Odour Problem and Cost-Effective Solution in Sewerage Industry

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Abstract : *Odour Problems have become an environmental issue with increasing populations and decreasing buffer boundaries resulting in much friction between firms and the local population. Today, the knowledgeable general public demands effective control and treatment of odour emissions from sewage handling, and treatment facilities. Installed Odour Control Systems must be cost efficient and sustainable long term.*

This Paper is on a specific Case Study of an Odour Control and Treatment System carried out in year 2010 for a Sewage Pumping Station with gaseous emissions of very high odour levels and dangerous Hydrogen Sulphide (H_2S) concentration unlike most other typical Sewage Pumping Stations. This Case Study will illustrate the required Accurate Odour Problem Definition of identifying the odour sources, their containment with practical covers/enclosures and local exhaust to maintain negative containment, followed by the Cost-effective Odour Treatment of the exhaust odorous gases before final emission to the atmosphere.

The findings confirm very high and dangerous H_2S levels among other odorous constituents in the incoming sewage. The results show clearly that combined Odour Treatment Technologies can effectively reduce the final treated odour level to below 1,000 OU/cu.m in compliance to the requirements of the Sewage Pumping Station Owner.

Key words: *accurate odour problem definition, odour concentration, odour control system, containment system, cost-effective odour treatment*

1. INTRODUCTION

From available research documents, published reports and case studies, the typical level of hydrogen sulphide (H_2S) should be less than 1 ppm with the overall odour concentration of less than 2,000 OU/cu.m for most of the Sewage Pumping Stations (SPS) operating in Malaysia. (refer to Table 1)

However if the sewage collected and transferred to a SPS contains very high loading of oil and grease contaminants, the level of hydrogen sulphide can be exceptionally high. High levels of H_2S are dangerous and may lead to very severe health risks including the possibility of death.

Table 1. Some Odorous Compounds in Exhaust Air of a Typical Sewage Pump Stations.

Odorous Component	Detection Threshold (ppb)	Typical Level (ppb)	Odour Conc. (OU/cu.m)	Maximum Level (ppb)	Odour Conc. (OU/cu.m)
Acetaldehyde	67	30	< 1	100	< 2
Ammonia	***17,000***	100	< 1	***2,000***	***< 1***
Dimethyl Amine	340	20	< 1	50	< 1
Dimethyl Sulphide	1	50	50	100	100
Ethyl Mercaptan	0.3	50	165	100	330
Hydrogen Sulphide (H_2S)	**0.5**	**1,000**	**2,000**	**30,000**	**60,000**
Methylamine	4,700	50	< 1	100	< 1
Methyl Mercaptan	**0.5**	**500**	**1,000**	**3,000**	**6,000**
Skatole	1	50	50	N/A	N/A

2. ODOUR PROBLEM DEFINITION

Accurate Odour Problem Definition for a SPS or any other sewage collection or processing facilities shall include identifying odour generating sources followed by optimal containment of the identified sources.

Figure 1. Typical Sewage Pumping Station in Malaysia without Odour Control System

Figure 2. Olfactometric Measurement carried out in typical Malaysian Sewage Pumping Stations

From the odour concentrations measured at site by Olfactometry to MS 1963:2007 of numerous Sewage Pumping Stations installed and commissioned by Excel Air Engineering Sdn. Bhd., we recommend the Design of an Odour Control and Treatment System (OCTS) for a typical Sewage Pumping Station to be based on an Inlet Odour loading of 10,000 OU/cu.m.

For typical Sewage Pumping Stations in Malaysia, our standard BIORID Biofilter Odour Treatment Unit (OTU) Performance Efficiency is :

Ninety percent (90%) Odour Removal Efficiency for Inlet Odour load of 10,000 OU/cu.m

OR

Less than 1,000 OU/cu.m at Outlet Discharge for Inlet odour loads of less than 10,000 OU/cu.m.

3. CASE STUDY of a Not Typical Sewage Pumping Station in Malaysia with inlet sewage of very high odour levels and dangerous H_2S concentration

3.1. First Installation

3.1.1. Preliminaries

First look at an Odour Control System Project awarded to us for an existing Sewage Pumping Station

Figure 3. Initial photo of the existing Sewage Pumping Station for installation of our BIORID Odour Control System

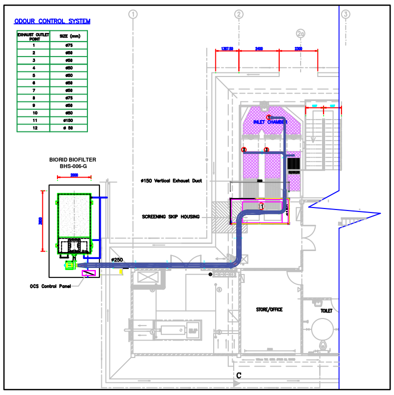


Figure 4. OCS Design Plan layout for a typical Sewage Pumping Station assumed applicable for this Project

3.1.2. First Installation at site

Closer look during onsite inspection for Installation

Figure 5. Onsite inspection showed the incoming sewage contain high oil and grease contents.

First Installation completed

Figure 6. Completed BIORID OCTS of Containment System and OTU.

3.1.3. Measurements and Air flow balancing on completion of First Installation

On completion of installation works in end December 2010, air flow measurements were carried out on all exhaust points with air flow balancing on pressure basis to achieve the design flow rates at each extraction point. No odours were detected outside of the containment enclosures as all the exhaust odorous gases are contained and channeled into the BIORID Biofilter OTU with the treated air discharged to atmosphere.

On commissioning of the installed BIORID OCTS, initial H_2S measurements at site by a hand held gas meter confirmed extraordinary high H_2S levels in the SPS incoming sewage (refer Figure 7).

The high acidity levels of both the BIORID Pre-scrubber and Biofilter effluent discharges at pH3 levels resulting from the extraordinary high H_2S concentration has severely corroded the concrete drain (refer Figure 8).

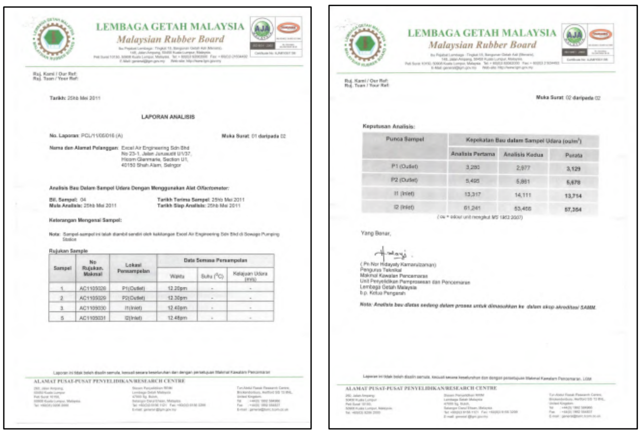
Figure 7. Hand held gas monitor detecting very high H_2S concentration above opening of wet well enclosure

Figure 8. Concrete drain badly corroded by acidic discharge from pre-scrubber and biofilter drain.

Sampling of the exhaust raw odorous gas and treated gas discharged at Outlet for H_2S and odour levels were carried out simultaneously with the collected gas samples sent to Lembaga Getah Malaysia (Olfactometry Laboratory approved by Jabatan Alam Sekitar) for determination of their odour levels by Olfactometry Analysis to MS1963:2007. (refer to Table 2 and Figure 9)

Table 2. Olfactometric Analysis to MS 1963:2007 was carried out on 24^{th} May 2011.

Sample		Odour Concentration (OU/cu.m)	H2S (ppm)
I1	Inlet raw gas before treatment	13,714	28.2
I2	Inlet raw gas before treatment	57,354	52.6
P1	Outlet treated gas	3,129	0.7
P2	Outlet treated gas	5,678	1.1



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Tarikh: 25hb Mei 2011

LAPORAN ANALISIS

No. Laporan: PCL/11/05/016 (A) Muka Surat: 01 daripada 02

Nama dan Alamat Pelanggan: Excel Air Engineering Sdn Bhd
No 23-1, Jalan Juruaudit U1/37,
Hicom Glenmarie, Section U1,
40150 Shah Alam, Selangor

Analisis Bau Dalam Sampel Udara Dengan Menggunakan Alat Olfactometer:

Bil. Sampel: 04 Tarikh Terima Sampel: 25hb Mei 2011
Mula Analisis: 25hb Mei 2011 Tarikh Siap Analisis: 25hb Mei 2011

Keterangan Mengenai Sampel:

Nota: Sampel-sampel ini telah diambil sendiri oleh kakitangan Excel Air Engineering Sdn Bhd di Sewage Pumping Station

Rujukan Sample

Sampel	No Rujukan Makmal	Lokasi Persampelan	Data Semasa Persampelan		
			Waktu	Suhu (°C)	Kelajuan Udara (m/s)
1	AC1105028	P1(Outlet)	12.20pm	-	-
2	AC1105029	P2(Outlet)	12.30pm	-	-
3	AC1105030	I1(Inlet)	12.40pm	-	-
5	AC1105031	I2(Inlet)	12.48pm	-	-

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Muka Surat: 02 daripada 02

Keputusan Analisis:

Punca Sampel	Kepekatan Bau dalam Sampel Udara (ou/m³)		
	Analisis Pertama	Analisis Kedua	Purata
P1 (Outlet)	3,280	2,977	3,129
P2 (Outlet)	5,495	5,861	5,678
I1 (Inlet)	13,317	14,111	13,714
I2 (Inlet)	61,241	53,466	57,354

(ou = odour unit mengikut MS 1963:2007)

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Figure 9. Olfactometric Measurement carried out after completion of installation

Fortunately, the hazardous and odorous sewage gases have been isolated from the SPS working environment by effective containment of these gases within the enclosures and covers of all the identified odour generating sources and exhausted to the inlet of the installed BIORID OTU.

3.1.4. Phase 1B Site Upgrading Works

Phase 1B Upgrading works were carried out on the installed BIORID OTU with addition of more organic biofilter media in the biofilter section increasing the effective biofiltration height by another 0.7 meter and topping up continuously fresh water into the pre-scrubber section for dilution of scrubbing water with continuous overflow draining back into the wet well.

On completion of Phase 1B Upgrading works, sampling of the exhaust raw odorous gas and treated gas discharged at OTU outlet for H_2S and odour levels were carried out simultaneously with the collected gas samples sent to Lembaga Getah Malaysia for determination of their odour levels by Olfactometry analysis to MS1963:2007 (refer to Figure 10 and Table 3).

Figure 10. H_2S levels measured in the incoming sewage at the channels, mechanical screens/skips and the inlet raw odorous gas to be abnormally high in some measurements recorded 200ppm H_2S which is the limit of the H_2S meter used.

Table 3. H_2S measurements taken at Odour Extraction Point and Inlet to BIORID Biofilter Odour Treatment Unit

		Ave. Velocity (m/s)	Volume (m^3 /h)	H_2S (ppm)
Main Duct - Inlet (Ø250mm)		4.12	727.19	170
Outlet at Exhaust BIORID Biofilter Plant				16
Point Extraction Velocities / **Point No.**	**Branch Duct mm**	**Ave. Velocity (m/s)**	**Volume (m^3 /h)**	**H_2S (ppm)**
1	75	6.29	100.09	16 ppm
2	50	7.31	51.65	151 ppm
3	50	6.69	47.30	>200 ppm
4	50	7.13	50.38	73 ppm
5	50	5.72	40.43	>200 ppm
6	50	2.27	16.07	>200 ppm
7	50	4.45	31.46	200 ppm
8	75	6.01	95.64	75 ppm
9	50	5.20	36.78	56 ppm
10	50	4.76	33.63	80 ppm
12	50	3.56	25.16	10 ppm
Note : No Olfactometric Measurement carried out due to the high H_2S level.				

3.1.5. Health responses to High H_2S gases exposure

The danger and health risks are shown in Table 4 below.

Table 4. Hydrogen Sulphide and Health Hazards

Concentration (ppm)	Health Response
0.01 - 0.7	least detectable odour
3 - 5	offensive odour
10	eye irritation
20	irritation to mucous membranes and lungs
50 - 100	irritation of respiratory tract
150	nose nerve paralysis
200	headache, dizziness
500 - 600	nausea, excitement, unconsciousness
700 and above	FATAL

3.1.6. Identifying and Removal of Hazardous Chemicals before Odour Treatment

TREAT ODOUR PROBLEMS for OFFENSIVE **SMELL (ODOUR)** ONLY AFTER REMOVAL of **IDENTIFIED HAZARDOUS CHEMICALS**

3.1.7. Recommended Solution

Problem : Remove H_2S from the extracted odorous gases to an acceptable level of below 5ppm H_2S before treating the remaining odorous gases by the existing BIORID Biofilter Plant.

Solution : Install an additional Wet Chemical Gas Scrubber to chemically treat and remove H_2S from the extracted odorous gases to an acceptable level before treatment by the existing BIORID Biofilter Plant.

3.2. Phase II Installation of Upgrading Works

3.2.1. Wet Chemical Gas Scrubber

The selected Wet Chemical Gas Scrubber to remove the H_2S from the extracted raw odorous gases is shown in Figure 11. The Phase II Overall OCS Design Plan layout is shown in Figure 12.

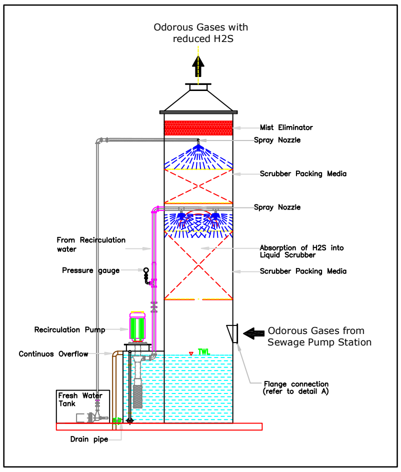


Figure 11. Selected Multiple Stage VCC Gas Scrubber for H_2S Removal

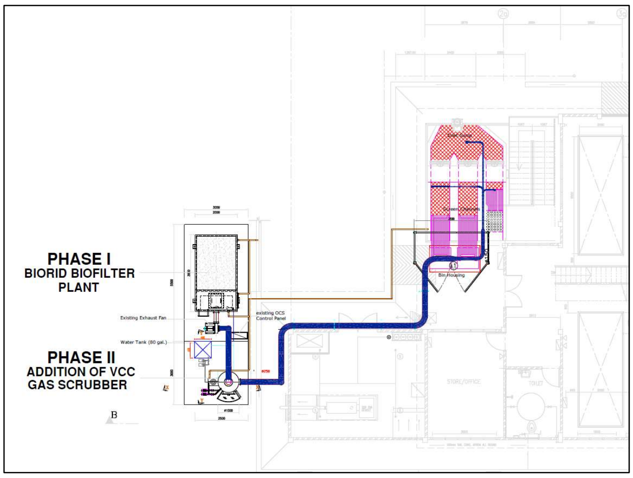


Figure 12. Phase II Overall OCTS Design Layout

3.2.2. Phase II Installation at site

Figure 13. Completed Phase II Installation

3.2.3. High costs of Chemicals and resultant Waste Effluent Treatment of Wet Chemical Gas Scrubber

Before start-up of the installed Wet Chemical Gas Scrubber, the cost of neutralization by sodium hydroxide chemical scrubbing including the required treatment of the resultant chemical waste effluent were calculated to be too high. Therefore, it was decided to downgrade this Wet Chemical Gas Scrubber to be used only as a Water Gas Scrubber.

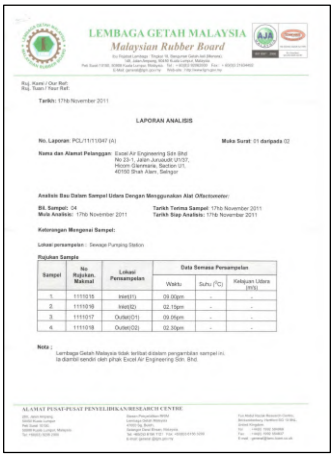
3.2.4. Measurements on completion of Phase II Upgrading Installation

On commissioning of the installed Upgraded OCTS of combined Water Gas Scrubber and BIORID Biofilter Plant in November 2011, sampling of the exhaust raw odorous gas, Water Gas Scrubber outlet and BIORID Biofilter final treated gas discharge for H_2S and odour levels were carried out simultaneously with the collected gas samples sent to Lembaga Getah Malaysia for determination of their odour levels by Olfactometry analysis to MS1963:2007. (refer to Table 5 and Figure 14)

Table 5. H_2S and Odour Measurements Of Odour Source, Local Exhaust Points, Raw Exhaust Gas Inlet to Water Gas Scrubber And Treated Exhaust Gas Outlet after BIORID Biofilter Plant From 14th Nov. To 16th Nov 2011

Point Extraction	Duct Size Ømm	Description	H_2S (ppm)											
			14-Nov-11	15-Nov-11						16-Nov-11				
			4:30 PM	11:40 AM	1:30 PM	2:45 PM	5:00 PM	7:40 PM	9:00 PM	8:30 AM	10:30 AM	10:50 AM	1:20 PM	2:15 PM
1	65	Inlet Chamber	50	90	109	98	55	130	110	64	93	67	126	98
2	65	Ch. Before Mech. Screen 1	116	115	139	115	108	110	80	64	114	63	145	110
3	65	Ch. Before Mech. Screen 2	125	72	111	98	111	76	65	28	72	30	92	86
4	100	Before Bypass screen	34	110	66	70	40	108	80	20	111	20	169	70
5	65	Ch. After mech screen 1	+OL	+OL	+OL	+OL	+OL	+OL	+OL	77	133	108	+OL	+OL
6	50	Ch. After mech screen 2	+OL	+OL	+OL	+OL	+OL	+OL	+OL	67	116	99	+OL	+OL
7	65	After bypass screen	+OL	+OL	+OL	+OL	+OL	+OL	+OL	45	125	97	+OL	+OL
8	65	Wet well	21	20	8	10	19	25	30	8	18	11	19	16
9	50	Wet well	48	50	0	13	20	55	20	5	51	33	22	18
10	50	Wet well	39	40	13	8	15	46	14	14	40	17	34	10
12	50	Underneath staircase	5	5	5	5	5	5	5	0	5	0	5	3
A) H_2S Concentration (ppm)														
Raw Inlet Exhaust Gas to Vertical Counter Current Scrubber (using water as scrubbing media)			71	100	94	65	86	118	66	31	73	44	77	53
Inlet to BIORID Biofilter Plant			64	85	82	60	76	96	47	31	68	40	70	45
Treated Exhaust Gas Outlet after Biofilter Plant			5	5	5	3	0	1	<1	0	0	0	0	0
B) Odour Concentration (OU/cu.m)														
Raw Exhaust Gases INLET			(1)	(1)	(1)	(1)	(1)	(1)	48,581	(1)	(1)	(1)	(1)	25,626
Treated Exhaust Gases OUTLET			(1)	(1)	(1)	(1)	(1)	(1)	5,924	(1)	(1)	(1)	(1)	5,028

Note : (1) OL : Over the limit of maximum 200ppm H_2S gas detection capability as shown in the instruments.
(2) Olfactometric analysis carried out only for 1 night time sampling and 1 day time sampling.



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Tarikh: 17hb November 2011

LAPORAN ANALISIS

No. Laporan: PCL/11/11/047 (A)   Muka Surat: 01 daripada 02

Nama dan Alamat Pelanggan: Excel Air Engineering Sdn Bhd
No 23-1, Jalan Juruaudit U1/37,
Hicom Glenmarie, Section U1,
40150 Shah Alam, Selngor

Analisis Bau Dalam Sampel Udara Dengan Menggunakan Alat Olfactometer:

Bil. Sampel: 04   Tarikh Terima Sampel: 17hb November 2011
Mula Analisis: 17hb November 2011   Tarikh Siap Analisis: 17hb November 2011

Keterangan Mengenai Sampel:

Lokasi persampelan : Sewage Pumping Station

Rujukan Sample

Sampel	No Rujukan. Makmal	Lokasi Persampelan	Data Semasa Persampelan		
			Waktu	Suhu (°C)	Kelajuan Udara (m/s)
1.	1111015	Inlet(I1)	09.00pm	-	-
2.	1111016	Inlet(I2)	02.15pm	-	-
3.	1111017	Outlet(O1)	09.05pm	-	-
4.	1111018	Outlet(O2)	02.30pm	-	-

Nota :
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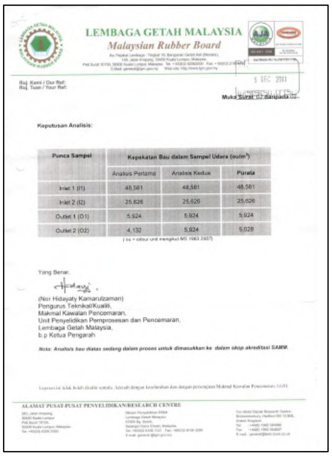

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Muka Surat 02 daripada 02

Keputusan Analisis:

Punca Sampel	Kepekatan Bau dalam Sampel Udara (ou/m³)		
	Analisis Pertama	Analisis Kedua	Purata
Inlet 1 (I1)	48,581	48,581	48,581
Inlet 2 (I2)	25,626	25,626	25,626
Outlet 1 (O1)	5,924	5,924	5,924
Outlet 2 (O2)	4,132	5,924	5,028

(ou = odour unit mengikut MS 1963:2007)

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Makmal Kawalan Pencemaran,
Unit Penyelidikan Pemprosesan dan Pencemaran,
Lembaga Getah Malaysia,
b.p Ketua Pengarah

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Figure 14. Olfactometric Measurement carried out after Phase II installation completion

3.2.5. Evaluation of Phase II Upgrading Installation

Now that the Wet Scrubber is using water as the scrubbing media, the level of H_2S at Scrubber Outlet is still very high (>30ppm H_2S). The existing BIORID Biofilter Plant has now been converted to a H_2S Removal Biofilter Plant and is unable to treat the remaining other odorous gases as shown clearly in Table 5 and Figure 14.

3.2.6. Recommended FINAL Solution

Problem : To further reduce the remaining odorous gases of 5,028 OU/cu.m after the Phase II installation to below < 1,000 OU/cu.m as required before discharge to the atmosphere

Solution : Install an Additional second BIORID Biofilter Plant after the Exhaust Gas Outlet of the of the existing Phase II OCTS Installation of Water Gas Scrubber and first BIORID Biofilter Plant

3.3. Phase III Installation of Further Upgrading Works

3.3.1. Additional second BIORID Biofilter Plant

The additional second BIORID Biofilter Plant is be of closed top design and located after the Water Gas Scrubber and before the existing open top BIORID Biofilter Plant. (Refer Figures 15 and 16)

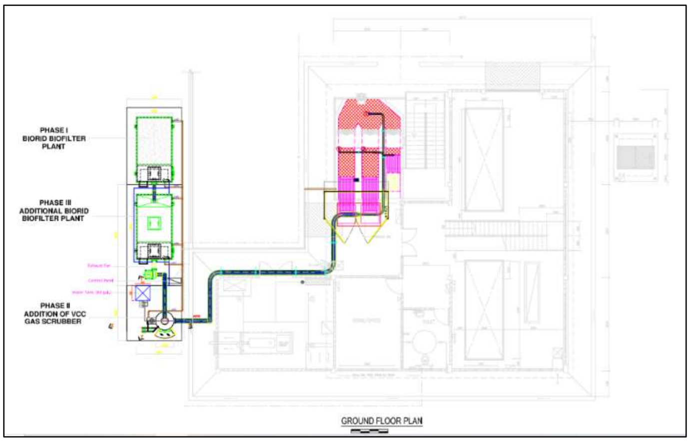


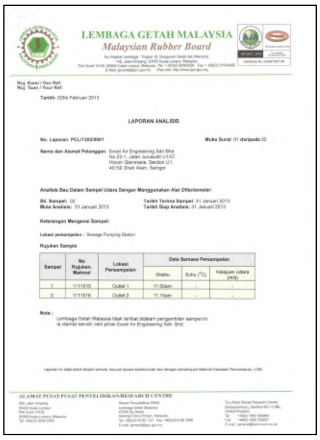
Figure 15. Phase III Overall OCS Design Plan layout

3.3.2. Phase III Installation at site

Figure 16. Completed Phase III Installation

3.3.3. Measurement on completion of Phase III Further Upgrading Installation

On commissioning of the Phase III Further Upgrading Installation in January 2013, sampling of the final treated odorous gas discharge for H_2S and odour levels were carried out at site with the collected gas samples sent to Lembaga Getah Malaysia for determination of their odour levels by Olfactometry analysis to MS1963:2007. (refer to Figure 17)



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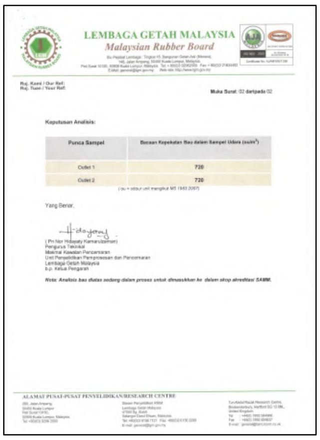

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Muka Surat: 02 daripada 02

Kepuhusan Analisis:

Punca Sampel	Bacaan Kepekatan Bau dalam Sampel Udara (ou/m³)
Outlet 1	720
Outlet 2	720

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Figure 17. Olfactometric Measurement carried out after commissioning of Phase III Installation

3.3.4. Evaluation of Phase III Upgrading Installation

Referring to Figure 17, the installation of the additional second BIORID Biofilter OTU has reduced the Phase II treated odour level of 5,028 OU/cu.m (as shown in Treated Exhaust Gas OULET in Table 6) to 720 OU/cu.m below the emission odour limit of 1,000 OU/cu.m as required by the Sewage Pumping Station Owner.

3.3.5. Summary of Results for all three of installations

The results of Phase III Further Upgrading Installation is compared to the earlier results of Phase II Upgrading Installation and First Installation is shown in Table 6.

Table 6. Summary of Measurement Result taken for all 3 Phases of OCTS Installations, From May 2011 to January 2013

Item	Date & Time of Site Sampling / Description	24-May-11		11-Aug-11		15-Nov-11				16-Nov-11		30-Jan-13	
		Phase 1A Biofilter Plant only		Phase IB Upgrade Biofilter Plant		Phase II Biofilter Plant with additional 2 stage VCC Water Scrubber						Phase III Additional Biofilter Plant	
		12:20 PM	12:40 PM	10:55 AM	1:50 PM	11:40 AM	1:30 PM	7:40 PM	9:00 PM	10:30 AM	2:15 PM	9:50 AM	10:50 PM
(A)	**H_2S Concentration (ppm)**												
1	Raw Exhaust Gases **INLET**	28.2	52.6	143	170.0	100.0	94.0	118.0	66.0	73.0	53.0	46.0	86.0
2	Treated Exhaust Gases **OUTLET**	0.7	1.1	11	16.0	5.0	5.0	1.0	<1.0	0.0	0.0	0.0	0.0
(B)	**Odour Concentration (OU/cu.m)**												
1	Raw Exhaust Gases **INLET**	13,714	57,354	(1)	(1)	(2)	(2)	(2)	48,581	(2)	25,626	(2)	(1)
2	Treated Exhaust Gases **OUTLET**	3,129	5,678	(1)	(1)	(2)	(2)	(2)	5,924	(2)	5,028	(2)	720

Notes : 1. Due yo excessive H2S concentration measured, olfactometric analysis were not carried out.
2. Olfactometric analysis carried out only for 1 night time sampling and 1 day time sampling.

3.4. CONCLUSION

From the Summary of Results in Table 6 and the actual site conditions in this Case Study, the requirements stated below must be strictly followed for all future Odour Control and Treatment Systems to be installed in a Sewage Pumping Station, Sewage Treatment Plant or any other Sewage Handling and Processing Facility.

1. Accurately define the actual odour Problem with focus on hazardous chemicals such as hydrogen sulphide, ammonia, methane, sulphur dioxide and others before treating the remaining odorous gases to below the allowable odour concentration level.
2. Optimal containment of identified odour generating sources is critical to isolate the odorous gases from the surrounding environment especially to prevent direct exposure to persons working in the facility.
3. Where practical, treat the defined odour problem at raw sewage collecting sources before inlet collection point at the facility. In this case study, the oils and grease contents should be removed or reduced from the incoming sewage before the Sewage Pumping Station.
4. Where specified or due to abnormally identified hazardous chemicals, combination of several odour treatment technologies should be considered.
5. The measured results show that a Biofiltration treatment system with proven design and successfully commissioned installations, is able to remove H_2S effectively
6. To be considered cost-effective, OCTS operation and maintenance costs must be carefully evaluated before selecting an OTU to be installed.

From the data collected at site and measurement results, it is reasonable to conclude that the **Better Solution** to treat sewage odorous gases of similar extraordinary high H_2S would be a **Combination** of one **Closed top Biofilter** and one **Open top Biofilter Odour Treatment System.**

4. ACKNOWLEDGMENTS

This work was carried out in compliance to the requirements of the Sewage Pumping Station Owner.

5. REFERENCES

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