracts O&M to Aria Energy (Aria).

The LFGE facility consists of a gas treatment process and two (2) Caterpillar model G3520C generator sets fueled by landfill gas (LFG) with a total combined nameplate capacity of 3.2 MW. The generator sets each consist of a spark-ignition reciprocating internal combustion engine attached to an electricity-generating unit. LFG collected from the gas collection and control system (GCCS) of the adjacent Millersville Landfill is routed to the LFGE facility during the facility operation. Excess LFG not routed to the LFGE facility is controlled by one or both of the landfill's flares, which consist of a utility flare and an enclosed ground flare.

Prior to conducting the audit, SCS developed an audit plan to determine the scope of the audit (see **Appendix A**). The audit plan was provided to the County and to Aria on August 12, 2019. The 2019 audit included the review of recent generator set maintenance items conducted by Aria, an interview with operator staff to discuss current O&M practices (as compared with the previous audit) and any on-going challenges or issues, and a tour of the interior and exterior of the plant. The 2019 audit also included the evaluation of external noise, odors, and visible emissions from the facility. Per the County's request, SCS also interviewed Aria regarding an increased number of cylinder detonations and electrical substation maintenance performed since the 2018 audit. The checklist and the field notes from the audit are included in **Appendix B**.

2 BACKGROUND

SCS staff present for the audit consisted of Robert McConnell of SCS Energy and Jacob Shepherd of SCS Engineers. Aria staff present on-site included Edgar Felan and Christopher Rosas. John Schott of the Authority was also present during the audit.

2.1 PROCEDURE

The audit was conducted according to the objectives of the 2019 audit plan and checklist. SCS first observed and discussed the recent gas collection system changes at the adjacent landfill since the 2018 audit. Then SCS entered the plant and began the interview with Aria staff. SCS reviewed the plant O&M modules and discussed plant operations, maintenance, and any on-going challenges. Additional details about the interview are included in Section 3.1. After the interview, SCS reviewed recent generator set maintenance items and inspected the engine room while the generator sets were in operation. Then, SCS conducted an external inspection to include the building exterior, outdoor equipment, and storage tanks. Lastly, SCS conducted an evaluation for visible emissions, odors, and environmental noise from the plant. Photographs of the plant taken during the audit are included in **Appendix C**.

2.2 FACILITY EQUIPMENT

The generating equipment of the facility consists of two Caterpillar G3520C LFG-fired generator sets. The engines solely combust landfill gas, which is generated by the Millersville Landfill. Electricity generated by the engines is transferred through two Enercon Electric switchgear modules (one for each generator set) and a utility transformer to increase the voltage before feeding into the power grid. The generator sets are equipped with engine jacket water cooling systems to control engine temperature. Liquid from the cooling systems is directed to two Smithco Americool horizontally mounted radiators located on towers just outside of the building. Additionally, the facility is equipped with intake and exhaust ventilation fans to control engine room temperature during operation.

LFG is directed from the adjacent landfill blower station through a gas treatment system to the generator sets. The treatment system includes a condensate knockout to remove moisture and particulates, and a radiator to decrease the temperature of the LFG. Methane concentration, heat content, and oxygen concentration of the gas are continuously monitored by a Siemens Ultramat 23 Gas Analyzer and gas flow rate is continuously monitored by a flow meter.

3 OPERATIONS AND MAINTENANCE AUDIT

3.1 OPERATOR INTERVIEW

3.1.1 General

The generator sets appeared to be operating normally and without any apparent issues during the audit. Routine maintenance is conducted according to the plant O&M manual, with slight variation as detailed below. Since the last audit, the plant has had an elevated number of cylinder detonation events. More information is included in Section 3.1.5.

3.1.2 Facility-Wide Practices

The plant O&M manual is categorized into modules with each covering a specific set of equipment or components of the facility. Maintenance items in each module are organized by the recommended frequency that each item is performed. SCS developed a checklist based on the O&M manual modules to check that maintenance is performed according to the manual and Caterpillar recommendations and to track changes in O&M practices from year to year. As mentioned in previous audit reports, current maintenance practices vary slightly with the Caterpillar recommended maintenance schedules, with some items being performed more-frequently and some being performed less-frequently. Based on SCS's observations, the generator sets appear to be in normal working condition and the plant appears to be in overall good condition. The plant completes daily logs and monthly reports to monitor plant operation and equipment. Logs and records reviewed during the audit indicate that the daily and monthly maintenance listed in the plant O&M manual is being conducted regularly and generally according to the schedule in the O&M manual.

Plant O&M practices were generally unchanged as compared to the practices indicated during the 2018 audit. No changes were observed with O&M practices for the gas system, the coolant water system, the lube/waste oil system, the exhaust systems, the compressed air system, the building ventilation, the electrical building support system, or the building related equipment.

3.1.3 Caterpillar Generator Set Practices

During previous audits, the engine maintenance practices of the plant were compared with the maintenance schedules in the Caterpillar O&M manual and the plant O&M manual. Although the current generator set maintenance schedules vary slightly with the Caterpillar O&M manual, the variations do not appear to damage or reduce performance life of the generator sets.

Current O&M practices remain unchanged as compared with practices observed during the 2018 audit. However, Aria noted that most of the Caterpillar recommended 1,000-hour maintenance items are performed every 1,100 hours (previously, Aria indicated that some items were performed every 2,200 hours). Major maintenance services are performed within the range specified in the Caterpillar O&M manual.

3.1.4 Electrical Substation Equipment

In 2017, the electrical substation equipment at the plant had malfunctioned, and as a result, plant equipment was unable to provide information to the electrical company, Baltimore Gas & Electric (BGE). Upon review of the equipment, an independent contractor concluded that an arcing event in the substation equipment had occurred, likely due to the build-up of dust and debris in the equipment enclosure.

The plant O&M manual contains scheduled preventative maintenance for the electrical substation in Module 11, which includes an annual inspection and cleaning of the equipment. SCS discussed recent electrical substation maintenance and reviewed relevant records. Based on Aria's records, Aria performed the annual cleaning listed in the plant O&M manual in December 2018. Additionally, in July 2018 cleaning was performed on the metering equipment located next to the electrical substation equipment. Because this equipment affects financial transactions between BGE and Aria, BGE was on-site to supervise this cleaning.

SCS will continue to review the annual substation maintenance listed in the plant O&M manual during the regular audits.

3.1.5 Cylinder Detonation Events

Prior to the audit, the County indicated that the generator sets had been experiencing an elevated rate of cylinder detonation events. Additionally, information provided by Aria prior to the audit indicated that since the previous audit, multiple maintenance events were performed that included the replacement or cleaning of cylinder heads.

Cylinder detonations occur when there is pre-ignition of fuel inside a cylinder prior to ignition by the spark plug. Detonation events can be caused by a variety of reasons. To evaluate the potential cause of the cylinder detonation events, SCS discussed the recent maintenance events since the previous audit that involved cylinder heads. Most of the cylinder heads replacements were performed on generator unit number 1. Cylinder heads and gaskets were first replaced after coolant leaks were discovered. Aria then encountered high gas temperatures, which it was discovered was due to clogged aftercoolers. The aftercoolers on Unit 1 and Unit 2 were replaced in April and August, respectively. In June, Aria conducted combustion clean out (CCO) events on both generator sets, which involve cleaning of the top-end engine components and may involve cylinder head replacements. Following the April aftercooler replacement and the June CCO events, Aria indicated that the number of detonations decreased.

One common reason for cylinder detonations is the build-up inside of the cylinders of compounds (consisting mainly of siloxanes) precipitated out of the LFG during combustion. Cylinder detonations caused by this build-up can occur due to the associated change in compression ratio and cylinder timing. The concentrations of siloxanes in landfill gas varies between sites and can increase or decrease during the life of a landfill. In some cases, gas system expansion at landfills has caused an increase in the concentrations of siloxanes in the gas. Because the gas collection system at the landfill adjacent to the plant was recently upgraded and expanded, SCS considered the possibility that siloxane accumulation could be contributing to the cylinder detonation events. Aria indicated that during the head replacements and the CCO events, there was not a high amount of accumulation within the cylinders, which indicates that siloxane build-up inside the cylinders was not a likely cause of the detonation events. However, it is likely that siloxanes accumulated instead inside the aftercoolers and caused clogging in that equipment. The clogging of the aftercoolers likely affected conditions of the inlet gas, contributing to the detonation events.

SCS noted that the generator sets are approaching the next major maintenance interval. Typically, as generator sets approach the major maintenance interval, cylinder detonations increase. The frequency of cylinder detonations is a common indicator that operators may use to determine if the major maintenance needs to be performed earlier. Therefore, the interval varies based on site-specific conditions and may need to be altered depending on the quality of the gas. The major maintenance will include the replacement of cylinder heads and other top-end engine equipment. Additionally, the engine operation tuning will be performed. The number of cylinder detonations may indicate that the

major maintenance should be performed earlier than expected. Aria currently anticipates performing this maintenance in the second quarter of 2020.

SCS noted frequent spark plug replacements on the generator sets, which may indicate the use of lower quality spark plugs with shorter usable lives. Based on SCS experience, spark plug quality may contribute to cylinder firing issues. Therefore, SCS typically recommends using higher quality spark plugs to decrease replacement frequencies and the potential for cylinder firing issues.

3.2 RECENT GENERATOR SET MAINTENANCE

Prior to performing the audit, SCS received a list of maintenance performed on the generator sets since the 2018 audit. Typically, SCS selects significant maintenance items to review with Aria during the audit. SCS received this list of maintenance items since the previous audit. However, due to the high number of cylinder head replacements, SCS focused on the cylinder head maintenance and cylinder cleaning events during the operator interview. Following the interview, SCS inspected the engine room.

3.2.1 Review of Recent Maintenance Records

SCS reviewed the procedures that Aria used during the cylinder head replacements and CCO events. The procedures used appear to be consistent with accepted industry standard practices. The records of these events are adequately detailed and were easily accessed by Aria staff during the audit.

In general, the facility conducts maintenance on the generator sets in accordance with the Caterpillar maintenance manual and the facility's O&M manual, with slight variation. Depending on gas quality and flow rate, routine maintenance items, including overhauls, may need to be performed more frequently.

3.2.2 Engine Room Inspection

The engines appeared to be operating normally during the audit. SCS did not observe any indications that any recent maintenance was performed poorly. No unsafe conditions or potential hazards were observed in the engine room. The plant was clean and well organized during the site visit, indicating good housekeeping practices. The site appears to have a good stock of spare parts and items for preventative maintenance. Spare parts are supplied by Aria and are kept on-site or are shipped to the site prior to performing planned maintenance.

3.3 FACILITY INSPECTION

3.3.1 Operations Room

The facility is staffed for 8 hours per day on weekdays and includes a call-out system for plant alarms or shutdowns. The operations room appears well organized and clean. Safety equipment is organized and accessible. The floor space was clear of debris and equipment. Potential hazards are marked with visible and conspicuous signs. Waste and flammables are stowed away in designated safe locations. There were no adverse safety conditions noted during the inspection. All maintenance records requested by SCS were readily available.

3.3.2 Plant Equipment

Engine control and monitoring equipment, including two SCADA panels, one for each engine, are installed at the plant. Upon review of these systems, SCS observed that equipment appears to be in good working order and display all necessary parameters for operation. There are various controls to stop operation of equipment in the case of an emergency. The methane analyzer is regularly calibrated and appeared to be in good condition during the audit.

3.3.3 Building Exterior

The facility is secure and is locked when the building is unstaffed. The door, fence, and barbed wire all appear to be in good shape and free of rust or significant damage. The liquid storage area did not have any apparent damage. Each storage tank is placed within a concrete containment and surrounded by a gravel area. The containments and gravel area are free of chemicals and there was no evidence of recent spills. Sound walls are secured onto parts of the fencing and are placed around the plant on all sides not adjacent to the landfill. SCS noted that the cooling tower for the gas compressor had an unusually high level of noise and vibration and discussed this issue with Aria. Aria indicated that they were aware of the problem and are planning to replace shims during maintenance in December.

3.4 DOWNTIME RESPONSE

During the interview, SCS also requested information regarding Aria's after-hours response to events of downtime. During power outages, Aria remains in close communication with BGE and waits for approval before restarting the plant. A call-out machine is used to notify Aria of issues or downtime at the plant via a phone that is rotated among operators. The call-out machine has a battery backup installed. Typically, Aria responds to downtime within an hour. If the downtime is due to equipment issues and requires more than 2 hours to solve, a regional manager will be contacted to provide assistance. In advance of large storms, schedules are adjusted when power outages are expected.

3.5 EXTERNAL ENVIRONMENTAL INSPECTION

Following the inspection of the engine room, SCS performed an exterior inspection for environmental nuisances including visible emissions from the generator stacks, the presence of any odors, and an evaluation of the environmental noise caused by the plant.

No visible emissions occurred during the audit. SCS did not observe any indication of any recent visible emission events (such as discoloration on the building). Additionally, no odors were identified during the audit. Based on the noise evaluation, the plant is not causing any nuisances due to noise levels.

4 AUDIT SUMMARY

O&M practices vary slightly from the caterpillar maintenance recommendations and the plant O&M manual. Some maintenance items are performed less frequently and some maintenance items are performed more frequently. However, these variations do not appear to reduce operational life of the generator sets. Recent generator set maintenance items reviewed by SCS appear to have been conducted according to Caterpillar and industry standards. The plant maintains good records of these maintenance items, as well as every maintenance item performed at the plant.

4.1 CYLINDER DETONATIONS

Recently, the plant has experienced an elevated frequency of cylinder detonation events. SCS discussed these events with Aria staff during the interview. Based on the audit, SCS observed the following:

1. Siloxanes – Aria did not observe siloxane accumulation within the cylinders, but did indicate that the aftercoolers were replaced after they were identified as clogged. While SCS did not identify the source or material of the aftercooler clog, it is possible that the clog was due to siloxane accumulation. It is unclear whether the clog formed gradually since plant startup or quickly following recent gas system expansion. However, Aria noted that the cylinder detonation frequency decreased following the aftercooler replacements and cylinder cleaning.

SCS recommends regular cleaning and/or replacement of the aftercoolers to avoid future clogging. Additionally, SCS recommends initial and follow-up gas testing for siloxanes to characterize the gas and monitor concentrations over time. Based on the concentrations encountered, the plant may need to evaluate operational or O&M changes.

2. Major Maintenance Intervals – Aria indicated that the engines are nearing the next major maintenance interval. It is common for cylinder detonations to increase as the major maintenance interval approaches. If the frequency increases, SCS recommends conducting major maintenance earlier than what is currently planned.
3. Engine Consumables – SCS noted that spark plug changes were occurring more frequently than typical industry intervals. Based on SCS's experience, spark plug quality may affect cylinder detonations, and as such, SCS typically recommends using higher quality spark plugs to reduce change frequency and decrease potential for cylinder firing issues. While it is unclear if the spark plugs currently being used contributed to the detonation events, SCS recommends that Aria evaluate the quality of current spark plugs and determine whether higher quality spark plugs are needed.

4.2 ELECTRICAL SUBSTATION

Aria indicated that cleaning of the electrical substation equipment was performed since the previous audit in December 2018, which fulfills the plant O&M manual module. SCS recommends that Aria continue with the annual cleaning of this equipment.

4.3 ENVIRONMENTAL EVALUATION

SCS did not observe any environmental nuisances during the audit, including visible emissions, odors, or environmental noise. SCS recommends that Aria continue regular visible emission observations and continue to maintain the sound walls currently installed on the exterior of the plant.

4.4 PLANT CONDITION

During the audit, the plant was clean and appeared to be in good condition. No safety issues were apparent during the audit. Based on the interview with operator staff and review of daily and monthly maintenance logs, Aria conducts maintenance for the building and operations equipment according to the schedule in the plant O&M manual. The building exterior, sound walls, and fencing are in good condition and free of significant damage. Liquid storage areas appear to be free of leaks. SCS recommends that Aria conduct maintenance on the cooling tower located adjacent to the gas compressor to reduce the noise and vibration and prevent extended downtime of the gas compressor.



Appendix A
Audit Plan

August 12, 2019
File No. 02211047.13

Mr. Mark Morris
Environmental Monitoring Manager
Waste Management Services
Anne Arundel County Department of Public Works
Millersville Landfill and Resource Recovery Facility
389 Burns Crossing Road
Severn, Maryland 21144

via electronic mail

Subject: 2019 Operations and Maintenance Audit Plan
Millersville LFGE Facility

Dear Mark:

SCS Engineers (SCS) has scheduled the 2019 Operations and Maintenance (O&M) Audit of the Millersville Landfill Gas-to-Energy Plant (plant) for Wednesday, September 25, 2019 at 10:00 a.m. SCS expects that during the audit both generator sets will be in operation and plant operations staff will be available to provide any requested documentation (records, permits, logs, etc.) and answer questions about O&M practices. Unless directed otherwise, SCS understands that the County will coordinate with the plant operations staff on availability and provide relevant details about the audit to operations staff.

SCS plans to conduct the following activities during the audit:

1. Conduct an interview with plant operations staff. This will involve a review of the O&M manual module checklist (supplemented with Caterpillar manufacturer recommendations), a comparison of current practices with practices in-place during the previous audit, and a discussion of plant status and any current or on-going challenges. SCS may request records to document that O&M practices and activities conform to the plant O&M manual and acceptable industry practices.
2. Tour the interior and exterior of the plant to include the operations and controls area, the gas compressor room, the generator set room, sound walls, exterior piping, exterior storage tanks, cooling equipment, and building exterior. SCS may photograph areas of interest (inside and outside of the plant) and ask questions or request additional information if necessary.
3. Review recent generator set maintenance conducted since the previous audit. SCS requests a list of significant maintenance performed since the date of the previous audit (September 19, 2018) prior to performing the audit. From this list, SCS will select multiple maintenance activities to review and determine if they were performed according to accepted industry practices. The review will involve a discussion with operators, review of applicable documentation, and an inspection of the generator sets and any related equipment on which maintenance was performed.



4. Review maintenance conducted on the generator sets to troubleshoot cylinder detonations. Based on previous communications, we understand that the operators have conducted maintenance and other activities on the generator sets in response to an above-normal frequency of cylinder detonations. We will review these actions and determine if the detonation frequency has been reduced or if additional actions are required.
5. Review the O&M activities performed for the switchgear and electrical substation equipment (listed in the plant O&M manual) since the 2018 audit. This may involve the review of O&M records related to the activities performed on this equipment. SCS will not perform any activities that require plant shutdown and/or de-energization of equipment.
6. Evaluate the plant exterior for the presence of environmental nuisances, including noise, odors, and visible emissions.
7. Review practices for response to after-hour downtime and emergencies.

A general checklist of planned audit activities is attached. SCS may expand the scope of the audit or request more information depending on operator responses, the records review, or observations recorded during inspections of the plant and plant equipment. Following the audit, we will prepare a report to summarize the procedures and observations of the audit, and present findings and any recommendations to the County.

Should you have any questions, please feel free to contact us by email or via phone at (703) 471-6150.

Sincerely,



Jacob Shepherd, P.E.
Senior Project Engineer
SCS Engineers



Robert McConnell
Operations Manager
SCS Energy

cc: Michael Kalish, P.E. – SCS Engineers
Joshua Roth, P.E. – SCS Engineers

Attachments

Appendix B
Field Notes

ANNE ARUNDEL PLANT AUDIT CHECKLIST

Date: September 25, 2019

Plant Staff: Edgar Felan; Christopher Rosas

Audit Team: Jacob Shepherd; Robert McConnell

Inspection Item	Completed		Comment/Result
	Yes	No	
Check in and sign in at admin bldg and plant	X		
Interview operator staff	X		
Discuss current / future challenges/issues	X		
Review Module O&M Checklist with staff	X		
Check for changes in practices	X		Clarified 1,000-hour CAT maintenance items
Review recent generator set maintenance	X		Cylinder cleaning and head replacements
Review other generator set maintenance	X		
Inspect the generator sets	X		No issues noted
Review switchgear / substation equipment	X		Maintenance completed Dec. 2018
Review O&M logs for switchgear / substation	X		
Review after-hour / emergency downtime response	X		
Tour the interior and exterior of the plant	X		Noted noise from gas compressor cooling tower
Inspect building exterior, sound walls, and fencing	X		
Check for noise, odors, and visible emissions	X		No odors/visible emissions; noise levels measured
Visible/audible issues noted?	X		Gas compressor cooling tower
Checks performed on other equipment	X		
Review of records/logs?	X		
Downtime Below 5%?	X		Yes
Check on any gas quality issues	X		None
Photographs of plant	X		

2019 Operations and Maintenance Audit

Millersville LFGE Facility

Millersville LFGE Plant O&M Module Checklist

September 25, 2019

SCS Engineers / SCS Energy

MODULE 1: GAS SYSTEM

Daily

X	Record readings of all pressure and temperature devices and verify they are within normal range.
X	Check site glasses for condensate level in primary & polishing filter vessels.
X	Check oil level in compressor.
X	Visual/Audible inspection for anything unusual (leaks, squeals, etc.)
X	Check gas composition at analyzer, verify auto calibration occurred.
X	Check gas control panel and switchgear for any alarm conditions.
X	Verify gas flow meter is operating and recording properly.

Monthly

X	Span gas analyzer.
X	Check/adjust belt tension on compressors.
X	Check/adjust belt tension and wet screws on gas cooler.
X	Grease fan bearings on gas cooler.
X	Blow-off dust and dirt from all electric motors, fans, and shrouds.

Semi-Annual

X	Grease electric motor bearings for gas cooler and compressor
X	Test vibration switch on gas cooler.
X	Check belts for wear and cracking.
X	Change inlet condensate filter on gas analyzer.
X	Change compressor oil.

Annual

X	Clean cooling fins on gas cooler.
	Perform complete inspection of gas cooler (e.g.: fan blades, pivot points, actuators, nuts, bolts, pulley sheaves, bearings, etc.)
X	Change filters in primary and polishing filter vessels.
X	Inspect and clean VFDs.

Bi-Annual

X	Rebuild condensate diaphragm pumps
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MODULE 2: ENGINE GENERATOR SETS

Daily (Plant Practices & Caterpillar Maintenance)

<input checked="" type="checkbox"/>	Record readings of all pressure and temperature devices and verify they are within normal range.
<input checked="" type="checkbox"/>	Visual/Audible inspection for anything unusual (leaks, squeals, etc.)
<input checked="" type="checkbox"/>	Check oil level, record oil consumption from make-up oil tank.
<input checked="" type="checkbox"/>	Measure/record crankcase blowby.
<input checked="" type="checkbox"/>	Check compressor bypass.
<input type="checkbox"/>	Measure/record crankcase blowby.
<input checked="" type="checkbox"/>	Measure/record cylinder pressure.
<input checked="" type="checkbox"/>	Check engine mounts.
<input checked="" type="checkbox"/>	Check engine protective devices.
<input checked="" type="checkbox"/>	Inspect starting motor.

Daily - Maintenance Manual

<input checked="" type="checkbox"/>	Check air starting motor lubricator oil level.
<input checked="" type="checkbox"/>	Drain air tank moisture and sediment.
<input checked="" type="checkbox"/>	Measure/record bearing temperature.
<input checked="" type="checkbox"/>	Check cooling system coolant level.
<input checked="" type="checkbox"/>	Inspect engine air cleaner service indicator.
<input checked="" type="checkbox"/>	Check engine oil level.
<input checked="" type="checkbox"/>	Check fuel system fuel filter differential pressure.
<input checked="" type="checkbox"/>	Check fumes disposal filter differential pressure.
<input checked="" type="checkbox"/>	Check generator load.
<input checked="" type="checkbox"/>	Check power factor.
<input checked="" type="checkbox"/>	Check voltage and frequency.
<input checked="" type="checkbox"/>	Walk-around inspection.

Quarterly

<input checked="" type="checkbox"/>	Obtain cooling system coolant sample (level 2).
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Biannually

<input checked="" type="checkbox"/>	Top-End Overhaul (CCO at 8,000 hrs; T.E. at 16,000)
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As-Needed

<input checked="" type="checkbox"/>	Replace engine air cleaner element.
<input checked="" type="checkbox"/>	Check fuel metering valve.
<input checked="" type="checkbox"/>	Dry generator.
<input checked="" type="checkbox"/>	Test generator set.
<input checked="" type="checkbox"/>	Test insulation.
<input checked="" type="checkbox"/>	Measure/record stator winding temperature.
<input checked="" type="checkbox"/>	Check throttle control valve.
<input checked="" type="checkbox"/>	Measure/record valve stem projection. (every service - 2015)

MODULE 2: ENGINE GENERATOR SETS

MILLERSVILLE PRACTICES / CATERPILLAR-SPECIFIED MAINTENANCE

Every 500 Hours

X	Measure/record cylinder pressure.
X	Measure/record valve stem projections.
X	Replace ignition system spark plugs (every 3,000 hours by Cat)

Every 1100 Hours (1000 hours by Cat)

X	Drain aftercooler condensation
X	Inspect alternator
X	Inspect/adjust/replace belts.
X	Measure crankcase pressure. (daily)
X	Inspect crankshaft vibration damper.
X	Clean engine crankcase breather.
X	Change engine oil. (and as-needed)
X	Change engine oil filter.
X	Adjust engine valve lash and bridge.
N/A	Clean/inspect engine speed/timing sensor.
N/A	Drain gas pressure regulator condensation.
X	Inspect/replace hoses and clamps.
X	Check/adjust ignition system timing.
X	Inspect inlet air system.
X	Clean radiator. (performed annually)
X	Inspect water pump.

Every 2200 Hours (2000 hours by Cat)

X	Lubricate bearing (ball).
X	Clean/inspect engine speed/timing sensor.
X	Inspect generator.
X	Inspect generator set vibration.
X	Check stator lead.

MODULE 2: ENGINE GENERATOR SETS

MILLERSVILLE PRACTICES / CATERPILLAR-SPECIFIED MAINTENANCE

Every 8000 Hours

- Check rotating rectifier. (every 2200 hours)
- Inspect turbocharger.
- Test varistor
- Replace water temperature regulator. (and as-needed)
- Testing winding. (and as-needed)

Between 10,000 and 20,000 Hours

- Top end overhaul.

Every 24,000 Service Hours/3 Years

- Change cooling system coolant (NGEC).

Between 30,000 and 60,000 Hours

- In-frame overhaul (last performed 2016 at 40k hours; currently at 61k hours).

Between 50,000 and 100,000 Hours

- Inspect bearings. (16,000 hours)
- Major overhaul.

MODULE 3: COOLING WATER SYSTEMS

Daily

- | | |
|---|--|
| X | Record readings of all pressure and temperature devices and verify they are within normal range. |
| X | Check site glasses for proper level |
| X | Visual/Audible inspection for anything unusual (leaks, squeals, etc.) |

Monthly

- | | |
|---|---|
| X | Check/Adjust belt tension and set screws on radiator. |
| X | Grease fan bearings on radiator. |
| X | Check fan blades for damage and proper movement. |
| X | Test coolant for condition/stabilizer |

Semi-Annual

- | | |
|---|--|
| X | Grease electric motor bearings for radiator. |
| X | Test vibration switch on radiator. |
| X | Check belts for wear and cracking. (replace as needed) |

Annual

- | | |
|---|---|
| X | Clean cooling fins on radiator bundles. |
| | Perform complete inspection of radiator (e.g.: fan blades, pivot points, actuators, nuts, bolts, pulley sheaves, bearings, etc.) [Third-party?] |
| X | |

MODULE 4: LUBE & WASTE OIL SYSTEMS

Daily

- Record readings of all pressure and temperature devices and verify they are within normal range.
- Visual inspection for any leaks.
- Check site glasses for level in storage tanks and make-up oil tanks.
- Check/pump rain water from containment area. Record any pumping activity in log book.
- Inspect all piping for oil leaks.

Monthly

- Inspect storage tanks for any exterior rusting.
- Change oil and filters. [1,400 hours?]

MODULE 5: EXHAUST, CRANKCASE VENT, & COMBUSTION AIR SYSTEMS

Daily

- Record readings of all pressure and temperature devices and verify they are within normal range.
- Check site glass on accumulator tank and drain if necessary.
- Visual/Audible inspection for anything unusual (leaks, squeals, etc.)

Monthly

- Check/change combustion air filter material.
- Check/change crankcase vent filter.

Annually

- Change engine crankcase vent filter.

MODULE 6: COMPRESSED AIR SYSTEMS

Daily

- Record readings of all pressure and temperature devices and verify they are within normal range.
- Check fluid level.
- Visual/Audible inspection for anything unusual (leaks, squeals, etc.)

Monthly

- Clean aftercooler fins.
- Blow-off dust and dirt from all electric motors, fans, & shrouds.

Bi-Monthly

- Take oil sample.
- Change oil filter.

Semi-Annual

- Grease motor bearings
- Clean/replace air filters (monthly in modules)

Annual

- Change compressor oil.
- Replace air/fluid separator elements.

MODULE 7: BUILDING VENTILATION

Daily

- Record readings of methane detection panel and verify they are within normal range.
- Visual/Audible inspection for anything unusual (leaks, squeals, etc.)

Weekly

- Check pre-filter pads on vent fans.

Monthly

- Check/adjust belt tension on vent fans.
- Grease fan bearings on vent fans.
- Change pre-filter pads on vent fans.
- Check belts and filters on HVAC unit. (and replace)

Semi-Annual

- Grease electric motor bearings (if not sealed bearing motor)

Annual

- Clean HVAC unit cooling fins.
- Change filters on HVAC unit. (Quarterly in modules)

As-Needed

- Check pre-filter pads on vent fans.

MODULE 8: ELECTRICAL SUPPORT SYSTEMS

Daily

- Record readings of all electrical devices and verify they are within normal range.
- Visual/Audible inspection for anything unusual (smoke, burn marks, etc.)

Weekly

- Check electrolyte level in batteries (48V and 24V systems), except on sealed batteries.
- Check battery connections for corrosion (48V and 24V systems)

Monthly

- Clean battery chargers with compressed air.
- Clean transformer coils and interior with vacuum and compressed air.
- Inspect all connections for tightness and corrosion. Inspect coils for tracking
- Clean motor control center with vacuum and compressed air.
- Inspect all connections for tightness and corrosion.
- Inspect overloads and motor starters for signs of excess heat or arcing.

MODULE 9: SWITCHGEAR - BREAKER & CONTROL EQUIPMENT

Daily

- Record readings of all electrical devices and verify they are within normal range.
- Visual/Audible inspection for anything unusual (smoke, alarm lights, etc.)

Annual

- Clean switchgear with vacuum and compressed air.
- Inspect all connections for tightness and corrosion.
- Inspect all components and wiring for signs of excess heat and/or deteriorated insulation.
- Manually operate all circuit breakers three times, checking for abnormal operation.

* De-energize and ground substation before inspections.

MODULE 10: BUILDING RELATED EQUIPMENT

Daily

- Record readings of all pressure devices and verify they are within normal range.
- Verify Fire Alarm Panel has power and is in normal operation.
- Verify maintenance equipment requiring charging is plugged-in.

Monthly

- Inspect building for cracks in walls and concrete
- Inspect roof for cuts, tears, and holes.
- Inspect asphalt paving for cracks.
- Inspect fencing for damage.
- Inspect gravel areas for weeds, etc.
- Have Fire Extinguishers inspected.

Annual

- Test Fire Alarm Panel, devices and monitoring. (Completed by Fire Hawk annually)

MODULE 11: ELECTRICAL SUBSTATION EQUIPMENT

Daily

- Record readings of all electrical devices (volts, amps, & kW) and verify they are within normal ranges.
- Visual/audible inspection for anything unusual (smoke, burns marks, arcing, etc.)
- Inspect/pump transformer container for rain water. Document all pumping activities in log book.

Monthly

- Inspect gravel areas for weeds, etc.

Annual (last Dec 2018)

- Clean breaker with vacuum and compressed air.
- Inspect all connections for tightness and corrosion.
- Inspect all components and wiring for signs of excess heat and/or deteriorated insulation.
- Manually operate all circuit breakers three times, checking for abnormal operation.
- Inspect primary transformer connections and safety devices, take oil sample for testing.

* De-energize and ground substation before inspections.



Appendix C
Photographs

APPENDIX C – PHOTOGRAPHS



SCADA system panel



Generator room



Generator room



Methane analyzer



Behind the SCADA system



SCADA Panel



Entryway to gas compressor and generator room



Outside electrical equipment (substation in center)