

Report on Treatment Trial

SciCorp BIOLOGIC® SR2

**Odor Control of
Michigan Wastewater Treatment Plant Sludge**

Prepared by:

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EXECUTIVE SUMMARY

Maat Environmental Engineering Corp. (MAAT) has completed comparative testing of SciCorp BIOLOGIC® SR2 and Planet Breeze on samples of three (3) different sludge types being processed and generated at a Michigan wastewater treatment facility. The goal of the testing was to compare odor reduction performance of the products with a focus on hydrogen sulphide (H₂S). There is a general correlation between the magnitude of hydrogen sulphide (H₂S) concentration and the intensity of malodors detectable by humans; therefore the decision was made to analyze H₂S as a proxy variable for the presence of malodors in all three sample sets. However, in one sample set, ten (10) other sulphur compounds, including many mercaptans, were also analyzed, with nine of those compounds measuring as undetectable.

All analyses were carried out by ORTECH Consulting Inc. (ORTECH), an independent odor assessment and analytical consultant located in Mississauga, Ontario. The methodology employed included obtaining air samples from the head space of the test containers and measuring those samples using a Jerome J605 Hydrogen Sulfide Analyzer or a Chromatotec model Chroma-S gas chromatograph. The results showed that BIOLOGIC® SR2 consistently outperformed Planet Breeze in terms of H₂S reduction rates as compared to the control tests. The complete ORTECH report is included with this report.

1.0 BACKGROUND

Sludge samples for testing were obtained from the Senior Process Engineer at the wastewater plant. According to Engineer, flow rate of blended sludge at the Wastewater Treatment Plant to its dewatering facilities is 3.0 MGD. The solids concentration in the blended sludge ranges from 3.8 to 5.6 %. The sludge samples received were analyzed for TSS and VSS internally by the wastewater treatment plant. The analytical results are presented in Table 1.

Table 1: Sludge Properties

No.	Sludge Source	TSS (mg/L)	VSS (mg/L)	Volatile % of Solids (%)
1.	Primary Sludge	22,045	12,530	56.8
2.	Blended Sludge (Tank 1)	57,590	29,045	50.4
3.	Blended Sludge (Tank 4)	38,200	27,780	59.7
4.	Thickened Waste Activated Sludge	27,250	19,120	69.5

The sludge was obtained from holding tanks and process lines on Aug. 8, 2014. The sludge samples were placed in 20 liter air tight containers and transported to Maat Environmental offices in Oakville, Ontario. Of the four (4) samples obtained, the sample labelled “Blended Sludge (Tank 4)” was not tested since it had already been treated with Planet Breeze in the holding tanks from where the sludge was taken.

2.0 SLUDGE TESTING PROTOCOL

The protocol that was used to test the odor control performance of SciCorp BIOLOGIC® SR2 and Planet Breeze was as follows.

A. *Sludge Sampling*

- A.1 0.5 liter samples of Primary and Blended sludge were extracted from the 20 liter containers and placed in 4 liter air tight containers.
- A.2 1.0 liter samples of Thickened Waste Activated Sludge were extracted from the 20 liter container and placed in 4 liter air tight containers.
- A.3 Use of 4 liter containers allowed for 3 and 3.5 liter headspace for the accumulation of off gases from the sludge samples.

B. *Odor Control Product Dosing*

- B.1 A control sample containing the specified sludge volume was prepared without the addition of an odor control additive.
- B.2 A specific odor control dose for each test sample was prepared based on the stated application dosage as documented in the ORTECH Report.
- B.3 For each treatment test sample the odor control additive (SciCorp BIOLOGIC® SR2 or Planet Breeze) was applied at a dilution of 1000:1 to enable accurate dosing of sludge samples.
- B.4 After the odor control additive was added to the sample, each 4 liter container was sealed and shaken to ensure complete mixing of the additive with the sludge.
- B.5 The sludge test containers for each series of tests, including the control, were allowed to sit for 48 hours at room temperature prior to testing of headspace vapors for the presence of H₂S by ORTECH.
- B.6 The sealed 4 liter test containers were then transported to the ORTECH laboratory for headspace analysis.

C. *Headspace Analysis*

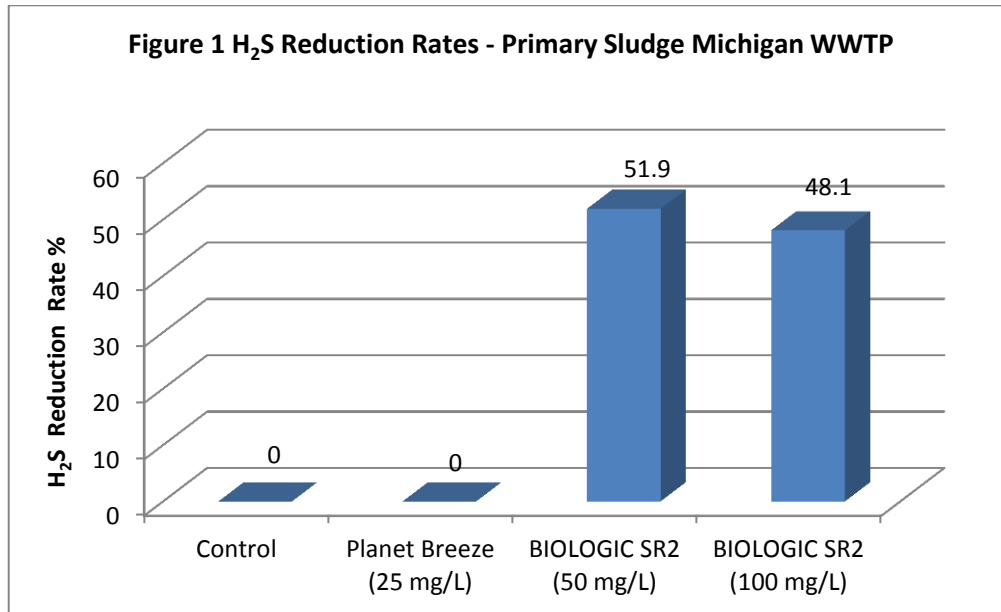
ORTECH carried out two (2) types of headspace analysis as outlined in the attached report. The first method of analysis utilized a Jerome J605 Hydrogen Sulfide Analyzer. The second method of analysis utilized a Chromatotec model Chroma-S gas chromatograph. To assess the effectiveness of each treatment option, ORTECH measured the difference in sulphur compounds in the head space of the test containers between the treated samples and the control sample after 48 hours.

3.0 ORTECH RESULTS

The following comments are offered by Maat Environmental Engineering Corp. based on review of the ORTECH Report:

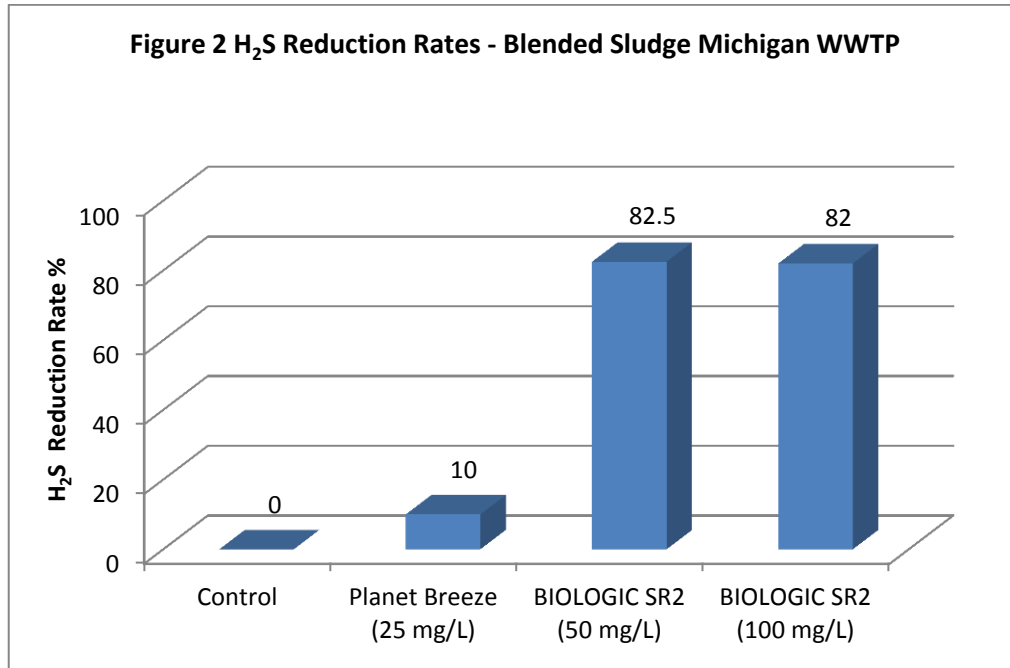
3.1 Primary Sludge

The results of the odor control tests on the Primary Sludge sample showed no significant reduction in the test dosed with Planet Breeze at 25 mg/L compared to the control. The tests dosed with SciCorp BIOLOGIC® SR2 at 50 mg/L and at 100 mg/L showed H₂S reductions approximately equal to 50% compared to the control. Figure 1 graphically depicts the overall H₂S reduction rates for each test compared to the control.



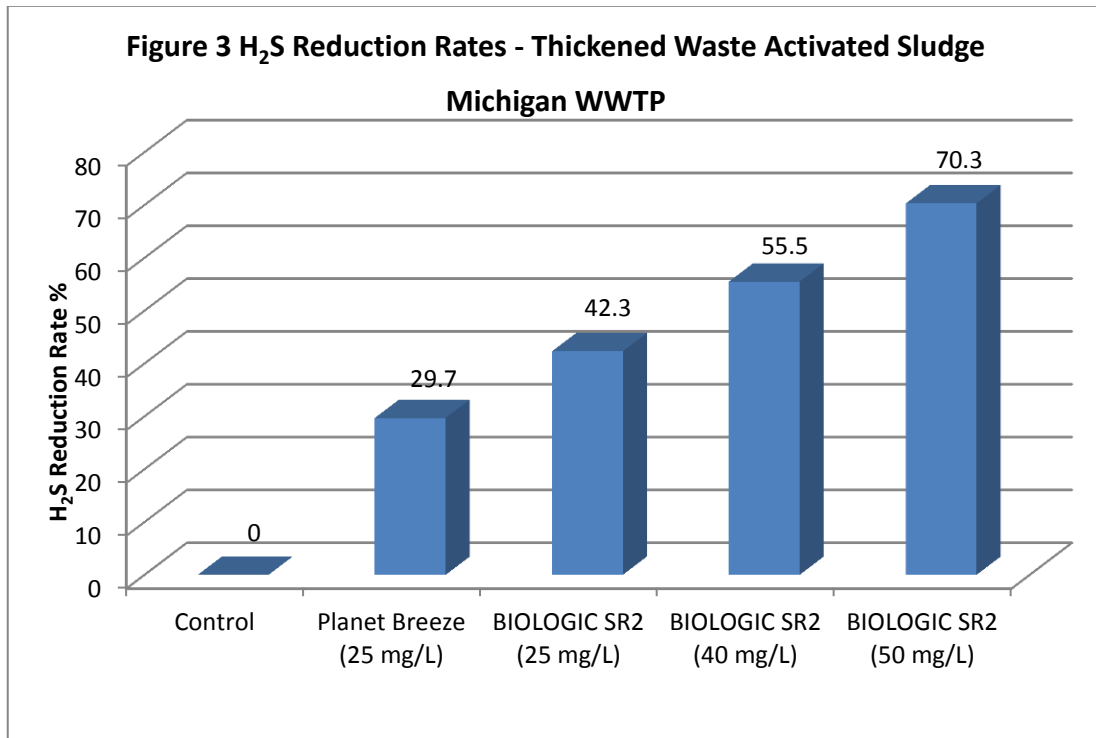
3.2 Blended Sludge

The results of the tests on the Blended Sludge sample dosed with Planet Breeze at 25 mg/L showed a 10% reduction in H₂S compared to the control. The Blended Sludge samples dosed with SciCorp BIOLOGIC® SR2 at 50 mg/L and 100 mg/L both showed H₂S reductions in the range of 82% compared to the control. Figure 2 graphically depicts the overall H₂S removal rates for each test compared to the control.



3.3 Thickened Waste Activated Sludge

The Thickened Waste Activated Sludge sample dosed with Planet Breeze at 25 mg/L showed a 29.7% reduction in H₂S compared to the control. The Blended Sludge samples dosed with SciCorp BIOLOGIC® SR2 at 25 mg/L, 40 mg/L and 50 mg/L showed H₂S reductions of 42%, 55% and 70% respectively compared to the control. Figure 3 graphically depicts the overall H₂S removal rates for each test compared to the control.



4.0 CONCLUSIONS AND RECOMMENDATIONS

1. The results of the ORTECH analyses of the sludge testing indicate that H₂S reduction rates attributed to SciCorp BIOLOGIC® SR2 ranged from 50 % to 82.5 % compared to the control, when the product was applied at a rate of 50 mg/L to sludge samples from the WWTP.
2. The results of the ORTECH analyses of the sludge testing indicate that H₂S reduction rates attributed to Planet Breeze ranged from 0 % to 29.7 % compared to the control, when the product was applied to sludge at 25 mg/L, the current treatment rate at the WWTP.
3. The results of the ORTECH analyses of the Thickened Activated Sludge indicated that the H₂S reduction rate was 42.3 % for the SciCorp BIOLOGIC® SR2 test compared to 29.7 % for the Planet Breeze test, when both technologies were applied to similar samples at 25 mg/L and compared to the control.
4. Based on the testing results, H₂S reduction rates increased as the dosage of SciCorp BIOLOGIC® SR2 increased, to a maximum of 50 mg/L. A dose rate of 100 mg/L showed no significant benefit compared to a dose rate of 50 mg/L.
5. Ten (10) other sulphur compounds, in addition to H₂S, were measured during the Thickened Waste Activated test using a gas chromatograph. All ten compounds were not detectable

above the detection limit of the instrument, with the exception of Dimethyl Sulphide, which was measured at the detection limit in instance.

SciCorp International Corp. is represented by Pure Bioclean Solutions Inc. (Pure Bioclean) for this project. Pure Bioclean is an authorized distributor of SciCorp technology.

Please do not hesitate to contact the undersigned with any comments or questions you may have.

Respectfully submitted



Derk Z. Maat M.Eng., P.Eng.
Chief Engineer
Maat Environmental Engineering Corp.



Report:

Maat Environmental Engineering Corp.
Analysis of Samples for Reduced Sulphur Compounds

Date: September 8, 2014



Report:

Maat Environmental Engineering Corp. Analysis of Samples for Reduced Sulphur Compounds

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Revision History

Version	Date	Summary Changes/Purpose of Revision
1	September 8, 2014	None

NOTICE:

The material in this report reflects the judgment of ORTECH based on information available to them at the time of preparation. Unless manifestly incorrect, ORTECH assumes information provided by others is accurate. Changed conditions or information occurring or becoming known after the date of this report could affect the results and conclusions presented. Unless otherwise required by law or regulation, this report shall not be shared with any Third Party without the express written consent of ORTECH. ORTECH accepts no responsibility for damages, if any, suffered by any Third Party which makes use of the results and conclusions presented in this report.

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1. INTRODUCTION

Sludge samples from a Detroit waste water treatment plant were delivered to ORTECH Environmental (ORTECH) by the Maat Environmental Engineering Corporation (MAAT) for reduced sulphur compound analysis of the head space contents. The containers were approximately 4 L volume polyethylene jugs typically containing about 500 mL to 1000 mL of liquid sludge.

Three types of sludge samples were analyzed. These sludge samples were:

- Primary sludge (PS)
- Blended sludge (BS)
- Thickened waste activated sludge (TWAS)

Some of the sludge samples were treated with one of two kinds of additives at various dosages and some samples were untreated (control samples) prior to analysis. The additives were Planet Breeze (PB) and BIOLOGIC SR2 (SR2)

The sample designations indicating the type of sludge, the kind of additive and the additive dosages were:

• PS-C-2 (control)	-	0 mg/L
• PS-4	SR2	50 mg/L
• PS-5	SR2	100 mg/L
• PS	PB	25 mg/L
• BS1-C-2 (control)	-	0 mg/L
• BS1-4	SR2	50 mg/L
• BS1-5	SR2	100 mg/L
• BS1	PB-2	25 mg/L
• TWAS2-C (control)	-	0 mg/L
• TWAS2	SR2-1	25 mg/L
• TWAS2	SR2-2	40 mg/L
• TWAS2	SR2-3	50 mg/L
• TWAS2	PB	25 mg/L

The samples were analyzed by ORTECH on August 15 (PS and BS samples) and August 29 (TWAS samples), 2014.

2. TEST METHODOLOGY

2.1 Total Reduced Sulphur Compound Analysis

The total reduced sulphur compound concentrations in the headspace of some samples were determined using a Jerome J605 Hydrogen Sulfide Analyzer. A Teflon sampling probe connected the analyzer to the head space in each jug via a small hole in the wall of the jug. Three separate test measurements were recorded for each sample over a period of about 5 minutes.

The Jerome Analyzer has a 100% response to hydrogen sulphide concentrations but also has a lesser response to other low molecular weight reduced sulphur compounds.

2.2 Speciated Reduced Sulphur Compound Analysis

Some samples were analyzed for speciated reduced sulphur compounds using a Chromatotec model Chroma-S gas chromatograph with an all Teflon sample pathway consisting of a MXT5 4 m column and a MXT624 30 m column, a gas sampling valve (GSV) fitted with a Teflon loop and a flame photometric detector with a double flame. The resulting data were processed using VistaCHROM model 1.47a software.

Method references were:

- ASTM Method D6228-98: “Standard Test Method for Determination of Sulphur Compounds in Natural Gas and Gaseous Fuels by Gas Chromatography and Flame Photometric Detection.

3. TEST RESULTS

3.1 Total Reduced Sulphur Compound Concentrations

The measured total reduced sulphur compound concentrations, expressed as parts per million by volume, for the primary sludge (PS) and blended sludge (BS) samples were:

Sample	Total Reduced Sulphur Compound Concentration				Removal Efficiency %
	Test 1 (ppmv)	Test 2 (ppmv)	Test 3 (ppmv)	Average (ppmv)	
PS-C-2 (control)	0.52	0.52	0.51	0.52	-
PS-4, SR2	0.25	0.25	0.26	0.25	51.9
PS-5, SR2	0.27	0.28	0.27	0.27	48.1
PS, PB	0.71	0.76	0.76	0.74	-
BS1-C-2 (control)	0.21	0.19	0.19	0.20	-
BS1-4, SR2	0.033	0.036	0.034	0.035	82.5
BS1-5, SR2	0.033	0.036	0.039	0.036	82.0
BS1, PB-2	0.17	0.18	0.18	0.18	10.0

PB is Planet Breeze additive

SR2 is BIOLOGIC SR2 additive

Reduced sulphur compound removal efficiencies for the additives were calculated from the average concentration for samples with additive compared with the control samples (no additive). The removal efficiencies for the primary sludge (PS) samples with SR2 additive were 51.0% with an addition rate of 50 mg/L and 48.1% with an addition rate of 100 mg/L. The removal efficiencies for the blended sludge (BS) samples with SR2 additive were 82.5% with an addition rate of 50 mg/L and 82.0% with an addition rate of 100 mg/L.

Removal efficiencies were slight or negative with the PB additive.

3.2 Speciated Reduced Sulphur Compound Concentrations

Speciated reduced sulphur compound analytical results, shown in Appendix 1, were obtained for the five thickened waste activated sludge (TWAS) samples analyzed. Hydrogen sulphide was detected in all of the samples and dimethyl sulphide was detected in one sample. Nine additional reduced sulphur compounds (carbonyl sulfide, carbon disulphide, methyl mercaptan, thiophene, dimethyl disulfide, ethyl mercaptan, isopropyl mercaptan, n-propyl mercaptan and t-butyl mercaptan) were not detected in any of the samples at a detection limit of 0.01 ppmv.

The results for the detected compounds were as follows:

Sample	Reduced Sulphur Compound Concentration			Removal Efficiency (%)
	Hydrogen Sulphide (ppmv)	Dimethyl Sulphide (ppmv)	Total (ppmv)	
TWAS2-C (control)	1.81	0.01	1.82	-
TWAS2, SR2-1	1.05	<0.01	1.05	42.3
TWAS2, SR2-2	0.81	<0.01	0.81	55.5
TWAS2, SR2-3	0.54	<0.01	0.54	70.3
TWAS2, PB	1.28	<0.01	1.28	29.7

PB is Planet Breeze additive

SR2 is BIOLOGIC SR2 additive

Reduced sulphur compound removal efficiencies for the additives were calculated from the average concentration for samples with additive compared with the control samples (no additive). The removal efficiencies for the thickened waste activated sludge (TWAS) samples with SR2 additive were 42.3% with an addition rate of 25 mg/L, 55.5% with an addition rate of 40 mg/L and 70.3% with an addition rate of 50 mg/L. The removal efficiency for the thickened waste activated sludge blended sludge (TWAS) sample with PB additive was 29.7% with an addition rate of 25 mg/L.



Stephen Thorndyke, M.Eng., P.Eng.
Principal, Odour Assessment/Analytical Services

APPENDIX 1

Speciated Reduced Sulphur Compound Analyses (5 pages)

**SULPHUR ANALYSIS
Tedlar Bag Sample
for MAAT Environmental**

By: E. Shereshevsky
ORTECH¹ ID: 26154-C-6

Analysis Date: 29-Aug-14

Date: NA

Time (hrs): NA

Sample ID: TWAS2-C

Component ²	Component ³ ppmv
Hydrogen Sulphide	1.810
Carbonyl Sulphide	<0.010
Dimethyl Sulphide	0.010
Carbon Disulphide	<0.010
Thiophene	<0.010
Dimethyl Disulphide	<0.010
Methyl Mercaptan	<0.010
Ethyl Mercaptan	<0.010
Iso-Propyl Mercaptan	<0.010
n-Propyl Mercaptan	<0.010
t-Butyl Mercaptan	<0.010
Total Sulphur Content	1.820

1. ORTECH Environmental.
2. Method References: ASTM Method D6228-98
3. Parts per million by volume.

**SULPHUR ANALYSIS
Tedlar Bag Sample
for MAAT Environmental**

By: E. Shereshevsky
ORTECH¹ ID: 26154-C-7

Analysis Date: 29-Aug-14

Date: NA

Time (hrs): NA

Sample ID: TWAS2-SR2-1

Component ²	Component ³ ppmv
Hydrogen Sulphide	1.050
Carbonyl Sulphide	<0.010
Dimethyl Sulphide	<0.010
Carbon Disulphide	<0.010
Thiophene	<0.010
Dimethyl Disulphide	<0.010
Methyl Mercaptan	<0.010
Ethyl Mercaptan	<0.010
Iso-Propyl Mercaptan	<0.010
n-Propyl Mercaptan	<0.010
t-Butyl Mercaptan	<0.010
Total Sulphur Content	1.050

1. ORTECH Environmental.
2. Method References: ASTM Method D6228-98
3. Parts per million by volume.

SULPHUR ANALYSIS
Tedlar Bag Sample
for MAAT Environmental

By: E. Shereshevsky
ORTECH¹ ID: 26154-C-8

Analysis Date: 29-Aug-14

Date: NA

Time (hrs): NA

Sample ID: TWAS2-SR2-2

Component ²	Component ³ ppmv
Hydrogen Sulphide	0.810
Carbonyl Sulphide	<0.010
Dimethyl Sulphide	<0.010
Carbon Disulphide	<0.010
Thiophene	<0.010
Dimethyl Disulphide	<0.010
Methyl Mercaptan	<0.010
Ethyl Mercaptan	<0.010
Iso-Propyl Mercaptan	<0.010
n-Propyl Mercaptan	<0.010
t-Butyl Mercaptan	<0.010
Total Sulphur Content	0.810

1. ORTECH Environmental.

2. Method References: ASTM Method D6228-98

3. Parts per million by volume.

**SULPHUR ANALYSIS
Tedlar Bag Sample
for MAAT Environmental**

By: E. Shereshevsky
ORTECH¹ ID: 26154-C-9

Analysis Date: 29-Aug-14

Date: NA

Time (hrs): NA

Sample ID: TWAS2-SR2-3

Component ²	Component ³ ppmv
Hydrogen Sulphide	0.540
Carbonyl Sulphide	<0.010
Dimethyl Sulphide	<0.010
Carbon Disulphide	<0.010
Thiophene	<0.010
Dimethyl Disulphide	<0.010
Methyl Mercaptan	<0.010
Ethyl Mercaptan	<0.010
Iso-Propyl Mercaptan	<0.010
n-Propyl Mercaptan	<0.010
t-Butyl Mercaptan	<0.010
Total Sulphur Content	0.540

1. ORTECH Environmental.
2. Method References: ASTM Method D6228-98
3. Parts per million by volume.

**SULPHUR ANALYSIS
Tedlar Bag Sample
for MAAT Environmental**

By: E. Shereshevsky
ORTECH¹ ID: 26154-C-10

Analysis Date: 29-Aug-14

Date: NA

Time (hrs): NA

Sample ID: TWAS2-PB

Component ²	Component ³ ppmv
Hydrogen Sulphide	1.280
Carbonyl Sulphide	<0.010
Dimethyl Sulphide	<0.010
Carbon Disulphide	<0.010
Thiophene	<0.010
Dimethyl Disulphide	<0.010
Methyl Mercaptan	<0.010
Ethyl Mercaptan	<0.010
Iso-Propyl Mercaptan	<0.010
n-Propyl Mercaptan	<0.010
t-Butyl Mercaptan	<0.010
Total Sulphur Content	1.280

1. ORTECH Environmental.

2. Method References: ASTM Method D6228-98

3. Parts per million by volume.