WASTE MANAGEMENT, INC.

PINE TREE ACRES' MALFUNCTION ABATEMENT PLAN FOR THE HYDROGEN SULFIDE REMOVAL SYSTEM

4/2/2015

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Permit condition III.4 for FGENGINES and condition IV. 1 for FGFLARES in Pine Tree Acres' (PTAs) Renewable Operating Permit #MI-ROP-N5984-2013 require a Malfunction Abatement Plan (MAP) for the hydrogen sulfide-removal system. The monitoring frequency increased from monthly to daily with issuance of Permit to Install #160-14. Therefore, the following MAP has been revised to reflect recent changes. The underlying applicable requirement is State Rule 911 that specifies minimum requirements for a MAP. The following paragraphs document PTA's MAP for the hydrogen sulfide-removal system in accordance with the provisions of Rule 911.

PTA's hydrogen sulfide-removal system is comprised of two distinct technologies. The Thiopaq® process is PTA's primary H2S control and the SulfaTreat® process serves as a secondary/backup control. Since these are distinct H2S control technologies, they are discussed separately in the following MAP. The following plans identify operating variables to be monitored to detect equipment malfunction. In addition, the plans identify normal ranges of these operating variables and the method of inspection. The plans also identify relevant equipment, inspection/service frequency, and replacement parts maintained in inventory. Inspection records are maintained electronically and saved to a WM network drive. In addition, hardcopy records are maintained in a logbook stored on-site.

R911(2)(a) – Supervisory Personnel Responsible for MAP

PTA identifies the following Supervisory personnel for the responsibility of overseeing the inspection, maintenance, and repair of the hydrogen sulfide-removal system.

Lee Bilinsky (primary for Thiopaq)
WMRE Plant Manager
586-531-8043

Joshua McFadden (primary for SulfaTreat)
Gas Operations Supervisor
586-531-8046

Rodney Nemeth (secondary for Thiopaq/SulfaTreat)
Gas Operations Manager
734-231-8578

R911(2)(b) – Operating Variables Monitored and Inspection Methods for SulfaTreat MAP

The following table identifies operating variables to be monitored to detect SulfaTreat malfunction along with the normal operating range of these operating variables and the method of inspection. SulfaTreat's product literature attached provides additional detail on operation and maintenance.

EQUIPMENT	OPERATING PARAMETER	MONITORING FREQUENCY	OPERATING RANGE
SulfaTreat vessel(s)	H2S concentration	Daily (minimum) exclusive of weekends and holidays	< 269 ppm (TRS equivalent)
SulfaTreat vessel(s)	Differential pressure (balance flow if multiple tanks on-line)	Weekly	1 – 2 psi differential pressure
Vessel drain lines	Ensure that condensate does not accumulate	Weekly	Sufficient to maintain adequate gas flow
SulfaTreat vessels & piping	Ensure structural integrity. Ensure that valves, flanges, and piping are leak free.	Monthly	No gas odors; no evidence of cracks, leaks, or metal fatigue

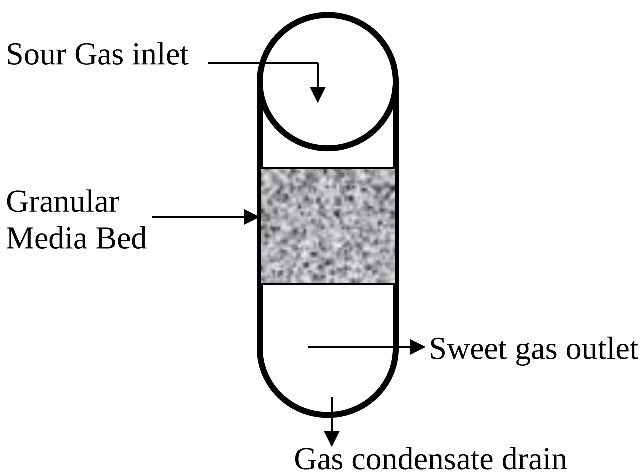
R911(2)(c) – Corrective Action in the event of MAP Noncompliance

PTA's utility flares 3 and 5, along with one of PTA's 3rd party engine plants (Aria Energy Plant II), operate as back-up control devices in the event of an extended malfunction of the hydrogen sulfide-removal system. Flares 3 and 5 have a combined capacity of 5,100 scfm. Permit MI-ROP-N5984-2013 does not require hydrogen sulfide removal from landfill gas combusted in these two flares. Aria Energy's two-engine plant provides an additional 1,000 scfm of capacity, roughly. Therefore, flare and engine plant capacity is currently sufficient to extract landfill gas and maintain compliance. The media-based SulfaTreat control will serve as a back-up control to the primary Thiopaq control in the event of an extended malfunction.

SulfaTreat Process Description

The SulfaTreat process entails H2S-laden (sour) gas flowing through granular media contained in a pressure vessel. A chemical reaction occurs on the iron-oxide coating of the SulfaTreat media and H2S is permanently removed from the landfill gas stream. The spent media is nonhazardous. The general reaction and process are as follows:

Process Chemistry: H2S + SulfaTreat → H2O + FeS2 (iron pyrite)



H2S Monitoring of SulfaTreat Tank Operation

Manual, gear-operated butterfly valves in the header and tank piping serve as the mechanical means for adjusting and optimizing the system. Prints of the SulfaTreat tank system are provided in the attachment for reference. Differential pressure gauges serve as the monitored parameter to ensure flow equilibrium through each of the four tanks. Orifice plates located in the tank outlet piping operate in conjunction with these pressure gauges as an indirect measure of gas flow.

Outlet H2S concentration (ppm) will serve as the monitored parameter to properly adjust the inlet /outlet header piping. Two parallel 14-inch diameter blend lines connect the 24-inch diameter inlet and outlet header pipes. Manual adjustments of these 14-inch butterfly valves will ensure consistent H2S concentrations below 269 ppm (TRS equivalent).

Gas condensate collecting in the base of each tank is drained manually to the adjacent (north) Process Liquids Sump. From the Process Liquids Sump, condensate is automatically pumped into the leachate force main via 4-inch diameter pipes (with dual containment). The SulfaTreat gas condensate ultimately discharges to the 40,000-gallon aboveground leachate storage tank.

SulfaTreat Reference Material

The vendor literature attached provides general process information, vessel drawings, and basic monitoring and operating recommendations. Storage and handling guidance is provided along with procedures for media change out and disposal. A material safety data sheet is included along with a waste analysis of the spent media.

Thiopaq Process Description

The THIOPAQ process consists of three integrated steps. First, the sour gas is scrubbed with a mildly alkaline solution (pH 8 to 9). Hydrogen sulfide is absorbed into aqueous solution and sweet gas exits the contactor. The absorption of H2S and dissociation to hydrosulfide proceeds according to the following equation:

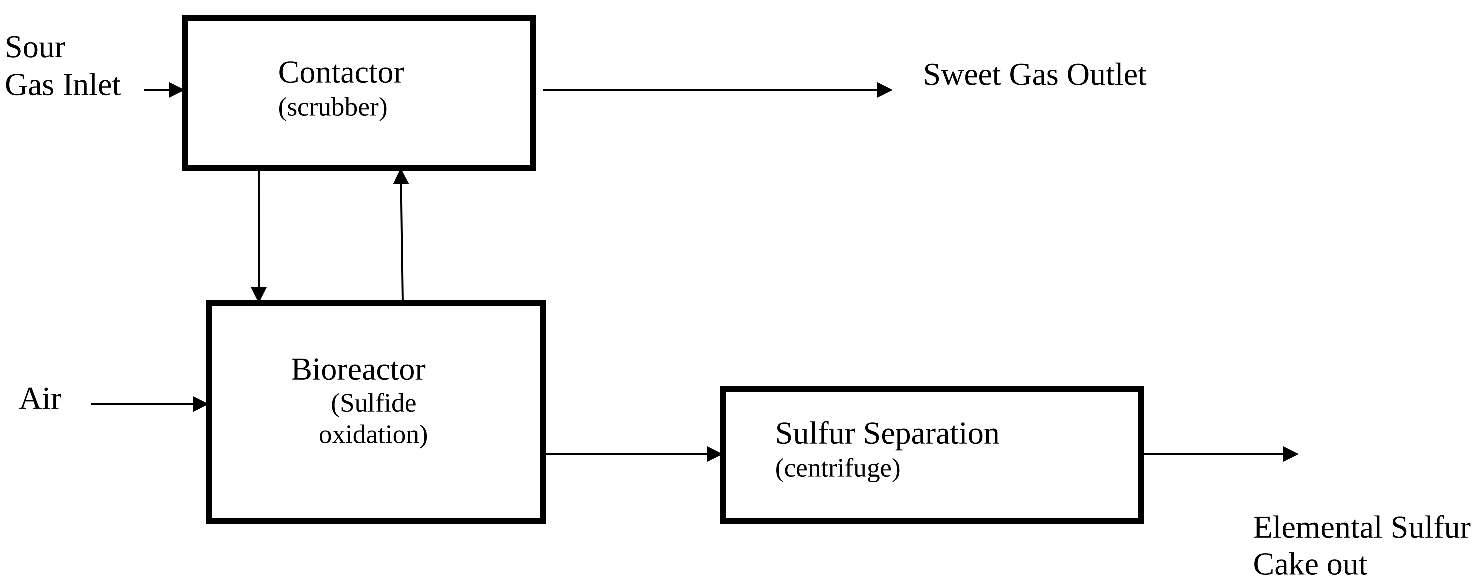
$$H_2S + OH^- \leftrightarrow HS^- + H_2O$$

Second, the solution flows to a bioreactor where a controlled amount of air is introduced. The Thiobacillus bacteria, a naturally occurring organism, consume the sulfide ions and excrete elemental sulfur. This biological process evolves a hydroxide ion effectively regenerating the caustic used in the first absorption step. The oxidation of hydrosulfide to elemental sulfur and the regeneration of hydroxide proceeds according to the following equation:

$$HS^- + \frac{1}{2} O_2 \rightarrow S^\circ + OH$$

Third, elemental sulfur is separated from the liquid phase as a concentrated sludge by a centrifuge. Thiopaq's Operations Manual, Sections 2 and 3, provide additional detail on the major process equipment and process chemistry.

Thiopaq Process Flow



R911(2)(b) – Operating Variables Monitored and Inspection Methods for Thiopaq MAP

The following table identifies operating variables to be monitored to detect Thiopaq equipment malfunction along with the normal operating range of these operating variables and the method of inspection. Thiopaq's Operations Manual, Sections 9 and 11, provides additional detail on the maintenance and inspection schedule.

For purposes of this plan, a "daily" monitoring frequency refers to normal plant operating days. This excludes holidays, weekends, mandatory training, etc. It is assumed that pump overhauls will be performed as necessary. Initially, detailed pump inspections and major service is anticipated to occur on an annual frequency. The following pumps and blowers are spared for redundancy to minimize operational downtime: solution circulation pumps, sulfur slurry pumps, filtrate pumps, and bioreactor air blowers.

PROCESS EQUIPMENT	EQUIPMENT TYPE	OPERATING PARAMETER	MONITORING FREQUENCY	OPERATING RANGE
Scrubber Skid Components				
Inlet Scrubber Pump	Diaphragm Pump	Liquid level in inlet scrubber	Daily	30 psig, 30 gpm, 1 HP motor
Outlet Scrubber Pump	Diaphragm Pump	Liquid level in outlet scrubber	Daily	30 psig, 30 gpm, 3 HP motor
Inlet Gas Scrubber	Vessel	Liquid level in inlet scrubber Gas pressure Structural integrity	Daily Daily Monthly	Below high level alarm < 10 psig Free of leaks, cracks
Outlet Gas Scrubber	Vessel	Liquid level in outlet scrubber H2S concentration Structural integrity	Daily Daily (minimum) Monthly	Below high level alarm <269 ppm (TRS equivalent) Free of leaks, cracks
Pump Skid Components				
Solution Cooler	Heat Exchanger	Temperature of Paques solution in Contactor	Daily	77 - 104 degrees F
Solution Circulation Pumps (3)	Pump	Liquid flow to contactor, sump sprays, and Sulfur Settler	Daily	50 psig, 2,000 – 3,300 gpm, 150 HP motor
Blower Skid Components				
Bioreactor	Vessel	pH, redox, liquid level Structural integrity	Daily Monthly	pH of 7.9 – 8.9, redox of -150 to -350 mV, liquid level within setpoint Free of leaks, cracks
Bioreactor Air Blower (2)	Blower	Mixing/oxidation in bioreactor	Daily	14 psig, 450 scfm, 50 HP motor

Bioreactor Air Cooler	Heat Exchanger	Air Temperature introduced to bioreactor	Daily	Air temperature of approximately 77 degrees F

PROCESS EQUIPMENT	EQUIPMENT TYPE	OPERATING PARAMETER	MONITORING FREQUENCY	OPERATING RANGE
Off Skid Components				
Decanting Centrifuge	Centrifuge	% solids in sulfur cake	Daily	65 – 85% elemental sulfur
Sulfur Slurry Pump (2)	Pump	Liquid flow to decanting centrifuge	Daily	Approximately 1 – 2 gpm
Caustic Dosing Pump	Pump	pH of bioreactor	Daily	Approximately 1 – 2 gph
PROCESS EQUIPMENT	**EQUIPMENT TYPE**	**OPERATING PARAMETER**	**MONITORING FREQUENCY**	**OPERATING RANGE**
Nutrient Dosing Pump	Pump	Oxidation in bioreactor	Daily	Approximately .1 - .2 gph 30 mL/kg S
Sulfur Settler	Vessel	Maintain slurry feed to centrifuge Structural integrity	Daily	Below high level alarm
Nutrient Tote	Vessel	Store nutrimix for bioreactor	Daily	Maintain sufficient level in 275-gallon tote
Contactor Vessel	Vessel	Liquid flow, pressure, differential pressure, temperature Structural integrity	Daily Monthly	Liquid level and pressure control settings established at commissioning Free of leaks, cracks
Filtrate Tank	Vessel	Store process bleed stream to maintain process conductivity Structural integrity	Daily Monthly	Conductivity range of 45 – 85 mS/cm Free of leaks, cracks
Filtrate Pump (2)	Pump	Liquid level in Filtrate Tank	Daily	30 psig, 5 gpm, 5 HP motor
Air Compressor	Compressor	Supply adequate instrument air to pumps and valves	Daily	80 psig, 30 – 50 cfm
Process Analytical Equipment	Redox and pH laboratory meters	Calibration	Weekly	Refer to vendor manuals

Process Analytical Equipment	Redox and pH probes	Inspect/Calibrate	Monthly	Refer to vendor manuals

Corrective Action for Thiopaq Malfunctions

In the event of Thiopaq malfunction, one or more of the following corrective actions will be taken. The following table lists possible malfunctions, affected equipment, corrective actions, and relevant timelines for corrective actions. Thiopaq's Operations Manual, Section 10, provides a detailed troubleshooting guide.

THIOPAQ MALFUNCTION	CORRECTIVE ACTION	APPROXIMATE TIMELINE
System shutdown	Investigate cause and restart Thiopaq. If extended downtime is anticipated, start SulfaTreat system.	Initiate investigation immediately. Timeline for correction depends on the nature of the shutdown.
Low H2S removal efficiency	Check gas composition. Verify that nutrient dosing pump is operational. Check for contamination in nutrients, caustic and water.	Initiate investigation immediately. Corrective action may require 1 – 2 days to resolve.
pH alarm	Check caustic storage tank levels. Verify proper control setpoints. Check caustic pump and settings. Check pH meter and calibrate if necessary.	Initiate corrective action within 24 hours of discovery. Corrective action may require 1 – 2 days to resolve.
Foaming	Adjust flow foam sprayers. Clean spray nozzles. Evaluate process stability.	Initiate within 72 hours of discovery. Corrective action may require 1 – 2 days to resolve.
Tank leakage/freeze up	Ensure proper containment. Ensure tank components are working properly.	Initiate containment/isolation immediately. Corrective action may require 1 – 2 days to resolve.
Air Compressor	Ensure that components are working properly. Inspect for damage and/or leakage. Replace/repair as necessary.	Initiate corrective action within 24 hours if compressor is not functioning or preventing the thiopaq from operating properly. Corrective action may take 1 – 2 days to resolve.
Electrical outage	Notify site electrician. Restart thiopaq once power is restored.	Corrective action may require 1 – 7 days depending on utility power.

As thiopaq accomplishes H2S removal via a biological process, establishing the proper bioreactor conditions is a time-dependent process. Process shakeout involves slowly acclimating the thiobacillus bacteria to the bioreactor environment to establish appropriate biomass. Therefore, landfill gas is gradually added to the process (e.g. 500 – 1,000 scfm/day increments). To initially establish, or re-establish, bacterial colonies may take 2 – 4 days, depending on process variables. Thiopaq's Operations Manual, Section 8, provides a detailed start up procedure.

It is anticipated that completely re-establishing bacterial colonies will occur infrequently, possibly due to shock loadings, extended power outages, or other significant process malfunctions. By contrast, re-establishing thiopaq process equilibrium, will occur periodically as a result of more routine, short-term outages/malfunctions (e.g. wellfield construction, gas quality fluctuations, power interruptions). SulfaTreat will be employed as a back up to thiopaq in response to process upsets.

H2S Sampling of SulfaTreat and Thiopaq Operations

PTA proposes to sample the inlet and outlet H2S concentration using Drager Tubes or other colorimetric sampling tubes (e.g. Gas Tech brand) of equal accuracy and quality. As an alternative, PTA will sample H2S concentration using Landtec's GEM 2000 Gas Analyzer. An H2S monitor (Pod) attaches to Landtec's standard landfill gas analyzer and is calibrated to accurately monitor H2S in the relevant range of 0 – 300 ppm.

H2S sampling will typically occur daily, exclusive of holidays and weekends, to document that the maximum outlet concentration does not exceed 269 ppm, Total Reduced Sulfur equivalent. Drager Tube and GEM Pod samples will be periodically quality assured by lab samples analyzed by EPA Methods 15 and 16.

SO2 Emission Recordkeeping

In accordance with permit #164-14, condition VI.6-c for FGENGINES and VI.2 for FGFLARES, PTA proposes to maintain monthly SO2 emission calculation records. The spreadsheet below illustrates how these records will be maintained. For flares 4 & 6, H2S-treated concentrations, measured daily by Drager Tube or GEM Pod, will be averaged to obtain a monthly, representative concentration. Mass emissions calculations will apply this average monthly concentration (ppm) to the total monthly operating time (hours) for flares 4 & 6. The resulting SO2 emission rate, recorded in pounds per hour, will demonstrate compliance with the permit limits in conditions I.1 and 2.

MONTH	FLARE #6 FLOW (MCF)	FLARE OPERATION (HOURS)	H2S CONC. (PPM)	SO2 EMISSIONS (LB/HR)	SO2 LIMIT (LB/HR)
Mar – '15	118,841	743	151	4.00	16.10

Example calculation for March 2015:

151 parts/10^6 parts x 32 lbs. S / lb. mole x 64 moles SO2 / 32 moles S x 1 lb. mole lfg / 386 cf x 118,841,000 cf / mo. x Mar. / 743 hrs = 4.00 lbs SO2/hr

For the WMRE Engine Plant, the SO2 limit is 1.57 lbs/hr *for each individual engine*. However, flow is not metered to each individual engine, but rather, to the entire 8-engine plant. As a surrogate to flow metering, electrical output (KW) from each engine is used to demonstrate compliance (see below). Actual monthly KW output and runtime hours are used to calculate the single highest engine's fuel flow for each month. For each month, the engine with the highest KW output and corresponding fewest engine hours is selected as the engine with highest fuel consumption (SCF/hr). Demonstrating compliance for the single, highest emitting engine demonstrates compliance for the entire 8-engine plant.

MONTH	HIGHEST ENGINE KW	EGINE OUTPUT (KW)	ENGINE OPERATION (HOURS)	ENGINE FLOW (SCF/hr)	H2S CONC. (PPM)	SO2 EMISSIONS (LB/HR)	SO2 LIMIT (LB/HR)
Mar – '15	Engine #4	1,182,410	736	35,322	154	0.90	1.57

Example (SCF/hr) calculation - Mar. '15

(17.8 MMBTU/hr x 1,182,410 KW-hr/mo. x 10^6 BTU/MMBTU) / (1,600 KW/engine x 736 hr/mo. x 506 BTU/SCF) = 35,322 SCF /hr

Example SO2 calculation – Mar. '15

154 parts/10^6 parts x 34 lbs. H2S / lb mole x 64 moles SO2 / 34 moles H2S x 1 lb. mole lfg / 386 cf x 35,322 SCF / hr = 0.90 lbs SO2/hr

Malfunction Abatement Plan Amendments

Pine Tree Acres' MAP for the hydrogen sulfide-removal system will be reviewed annually, or more frequently if conditions warrant. The MAP will be updated and plan amendments will be submitted to MDEQ-AQD for approval.

Attachment A:

- Pine Tree Acres' SulfaTreat Tank Arrangement – Plan View
- Pine Tree Acres' SulfaTreat Tank Detail – Elevation View
- SulfaTreat Product Literature – General Application of the SulfaTreat Process
- SulfaTreat Product Literature – Safety and Handling Considerations
- SulfaTreat Product Literature – Changeout Procedure
- SulfaTreat 410HP media Material Safety Data Sheet
- SulfaTreat Product Literature – Non-hazardous Environmental Characteristics and Reaction Products