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Thei

Member of VTC Group
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THE GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION

Drainage Services Department

CONTRACT NO. SPW 10/2016

Odour Survey for Yuen Long Effluent Polishing Plant

September 2016

By Odour Research Centre

Faculty of Science and Technology
Technological and Higher Education Institute of Hong Kong

(*Member of VTC Group*)

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1. Background

According to the EIA Study Brief No. ESB-241/2012 for Effluent Polishing Scheme at Yuen Long Sewage Treatment Works, odour impact assessment for the sewage treatment works (STW) and sludge generated during operational phase is required by the Drainage Services Department of Hong Kong Government. Odour survey shall be carried out to determine the odour conditions at the existing Yuen Long Sewerage Treatment Works (YLSTW) to build up the odour emission inventory for the future Yuen Long Effluent Polishing Plant.

2. Scope of the Work

- provision of all labour, transportation, materials, equipment and tools necessary for the satisfactory completion of the Services as per Technical Requirements within the course of the Services;
- to conduct odour sampling and olfactometry analysis to determine odour emission rates background odour concentration at the odorous source locations of the existing YLSTW;
- in conjunction with the odour sampling, to conduct on-site H_2S measurement at the identified odorous source locations of the existing YLSTW to obtain quantitative data on existing odour level during the odour sampling; and
- preparation and submission of Odour Analysis Report to the Project Manager (AECOM Asia Co. Ltd.).

3. Sampling Locations and Frequency

Odour sampling shall be carried out at the odour source locations within the existing YLSTW. The sampling shall be conducted at the effluent surface / screens surface / sludge surface of the different facilities which are open to the atmosphere. The respective locations are listed below and as shown in Appendix A:

Location of odour sampling at odourous source at YLSTW;
S1 - Screw Pump Pumping Station
S2 - Screening Skips at Inlet Works
S3 - Primary Sedimentation Tank Surface
S4 - Aeration Tank Surface
S5 - Final Sedimentation Tank
S6 - Consolidation Tank
S7 - S.A.S Thickener House
S8 - Sludge Holding Tank
S9 - Dewatered Sludge Skip at Sludge Deratering House
S10 - Return Activated Sludge Screw Pump Pumping Station
S11 - Screening Press House for Coarse Screens
S12 - Primary Sludge Distribution Chamber/Measurement Chamber
S13 - Settlted Sewage Overflow Chamber (SOC)
S14 - Fine Screens Screening
S15 - Sampling at Site Boundary at Downwind Direction (specific location is subject to on-site condition)

Two sampling events will be conducted for each sampling location on separate days with daytime's temperature measures greater than 30°C (during sampling period) at site.

4. Methodology

4.1. Odour Sampling

4.1.1 Odour gas sample at each survey location is collected by an odour sampling device of Sampling Device Standard consists of a vacuum container which is evacuated by a vacuum pump, in compliance with EN 13725. The sampling point and the standard sampler are connected by a probe.

4.1.2 Due to the evacuation in the sampling device, the sample bag, inside the device, sucks in sample air via the probe. During this process, none of its components come into contact with the sample air due to the construction of the sampling device.

4.1.3 The only materials, which the odorous air should contact, are stainless steel, borosilicate glass or one of polytetrafluoroethylenes (PTFE). The sample bags are to be manufactured from PTFE, Tedlar if the bags to be reused or from nalophane (NA^{TM}) if the sample bags are to be discarded after use.

Odour Sampling System

4.1.4 In order to determine a specific odour emission rate from an area source such as water surface, air sampling can use a "hood" method, whereby a Flux Hood is placed on the odour emission surface of selected locations and a stream of odour-free nitrogen gas from a certified gas cylinder is supplied into the Flux Hood to simulate a sweep wind blowing on the main section of sampling hood. The flow rate of odour-free nitrogen gas is 5 (L/min). The emission rate is then determined by the air flow through the hood and the odour concentration of the exit air. Air samples shall be collected using the above Sampling Device Standard and odour bags. The Flux Hood system is shown below.

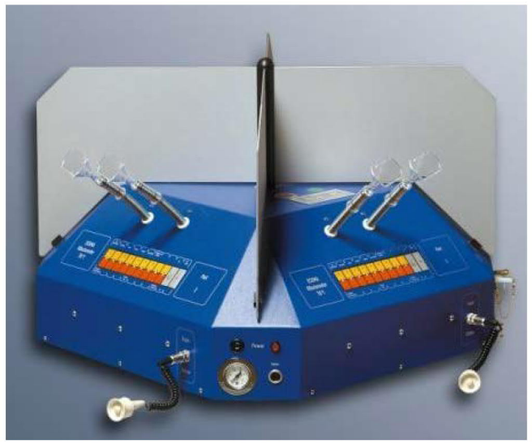
Flux Hood Systems

4.2. Olfactometry Analysis

4.2.1 The collected air sample in sample bag should be deliveried to Odour Research Centre of THEi and the odour concentration is determined by a Dynamic Olfactometer (TO9) in accordance with the European Standard Method (EN13725).

4.2.2 This European Standard specifies a method for the objective determination of the odour concentration of a gaseous sample using dynamic olfactometry with human assessors and the emission rate of odours emanating from point sources, area sources with outward flow and area sources without outward flow. The primary application is to provide a common basis for evaluation of odour emissions in the member states of the European Union.

4.2.3 This European Standard is applicable to the measurement of odour concentration of pure substances, defined mixtures and undefined mixtures of gaseous odorants in air or nitrogen, using dynamic olfactometry with a panel of human assessors being the sensor. The unit of measurement is the European odour unit per cubic metre: OU_E/m^3. The odour concentration is measured by determining the dilution factor required to reach the detection threshold. The odour concentration at the detection threshold is by definition 1 OU_E/m^3. The odour concentration is then expressed in terms of multiples of the detection threshold. The range of measurement is typically from 2^2 OU_E/m^3 to 2^{17} OU_E/m^3 (excluding pre-dilution).



Olfactometer TO9

4.3. Determination of Specific Odour Emission Rate

A dynamic flux hood system was employed in this sampling work to collect odour samples from water surface, in which an odour-free gas from a nitrogen gas cylinder was supplied to generate a known air inflow at a fixed flow rate of 5 L/min inside the hood. The specific odour emission rates (SOER) at the area source can be calculated by the following equation:

$$\text{SOER } (OU_E/m^2/s) = \frac{\text{Odour concentration } (OU_E/m^3) \times \text{Air flow rate inside hood } (m^3/s)}{\text{Covered water surface area } (m^2)}$$

Where air flow rate inside hood = 5.0 (L/min) x 10^{-3} / 60 = 8.33 x 10^{-5} (m^3/s), and covered surface area = 0.2 (m) x 0.2 (m) x 3.14 = 0.126 m^2.

4.4. Quality Control (QA/QC)

During each odour sampling day, one blank sample by purging odour-free nitrogen gas from the certified gas cylinder shall be prepared for a purpose of QA/QC.

4.5. On-site H_2S measurements

The concentration of H_2S is detected on site using Jerome J605 Hydrogen Sulfide Analyzer. The concentration unit is ppb. The detection limit is 3 ppb.

Jerome J605 Hydrogen Sulfide Analyzer

4.6. Quality Assurance

4.6.1. The odour laboratory shall be ventilated to maintain an odour-free environment and to provide fresh air to the panel members.

4.6.2. Each odour testing session shall comprise of at lease five qualified panellists. All of the panellists shall be screened beforehand by using a certified n-butanol standard gas. The qualified panellists should have their individual thresholds of n-butanol in the range of 20-80 ppb/v to comply with the requirement of EN13725. The certificates for the qualified odour panel members are provided in Appendix D.

4.6.3. Panel members must not eat or smoke for one hour prior to the testing session. Panel members should not use perfumes, shave lotions or any other fragment essences before the session. Panel member should not attend a session if he/she has a cold, influenza or any other health problems which will affect his/her nose.

4.6.4. Eating, drinking or smoking is not permitted while a session is in progress. The exception is during the mid-session break when water can be taken. If a lunch break is taken, food can also be eaten at one hour before the session. Smoking is not permitted during any breaks.

4.6.5. Each odour testing session should not last for more than 4 hours, in which at lease two breaks (ten minutes each) for olfactometry test shall be taken.

4.6.6. Exposure to direct sunlight shall be avoided for the samples. If any condensate is observed on the inner surface of the air bag, the sample should be discarded.

4.6.7. After sampling, the odour samples should be delivered to an odour laboratory as soon as possible and the odour samples shall be analysed within 24 hours.

4.6.8. Regular calibrations of the olfactometer should be performed to check the accuracy and repeatability of its dilution settings and to establish its calibration history. The calibration should be regularly performed using sulfur hexafluoride as a tracer gas and a sulfur hexafluoride monitor. The procedure of dynamic olfactometry used at THEi is shown in Appendix C.

5. Odour Sampling and Olfactometry Measurement

5.1. Sampling Activities

5.1.1 Two sampling events were conducted at identified odour source of sixteen locations respectively on 25 and 29 August 2016 with daytime's temperature measures greater than 30°C (during sampling period) at site. The sampling locations are shown in Table 1 and Appendix A.

5.1.2 On the effluent surface / screens surface / sludge surface of the different facilities at fourteen locations, the duplicate odour samples were taken from the surface using the Flux Hood, where a stream of odour-free nitrogen gas from a certified gas cylinder is supplied into the Flux Hood to simulate parallel winds blowing on the main section of sampling hood at a fixed flow rate of 5 L/min and the outlet gas from the Flux Hood was taken as odour samples.

5.1.3 At the two locations of site boundary, the ambient air was collected as odour samples.

5.1.4 During the sampling period, the concentration of H_2S was detected on site at sixteen locations using Jerome J605 Hydrogen Sulfide Analyzer.

5.1.5 During the odour sampling, relevant weather conditions including ambient temperature, relative humidity, wind speed, and wind direction were recorded on the sites for references. The data are shown in Table 1. The operation status of different unit/tanks at YLSTW during sampling period are referred to Appendix B.

5.1.6 In every sampling day, one blank sample by purging odour-free nitrogen gas from the certified gas cylinder was also prepared for a purpose of QA/QC.

5.1.7 A total of sixty-two gas samples on 25 and 29 August 2016 were collected and immediately transported to the Odour Research Centre of THEi after the sampling.

5.2. Olfactometry Analysis

Olfactometry analysis was conducted within 24 hours after the sampling work using a dynamic olfactometer in accordance with the European Standard Method (EN13725). Five qualified panellists participated in the odour testing session, who were previously selected through a set of screening tests using a certified n-butanol gas (60 ppm/v) as a standard reference.

5.3. Determination of Specific Odour Emission Rate

From the odour concentrations determined by olfactometry, the specific odour emission rates (SOER) at fourteen sampling locations (S1 – S14) were calculated by the following equation and the final results are shown in Table 1:

$$\text{SOER } (OU_E/m^2/s) = \frac{\text{Odour concentration } (OU_E/m^3) \text{ x Air flow rate inside hood } (m^3/s)}{\text{Covered water surface area } (m^2)}$$

Where air flow rate inside hood = 5.0 (L/min) x 10^{-3} / 60 = 8.33 x 10^{-5} (m^3/s), and covered surface area = 0.2 (m) x 0.2 (m) x 3.14 = 0.126 m^2.

5.4. Survey Results

Summary of sampling condition and results for odour sampling and olfactometry measurement are shown in Table 1.

Table 1. Summary of sampling condition and results for odour survey

Event 1											
Sample ID	Sampling Location	Date	Time	Sampling Method	Ambient Temp. ^{0}C	Humidity %	Wind Direction	Wind Speed m/s	H_2S (ppb) On Site	OC OU_E/m^3	SOER $OU_E/m^2.s$
S15A-1	Sampling at Site Boundary at Downwind Direction	25-8-2016	9:00	A	30.4	70.5	SE	0.2	< 3.00	10.6	
S15A-2			9:05	A					< 3.00	8.3	
S5A-1	Final Sedimentation Tank	25-8-2016	9:20	FH	31.0	69.2	SE	0.6	< 3.00	44.2	0.0292
S5A-2			9:30	FH					< 3.00	51.0	0.0337
S4-1	Aeration Tank Surface	25-8-2016	9:50	FH	32.3	68.4	SE	0.8	< 3.00	620	0.410
S4-2			10:00	FH					< 3.00	539	0.356
S14-1	Fine Screens Screening	25-8-2016	10:20	FH	33.1	67.9	SE	0.1	< 3.00	179	0.118
S14-2			10:31	FH					< 3.00	181	0.120
S11-1	Screening Press House for Coarse Screens	25-8-2016	10:40	FH	33.8	67.5	SE	0.2	3.20	74.5	0.0493
S11-2			10:50	FH					< 3.00	84.6	0.0559
S9-1	Dewatered Sludge Skip at Sludge Deratering House	25-8-2016	11:04	FH	34.5	66.8	SE	0.1	< 3.00	96.0	0.0635
S9-2			11:13	FH					< 3.00	109	0.0721
S8-1	Sludge Holding Tank	25-8-2016	11:34	FH	34.9	66.3	SE	0.5	< 3.00	181	0.120
S8-2			11:44	FH					< 3.00	207	0.137
S7-1	S.A.S Thickener House	25-8-2016	12:50	FH	35.6	65.7	SE	0.1	4.15	1454	0.961
S7-2			13:00	FH					3.87	1261	0.834
S6-1	Consolidation Tank	25-8-2016	13:27	FH	36.2	64.6	SE	0.3	< 3.00	65.7	0.0434
S6-2			13:36	FH					< 3.00	74.5	0.0493
S12-1	Primary Sludge Distribution Chamber/Measurement Chamber	25-8-2016	13:40	FH	36.7	64.2	E	0.4	199	1880	1.24
S12-2			13:50	FH					148	1653	1.09
S10-1	Return Activated Sludge Screw Pump Pumping Station	25-8-2016	14:09	FH	36.9	64.0	E	0.7	< 3.00	235	0.155
S10-2			14:18	FH					< 3.00	205	0.136
S13-1	Settlted Sewage Overflow Chamber (SOC)	25-8-2016	14:22	FH	37.1	63.6	E	0.6	180	2138	1.41
S13-2			14:32	FH					182	2484	1.64

S3-1	Primary Sedimentation Tank Surface	25-8-2016	14:45	FH	36.5	64.5	E	1.2	9.68	269	0.178
S3-2			14:55	FH					10.1	297	0.196
S1-1	Screw Pump Pumping Station	25-8-2016	15:05	FH	36.0	64.9	E	0.2	294	6691	4.42
S1-2			15:14	FH					286	5969	3.95
S2-1	Screening Skips at Inlet Works	25-8-2016	15:30	FH	35.7	65.6	E	0.6	35.7	10565	6.98
S2-2			15:40	FH					30.2	9425	6.23
QA/QC		25-8-2016	15:50							< 4.0	

Event 2

Sample ID	Sampling Location	Date	Time	Sampling Method	Ambient Temp. ^{0}C	Humidity %	Wind Direction	Wind Speed m/s	H_2S (ppb) On Site	OC OU_E/m^3	SOER $OU_E/m^2.s$
S15B-1	Sampling at Site Boundary at Downwind Direction	29-8-2016	8:50	A	30.2	72.8	NE	0.6	3.51	18.6	
S15B-2			8:55	A					3.03	16.1	
S5B-1	Final Sedimentation Tank	29-8-2016	9:05	FH	30.3	72.5	NE	0.7	< 3.00	38.3	0.0253
S5B-2			9:15	FH					< 3.00	33.3	0.0220
S4-1	Aeration Tank Surface	29-8-2016	9:23	FH	30.3	72.6	NE	0.9	< 3.00	467	0.309
S4-2			9:33	FH					< 3.00	537	0.355
S14-1	Fine Screens Screening	29-8-2016	9:43	FH	30.4	72.4	NE	0.2	< 3.00	205	0.136
S14-2			9:52	FH					< 3.00	235	0.155
S11-1	Screening Press House for Coarse Screens	29-8-2016	10:01	FH	30.5	72.2	NE	0.1	< 3.00	65.7	0.0434
S11-2			10:10	FH					< 3.00	57.9	0.0383
S9-1	Dewatered Sludge Skip at Sludge Deratering House	29-8-2016	10:20	FH	30.4	72.3	NE	0.1	< 3.00	84.6	0.0559
S9-2			10:29	FH					< 3.00	96.0	0.0635
S8-1	Sludge Holding Tank	29-8-2016	10:50	FH	30.4	72.2	NE	1.3	< 3.00	179	0.118
S8-2			11:00	FH					< 3.00	158	0.104
S7-1	S.A.S Thickener House	29-8-2016	11:30	FH	30.6	72.0	NE	0.1	4.59	1618	1.07
S7-2			11:40	FH					5.30	1801	1.19
S6-1	Consolidation Tank	29-8-2016	13:06	FH	30.7	71.8	NE	0.3	< 3.00	70.0	0.0463
S6-2			13:15	FH					< 3.00	63.0	0.0417
S12-1	Primary Sludge Distribution Chamber/Measurement Chamber	29-8-2016	13:31	FH	30.7	71.7	NE	0.6	150	1618	1.07
S12-2			13:40	FH					144	1454	0.961

S10-1	Return Activated Sludge Screw Pump Pumping Station	29-8-2016	13:55	FH	30.8	71.4	NE	1.0	< 3.00	161	0.106
S10-2			14:05	FH					< 3.00	179	0.118
S13-1	Settlted Sewage Overflow Chamber (SOC)	29-8-2016	14:17	FH	30.6	71.5	NE	0.7	142	1653	1.09
S13-2			14:27	FH					106	1801	1.19
S3-1	Primary Sedimentation Tank Surface	29-8-2016	14:40	FH	30.7	71.5	NE	1.4	6.36	224	0.148
S3-2			14:50	FH					5.92	200	0.132
S1-1	Screw Pump Pumping Station	29-8-2016	15:02	FH	30.5	72.0	NE	0.2	261	4774	3.16
S1-2			15:12	FH					270	5325	3.52
S2-1	Screening Skips at Inlet Works	29-8-2016	15:27	FH	30.5	72.1	NE	0.8	23.6	8408	5.56
S2-2			15:37	FH					27.4	9212	6.09
QA/QC		29-8-2016	15:45							< 4.0	

Remark: A: Ambient sampling; FH: Flux hood method; OC: Odour concentration; SOER: Specific odour emission rate;

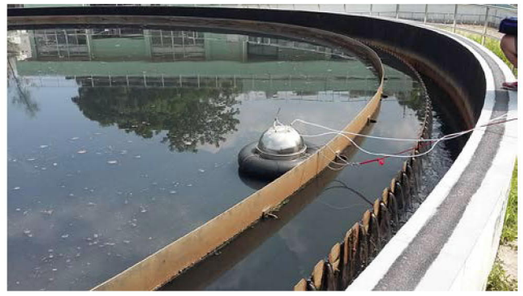
5.5. Site Observation and Site Photos

In the fourteen facilities of odour sources for sampling location, the operation all were in progress during the sampling. The odour smell were come from the effluent surface / screens surface / sludge surface of the different facilities. No any other odour sources were found. At the location S12 (Primary Sludge Distribution Chamber/Measurement Chamber), some foam floated at the surface of wastewater. At the location S15 (Sampling at Site Boundary at Downwind Direction), the odour smell was come from the facilities of YLSTW.

During the sampling, relevant photos were taken at the all sampling locations and are shown below:

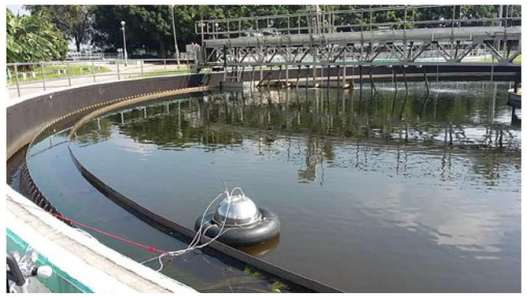
S1 - Screw Pump Pumping Station

S2 - Screening Skips at Inlet Works

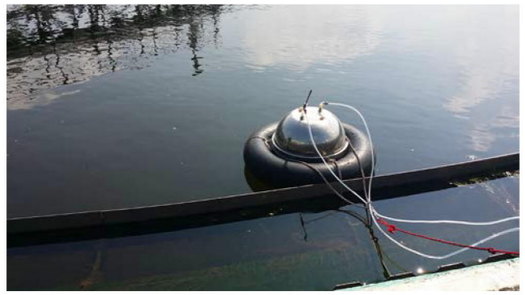


S3 - Primary Sedimentation Tank Surface

S4 - Aeration Tank Surface



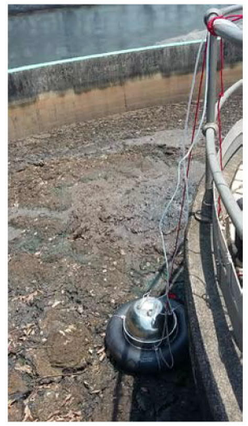
S5A - Final Sedimentation Tank



S5B - Final Sedimentation Tank

S6 - Consolidation Tank

S7 - S.A.S Thickener House



S8 - Sludge Holding Tank

S9 - Dewatered Sludge Skip at Sludge Deratering House

S10 - Return Activated Sludge Screw Pump Pumping Station

S11 - Screening Press House for Coarse Screens

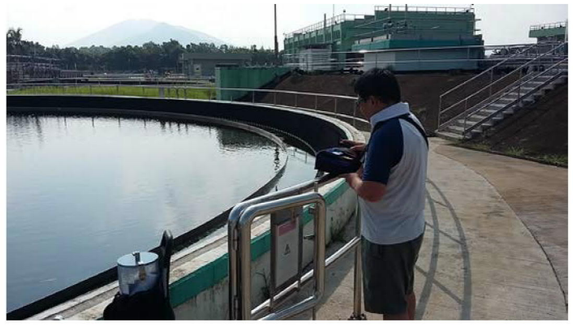
S12 - Primary Sludge Distribution Chamber/Measurement Chamber

S13 - Settlted Sewage Overflow Chamber (SOC)

S14 - Fine Screens Screening

S15A - Sampling at Site Boundary at Downwind Direction

S15B - Sampling at Site Boundary at Downwind Direction



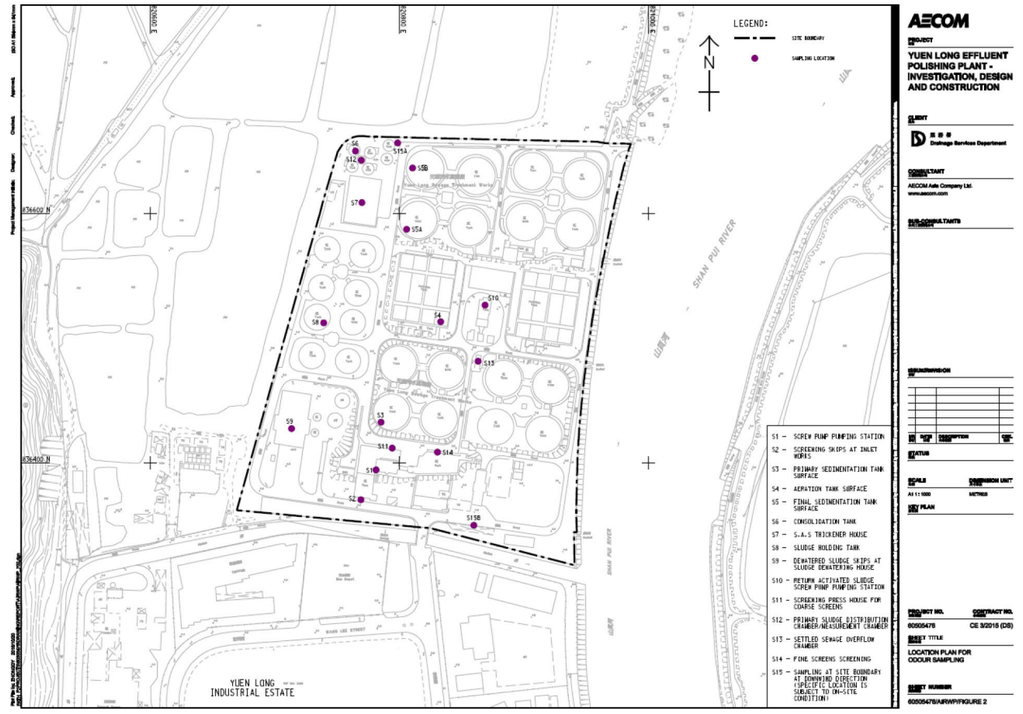
H_2S Measurement

Prepared by:

KH NG Signed:

Odour Research Centre at THEi

Appendix A: Location of odour sampling at odourous source at YLSTW



Appendix B: Operation status at YLSTW during sampling period

Sample ID	Sampling Location	Date	Time	Sewage/Sludge Temperature (°C)	Flow Speed (m/s)	Capacity of the units/ tanks during sampling (m^3)	Operation status of the units/ tanks (Operation, Standby, etc.)
S15A-1	Sampling at Site Boundary at Downwind Direction	25-8-2016	9:00	N.A	N.A	N.A	N.A
S15A-2			9:05	N.A	N.A	N.A	N.A
S5A-1	Final Sedimentation Tank No.1	25-8-2016	9:20	N/A	N/A	2200	In operation
S5A-2			9:30	N/A	N/A	2200	In operation
S4-1	Aeration Tank No. 4	25-8-2016	9:50	23.4	0.3	2970	In operation
S4-2			10:00	23.4	0.3	2970	In operation
S14-1	Fine Screens Screening	25-8-2016	10:20	N.A	N.A	N.A	In operation
S14-2			10:31	N.A	N.A	N.A	In operation
S11-1	Screening Press House for Coarse Screens	25-8-2016	10:40	N.A	N.A	N.A	In operation
S11-2			10:50	N.A	N.A	N.A	In operation
S9-1	Dewatered Sludge Skip at Sludge Deratering House	25-8-2016	11:04	N.A	N.A	N.A	In operation
S9-2			11:13	N.A	N.A	N.A	In operation
S8-1	Sludge Holding Tank No.3	25-8-2016	11:34	N/A	N/A	2550	In operation
S8-2			11:44	N/A	N/A	2550	In operation
S7-1	S.A.S Thickener House	25-8-2016	12:50	N.A	N.A	N.A	In operation
S7-2			13:00	N.A	N.A	N.A	In operation
S6-1	Consolidation Tank No. 2	25-8-2016	13:27	N/A	N/A	180	In operation
S6-2			13:36	N/A	N/A	180	In operation
S12-1	Primary Sludge Distribution Chamber/Measurement Chamber	25-8-2016	13:40	N.A	N.A	N.A	In operation
S12-2			13:50	N.A	N.A	N.A	In operation
S10-1	Return Activated Sludge Screw Pump Pumping Station	25-8-2016	14:09	N/A	0.3	N.A	In operation
S10-2			14:18	N/A	0.3	N.A	In operation
S13-1	SettIted Sewage Overflow Chamber (SOC)	25-8-2016	14:22	N.A	N.A	N.A	In operation
S13-2			14:32	N.A	N.A	N.A	In operation
S3-1	Primary Sedimentation Tank No. 1	25-8-2016	14:45	N/A	0.09	1650	In operation
S3-2			14:55	N/A	0.09	1650	In operation
S1-1	Screw Pump Pumping Station	25-8-2016	15:05	N/A	0.41	N.A	In operation
S1-2			15:14	N/A	0.48	N.A	In operation
S2-1	Screening Skips at Inlet Works	25-8-2016	15:30	N/A	N/A	N.A	In operation
S2-2			15:40	N/A	N/A	N.A	In operation
S15B-1	Sampling at Site Boundary at Downwind Direction	29-8-2016	8:50	N.A	N.A	N.A	N.A
S15B-2			8:55	N.A	N.A	N.A	N.A
S5B-1	Final Sedimentation Tank No.2	29-8-2016	9:05	N/A	N/A	2200	In operation
S5B-2			9:15	N/A	N/A	2200	In operation
S4-1	Aeration Tank No. 4	29-8-2016	9:23	30	0.3	2970	In operation
S4-2			9:33	30	0.3	2970	In operation
S14-1	Fine Screens Screening	29-8-2016	9:43	N.A	N.A	N.A	In operation
S14-2			9:52	N.A	N.A	N.A	In operation
S11-1	Screening Press House for Coarse Screens	29-8-2016	10:01	N.A	N.A	N.A	In operation
S11-2			10:10	N.A	N.A	N.A	In operation
S9-1	Dewatered Sludge Skip at Sludge Deratering House	29-8-2016	10:20	N.A	N.A	N.A	In operation
S9-2			10:29	N.A	N.A	N.A	In operation
S8-1	Sludge Holding Tank No.3	29-8-2016	10:50	N/A	N/A	2550	In operation
S8-2			11:00	N/A	N/A	2550	In operation
S7-1	S.A.S Thickener House	29-8-2016	11:30	N.A	N.A	N.A	In operation
S7-2			11:40	N.A	N.A	N.A	In operation
S6-1	Consolidation Tank No. 2	29-8-2016	13:06	N/A	N/A	180	In operation
S6-2			13:15	N/A	N/A	180	In operation
S12-1	Primary Sludge Distribution Chamber/Measurement Chamber	29-8-2016	13:31	N.A	N.A	N.A	In operation
S12-2			13:40	N.A	N.A	N.A	In operation
S10-1	Return Activated Sludge Screw Pump Pumping Station	29-8-2016	13:55	N/A	0.36	N.A	In operation
S10-2			14:05	N/A	0.36	N.A	In operation
S13-1	SettIted Sewage Overflow Chamber (SOC)	29-8-2016	14:17	N.A	N.A	N.A	In operation
S13-2			14:27	N.A	N.A	N.A	In operation
S3-1	Primary Sedimentation Tank No. 1	29-8-2016	14:40	N/A	0.09	1650	In operation
S3-2			14:50	N/A	0.09	1650	In operation
S1-1	Screw Pump Pumping Station	29-8-2016	15:02	N/A	0.23	N.A	In operation
S1-2			15:12	N/A	0.3	N.A	In operation
S2-1	Screening Skips at Inlet Works	29-8-2016	15:27	N/A	N/A	N.A	In operation
S2-2			15:37	N/A	N/A	N.A	In operation

Annex C: Procedure of Dynamic Olfactometry Used at THEi

1. Introduction

The method of odour measurement in our odour research centre follows the European Standard Method (EN13725). The scope of the method includes the measurements of odour concentration of pure substances, defined mixtures and undefined mixtures of gaseous odorants in air or nitrogen, using dynamic olfactometry with a panel of human assessors being the sensor. The unit of measurement is the odour unit per cubic meter (OU_E /m^3). The odour concentration is measured by determining the dilution factor required reaching the detection threshold. The odour concentration at the detection threshold is by definition 1 OU_E /m^3. The odour concentration is then expressed in terms of multiples of the detection threshold. The range of measurement is typically from 2^2 to 2^{17} OU_E /m^3 (excluding pre-dilution). The Dynamic Olfactometer (TO9) is a dilution apparatus designed to perform the odour threshold measurements. One measurement, using a panel of 4 - 8 persons, can be completed in less than ten minutes.

2. Principle of odour measurement

The odor concentration of a gaseous sample is measured by determining the dilution factor required reaching the detection threshold. The odor concentration at the detection threshold is by definition 1 OU_E/m^3, which has a probability of 50%, being detected under the conditions of the test. The odor concentration of the examined sample is then expressed in terms of multiples of one OU_E in a cubic of neutral gas at standard conditions. The range of measurement is typically from 2^2 to 2^{17} OU_E/m^3 (excluding pre-dilution).

The quality assurance for the performance of the analytical method as a whole and of equipment used to present the sample to the assessor is the core of the standard method. The principal indicators of data quality are its bias and precision, which when combined, express its accuracy which indicates the closeness of agreement between the test results and the accepted reference value. In addition, the instrumental calibration of olfactometers is done using a tracer gas (sulfur hexafluoride) at regular intervals and if the results of the calibration show that the instrument is not functioning within the requirements, technical intervention, such as maintenance or adjustment of settings may be required. The instability of dilutions produced by olfactometers is also determined. The calibration of the sensor of the sensory measurement, in this case the odor panel, is done on the basis of the reference odorant, n-butanol.

3. Odour measurement

3.1. Materials and apparatus

Olfactometer; Carbon filter, sulfur hexafluoride monitor; tubing for connecting gas cylinders, and vent lines; flow meter; Window 7 PC; Olfactometer Software, Odor free dry air; standard n-butanol gas (60 ppm); high purity nitrogen gas; standard sulfur hexafluoride gases in nitrogen (1000 ppm, 4 % and pure sulfur hexafluoride).

3.2. Procedure of odour measurement

a. *Procedure for operator*

1. Assign a number to each panelist, start from 1, 2 then 3 and so on;
2. Connect the sample bag into the olfactometer;
3. Start Olfactometer Software by double click on the corresponding icon;
4. Select measuring method of odour threshold;
5. Click on the “Start measurement” icon;
6. Select appropriate number of panelists as a team at olfactometer;
7. Select a start step;
8. Click on “OK” and measurement begins;
9. When the test is completed, print out the results and related information from Olfactometer Software.

b. Procedure for panelists

1. The panelists must take their places at the equipment;
2. When the initial signal lamps for inhalation illuminate-two circular LED’s for the panelists at the test positions, the sequence starts;
3. Press the key when the panelists perceive a positive odour impression;
4. By following odour impressions the panelists must press key again;
5. The panelists must not leave the equipment before the LED's are flickering;
6. The measurement is ended automatically as soon as all panelists have given a correct response to two successive dilution steps.

3.3. Flushing the olfactometer

After the completion of a testing run, the olfactometer should be flushed with clean air for a period in excess of required to purge all odorous air form the system of the olfactometer. Prior to the commencement of a run with an odour sample it is essential that the olfactometer is purged with the odour sample for a time sufficient to ensure that all odour free air, or any previous sample is completely purged form the olfactometer.

3.4. Measurement results

Here the value ZITE,pan is stated as a geometric mean of all the retrospective selections for valid panel member responses in a measurement. If the dilution value ZITE,pan is reduced back to the EROM value of 123µg/m^3, stated in EN 13725:2003, due to a reference substance measurement, then this dilution value can be stated on the odour threshold as OU_E/ m^3 (OU_E = European odour units). In the report the possible representation as per EN 13725:2003 is stated in brackets as a decimal figure after the code. Doing so is useful for an odour threshold = Cod, as the findings of a person are subject to a logarithmic scale on which the perceived effects are better represented. In the "Remarks" window a manual comment can be added to each measurement by the operator.

3.5. Presentation of results

The results should be presented on a sheet and an example calculation supplied. The results should be available for scrutiny and should include the number of panellists, their responses to each dilution for both the odour sample and the responses to the reference gas employed on that day.

4. Panel selection and control

4.1. Panel selection

In order to ensure repeatability of the sensor, composed of individual panel members, their olfactory sensitivity should be within a narrow bandwidth. To achieve this aim, assessors with a specific sensitivity to a reference odour are selected to be panel members. The screening is on reference material n-butanol with the concentration of 60 ppm in nitrogen (v/v).

At least 10 individual thresholds for the reference gas are collected for selection purposes. These data are collected in at least 3 sessions on separate days with a pause of at least one-day between sessions. To become a panel member, the data collected for that assessor must comply with certain criteria:

The geometric mean of the individual thresholds must fall between 20 and 80 ppb, when n-butanol standard gas is used.

A measuring history for each panel member is continuously recorded in following performance and compared with the selection criteria. If the panel member does not comply, he/she is excluded from all further measurements.

4.2. Panel control

Panellist must not eat or smoke for one hour prior to the session

Panellists should be in odour room 15 minutes before measurements.

Do not use perfumes, after shave lotions or any other fragrant essences before the session

Do not attend a session if you have a cold, influenza or any other health problem, which will affect your nose. If you don’t tell us, we will tell you that your performance is not satisfactory.

Eating, drinking or smoking is not permitted while a session is in progress. The exception is during the mid-session break when water can be taken. If a lunch break is taken food can also be eaten, one hour before the session. Smoking is **NOT** permitted during any break.

Panellists should not leave the room during a session, without the consent of the operator.

Panellists should never discuss their results with other panellists or comment on their perceptions of the odour run in progress. Remember, there is no right or wrong answer. You are not being judged.

Panellist will be expected to stay until the end of each session.

No panellist should be involved for more than 4 hours of odour testing. Within this period at least 2 ten minutes breaks for olfactory rest should occur.

The panel should be housed in an air-conditioned room that ensures it is odour free and comfortable. The flushing from the olfactometer should be exhausted from the room in which testing is being performed without contaminating the room air.

5. Quality requirement

To assess compliance with the overall quality criterion for accuracy of odour concentration measurements within one laboratory, a series of ten measurements should be carried out using 60 ppm n-butanol in nitrogen as a reference material in two days.

Geometric Repeatability $r' = e^{(t\, S_r\, \sqrt{2})} < 3$

Where t – *a factor from the Student's t-distribution for n-1 degrees of freedom with a confidence level of 95%*

s_r – standard deviation of odour measurement under constant conditions

The value of r' is the greatest ratio between two single measurement values obtained (with the same method, with an identical sample, under constant conditions as regards the laboratory, investigator and apparatus, and with a short interval of time) will, with a probability of 95%, be smaller than that value.

Geometric Reproducibility $R' = e^{(t\, S_R\, \sqrt{2})} < 4$

Where t – *a factor from the Student's t-distribution for n-1 degrees of freedom with a confidence level of 95%*

s_R – standard deviation of odour measurement under different conditions

The value of R' is the greatest ratio between two single measurement values obtained (with the same method, with an identical sample, under different conditions as regards the laboratory, investigator and apparatus, and with a short interval of time) will, with a probability of 95%, be smaller than that value.

This implies that two measurement values will differ from each other by no more than a factor of 3 and 4 respectively, with a probability of 95%.

6. Instrumental Calibration

The instrumental calibration of the olfactometer is required in EN13725. The objective of the calibration is to check the accuracy and repeatability of the dilution settings of the olfactometer at a regular interval (every year) and to establish a calibration history of the olfactometer. The calibration uses sulfur hexafluoride as a tracer gas and a sulfur hexafluoride monitor. The

accuracy and repeatability of the olfactometer are calculated from two sulfur hexafluoride concentrations: one measured at the sniffing port of the olfactometer and one with certified sulfur hexafluoride concentrations.

6.1. Procedure of olfactometer calibration

1. Activate the sampling system, measure and record the sulfur hexafluoride concentration of the room air in the laboratory;
2. Connect the sampling line to one port of the olfactometer;
3. Take a measure of reference air from the olfactometer. If this air contains over 1ppm sulfur hexafluoride, check for the cause before starting the calibration;
4. Continue with the calibration, taking five measurements for each dilution setting. Between measurements all controls of the instrument should be changed. Preferably use series of increasing concentration, as is done in normal olfactometry sessions. Mark exactly when the operator, or the control software, signals that the dilution that has been set is ready for "sniffing", this is the mark for the start of the calculation of results;
5. Check regularly the background concentrations in the neutral gas from the olfactometer and the room air;
6. Each measurement should provide about 12 individual readings. The time between subsequent readings should be a minimum of the lag-time of the calibration unit (about 5s);
7. The accuracy criterion requires that the averaged sulfur hexafluoride concentration measured at the sniffing port is within 20% of the expected sulfur hexafluoride value for each dilution setting. The repeatability criterion requires that the deviation of the measured sulfur hexafluoride concentration must be less than 5 % in any dilution setting with a probability of 95%;
8. Spot checks of the dilution produced in the different ports of a single diluting channel multi-port machine should be made to ensure that no systematic differences occur between the ports. Multiple diluting channel machines must have each channel and each dilution individually measured;
9. Take notes of all observations that may in any way be relevant;
10. Ensure safe storage of all data;
11. After completing measurements, check the neural gas from the olfactometer and the room air. If sulfur hexafluoride concentrations are higher than 1ppm, check the zero of the calibration unit using zero gas. If the zero has not drifted, check for any recycling of vented sulfur hexafluoride mixture back through the compressor or air conditioning unit.

6.2. Instrumental quality requirement

The accuracy criterion requires that the averaged sulfur hexafluoride concentration measured at the sniffing port is within 20% of the designed sulfur hexafluoride value for each dilution setting. The repeatability criterion requires that the deviation of the measured SF_6 concentration must be less than 5% in any dilution setting with a probability of 95%. One set of recent calibration data are presented in the following table.

Data of olfactometer calibration on 29 July 2016

Date: 29 July 2016

Settings	15	14	13	12	11	10	9 (39150 ppm)	9 (1025 ppm)	8 (39150 ppm)	8 (1025 ppm)	7	6	5	4	3	2	1
Dilution Factor	137852.1	34493.4	17231.5	8615.8	4308.4	2154.2	1081.5	971.6	536.4	490.0	244.0	122.0	61.0	30.5	15.2	7.6	3.8
	137900.7	34466.1	17233.8	8617.7	4307.9	2155.6	1081.3	968.8	536.9	490.4	243.7	121.9	61.0	30.5	15.2	7.6	3.8
	137852.1	34469.1	17239.1	8615.8	4308.4	2154.4	1080.7	974.3	536.9	491.1	243.1	121.9	61.0	30.5	15.2	7.6	3.8
	137852.1	34432.7	17233.0	8613.9	4306.9	2154.2	1080.4	969.7	536.0	491.6	243.2	121.9	61.0	30.5	15.2	7.6	3.8
	137852.1	34469.1	17239.1	8617.7	4308.4	2155.1	1080.9	968.8	535.8	490.9	244.0	121.9	61.0	30.5	15.2	7.6	3.8
	137852.1	34466.1	17233.8	8615.8	4308.8	2155.1	1081.0	972.5	536.0	490.2	244.2	122.0	61.0	30.5	15.2	7.6	3.8
	137852.1	34432.7	17234.5	8617.7	4312.1	2154.2	1081.5	969.7	536.2	489.3	244.4	122.0	61.0	30.5	15.2	7.6	3.8
	137949.3	34466.1	17223.9	8617.7	4309.3	2153.7	1082.5	973.4	536.4	489.5	244.6	122.0	61.0	30.5	15.2	7.6	3.8
	137900.7	34466.1	17233.0	8615.8	4308.4	2153.9	1081.7	974.3	537.0	488.3	244.9	122.1	61.0	30.5	15.2	7.6	3.8
	137900.7	34493.4	17233.8	8617.7	4306.0	2157.5	1081.7	970.6	536.7	489.7	244.7	122.1	61.0	30.5	15.2	7.6	3.8
	137852.1	34466.1	17239.1	8613.9	4307.9	2154.2	1081.6	971.6	536.4	490.0	244.5	122.1	61.0	30.5	15.2	7.6	3.8
	137852.1	34469.1	17233.0	8619.6	4308.4	2154.7	1081.5	972.5	536.4	490.0	244.2	122.1	61.0	30.5	15.2	7.6	3.8
	137852.1	34493.4	17233.8	8617.7	4312.6	2154.2	1081.3	970.6	535.9	487.6	244.0	122.1	61.0	30.5	15.2	7.6	3.8
	137900.7	34469.1	17223.9	8617.7	4307.4	2154.9	1080.9	971.6	535.7	490.4	243.9	122.0	61.0	30.5	15.2	7.6	3.8
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	137852.1	34432.7	17233.8	8617.7	4308.8	2154.2	1081.5	970.6	536.3	491.6	243.2	121.9	61.0	30.5	15.2	7.6	3.8
	137852.1	34469.1	17223.9	8615.8	4311.7	2154.1	1081.6	972.5	536.4	490.9	243.8	122.0	61.0	30.5	15.2	7.6	3.8
	137900.7	34493.4	17233.0	8617.7	4308.4	2153.7	1082.2	971.6	536.4	486.2	244.0	122.0	61.0	30.5	15.2	7.6	3.8
	137852.1	34469.1	17239.1	8619.6	4306.9	2154.4	1081.7	974.3	536.5	490.0	243.9	122.0	61.0	30.5	15.2	7.6	3.8
	137852.1	34466.1	17233.8	8617.7	4308.4	2153.7	1081.6	971.6	536.6	490.0	244.0	122.0	61.0	30.5	15.2	7.6	3.8
Average	137869.1	34467.4	17233.2	8617.2	4308.7	2154.4	1081.4	971.8	536.3	489.9	244.0	122.0	61.0	30.5	15.2	7.6	3.8
Standard Deviation (STDEV)	28.5	18.3	4.62	1.83	1.69	0.93	0.49	1.78	0.36	1.32	0.48	0.069	0.026	0.0066	0.0012	0.0004	0.0001
Instability (%)	0.04	0.104	0.053	0.042	0.077	0.085	0.089	0.36	0.131	0.528	0.39	0.111	0.084	0.042	0.015	0.011	0.005
Coefficient of Variation (%)							10.7		9.0								
Average for Coefficient of Variation (%)							9.9		9.9								
Average for Coefficient of Variation (%) / 2							4.93		4.93								
Adjusted Dilution Factor	131072.2	32768.2	16383.6	8192.4	4096.2	2048.2	1028.1	1019.7	509.9	514.1	256.0	128.0	64.0	32.0	16.0	8.0	4.0
Dilution Step	131072	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4		

Appendix D: Certificates for the qualified odour panel members

Certificate for a Qualified Odour Panel Member

Odour Research Centre
The Technological and Higher Education Institute
of Hong Kong (Member of VTC Group)
THEi Building, 20A Tsing Yi Road, Tsing Yi Island,
Hong Kong
Tel: (852) 2176 1836 / 9133 7248
Fax: (852) 2176 1419

17 June 2016

Re: A Certificate for a Qualified Odour Panel Member

This is to certify that Mr. Rex Li participated in a set of n-butanol screening tests in our centre between 13 June 2016 –17 June 2016 and his odour threshold of n-butanol in nitrogen gas was found to be in the range of 20 – 80 ppb/v and a standard deviation of R < 2.3. According to the requirement of the European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725), he is qualified to participate olfactometry analysis to determine odour concentration.

Yours sincerely

K. H. Ng
Odour Research Centre at THEi

THEi *K.H. Ng*

Certificate for a Qualified Odour Panel Member

Odour Research Centre
The Technological and Higher Education Institute
of Hong Kong (Member of VTC Group)
THEi Building, 20A Tsing Yi Road, Tsing Yi Island,
Hong Kong
Tel: (852) 2176 1836 / 9133 7248
Fax: (852) 2176 1419

17 June 2016

Re: A Certificate for a Qualified Odour Panel Member

This is to certify that Miss. Ashley Zhu participated in a set of n-butanol screening tests in our centre between 13 June 2016 –17 June 2016 and her odour threshold of n-butanol in nitrogen gas was found to be in the range of 20 – 80 ppb/v and a standard deviation of R < 2.3. According to the requirement of the European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725), she is qualified to participate olfactometry analysis to determine odour concentration.

Yours sincerely

K. H. Ng
Odour Research Centre at THEi

Certificate for a Qualified Odour Panel Member

Odour Research Centre
The Technological and Higher Education Institute
of Hong Kong (Member of VTC Group)
THEi Building, 20A Tsing Yi Road, Tsing Yi Island,
Hong Kong
Tel: (852) 2176 1836 / 9133 7248
Fax: (852) 2176 1419

17 June 2016

Re: A Certificate for a Qualified Odour Panel Member

This is to certify that Mr. Harry Ho participated in a set of n-butanol screening tests in our centre between 13 June 2016 –17 June 2016 and his odour threshold of n-butanol in nitrogen gas was found to be in the range of 20 – 80 ppb/v and a standard deviation of R < 2.3. According to the requirement of the European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725), he is qualified to participate olfactometry analysis to determine odour concentration.

Yours sincerely

K. H. Ng
Odour Research Centre at THEi

Certificate for a Qualified Odour Panel Member

Odour Research Centre
The Technological and Higher Education Institute
of Hong Kong (Member of VTC Group)
THEi Building, 20A Tsing Yi Road, Tsing Yi Island,
Hong Kong
Tel: (852) 2176 1836 / 9133 7248
Fax: (852) 2176 1419

17 June 2016

Re: A Certificate for a Qualified Odour Panel Member

This is to certify that Miss. Venus Choi participated in a set of n-butanol screening tests in our centre between 13 June 2016 –17 June 2016 and her odour threshold of n-butanol in nitrogen gas was found to be in the range of 20 – 80 ppb/v and a standard deviation of R < 2.3. According to the requirement of the European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725), she is qualified to participate olfactometry analysis to determine odour concentration.

Yours sincerely

K. H. Ng
Odour Research Centre at THEi

Certificate for a Qualified Odour Panel Member

Odour Research Centre
The Technological and Higher Education Institute
of Hong Kong (Member of VTC Group)
THEi Building, 20A Tsing Yi Road, Tsing Yi Island,
Hong Kong
Tel: (852) 2176 1836 / 9133 7248
Fax: (852) 2176 1419

17 June 2016

Re: A Certificate for a Qualified Odour Panel Member

This is to certify that Mr. Samuel Chow participated in a set of n-butanol screening tests in our centre between 13 June 2016 –17 June 2016 and his odour threshold of n-butanol in nitrogen gas was found to be in the range of 20 – 80 ppb/v and a standard deviation of R < 2.3. According to the requirement of the European Standard Method of Air Quality – Determination of Odour Concentration by Dynamic Olfactometry (EN13725), he is qualified to participate olfactometry analysis to determine odour concentration.

Yours sincerely

K. H. Ng
Odour Research Centre at THEi

THEi *K.H. Ng*

Odour Research Centre at THEi *30 – 30* *K. H. Ng*