

Report

Quantem (Terminals Pty Ltd)

Air Quality Impact Assessment Report

45 Friendship Road, Port Botany NSW 2036

8 November 2021

Environment, Health & Safety, and Sustainability Consultants

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Distribution Record:

Recipient	Date Issued	Number of Copies	Revision
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Peter J Ramsay & Associates Internal Copy			

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USE OF REPORT

The preparation of this report has been undertaken for the purpose of providing the results of a Level 1 Air Quality Impact Assessment of the emissions from the proposed thermal oxidiser for the bulk liquid storage facility located at 45 Friendship Road, Port Botany NSW.

This report is prepared solely for the benefit of Terminals Pty Ltd (Quantem). This report is provided on the condition that it or any part of it, will not be made available to, or relied upon by any other party for any purpose except with the prior written consent of Peter J Ramsay & Associates Pty Ltd (which consent may or may not be given at its discretion). Peter J Ramsay & Associates Pty Ltd consents to Quantem making this report available to other parties for the purpose of showing the scope of, and the recommendations provided in, this report, however those third parties cannot rely on the contents of this report.

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LIMITATIONS

Peter J Ramsay & Associates Pty Ltd has undertaken this assessment in accordance with New South Wales Environmental Protection Authority Approved Method for the Modelling and Assessment of Air Pollutants in New South Wales. The nature of the assessment is influenced by factors such as professional judgement, emission factors from sources from the site and the reliability of the information relating to the site which was obtained by the methodology described in this report. Reasonable care has been taken to verify the accuracy of the data and information available to Peter J Ramsay & Associates Pty Ltd.

The findings presented in this report are based on the information available during this assessment and some of those findings could vary if the information upon which they are based is determined to be false, inaccurate, or incomplete. Peter J Ramsay & Associates Pty Ltd disclaims all liability to any person for events taking place after the time during which the assessment was undertaken.

LIST OF UNITS Adelaide, South Australia

°C	degrees Celsius
µg/m3	microgram per metre cubed
g/s	grams/second
m	Metres
m/s	metres per second
m^3/s	metres cubed per second
mg/m3	milligrams per metre cubed

1. INTRODUCTION

Peter J Ramsay & Associates (PJRA) was engaged on 6 November 2020 by Terminals Pty Ltd (Quantem) to conduct a Level 1 Air Quality Impact Assessment for the operation of a proposed thermal oxidiser at Quantem's Port Botany facility.

Quantem operates a bulk liquid storage facility at 45 Friendship Road, Port Botany NSW (the Site) and the predominant activity at the site is the storage of petroleum products, liquefied petroleum gas (LPG) and liquid chemicals. There is an existing oxidiser on the site and Quantem is proposing to install an additional oxidiser.

The proposed thermal oxidiser is a control device that will reduce the impact of air emissions from the operations at the Site. The existing oxidiser utilises natural gas to thermally combust (oxidise) volatile organic compounds (VOCs) that exist as a vapour within the airspace of tanks which must be vented during filling of tanks. There will be minor residual emissions to air, and the oxidiser will unavoidably generate some combustion products, such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO) and particulate matter (PM).

The proposed oxidiser is to be utilised when the existing oxidiser at the area referred to as Site A within the Site is offline and also in conjunction with the existing oxidiser when peak loads are experienced at the facility. Quantem also proposes to use the new thermal oxidiser for disposal of liquid waste slops and as additional capacity for control of vapour emissions.

This assessment was undertaken to assess the predicted impacts on local air quality surrounding the site due to the changes in operation at the site. The report was updated to consider the impact under a realistic worst-case scenario, highest load possible to the existing and proposed combustors.

The Site is the subject of an Environment Protection Licence number 1048 (the EPL) issued by the NSW Environment Protection Authority (EPA). It is expected that the air emissions from TO-2 will be added to the discharge points listed on the EPL. The proposed maximum instantaneous emission limits are 20 mg/m^3 of total VOCs, 1 mg/m^3 of benzene, and 350 mg/m^3 of nitrogen dioxide. These equal the limits provided as standards of concentration for Group 6 equipment for afterburners, flares and vapour recovery units at scheduled premises, as per Schedule 2 of the *Protection of the Environment Operations (Clean Air) Regulations 2010*. The proposed licence limits are consistent with the concentration limits in the EPL for the discharge from the existing combustor.

2. METHODOLOGY

2.1 Objective

The objective is to assess the impact of emissions from the proposed thermal oxidiser, referred to in this report as TO-2. The cumulative impact of the emissions from this oxidiser is considered with the existing air emissions from the Site.

2.2 Destruction Efficiency of Proposed Oxidiser

The increase in emissions due to the proposed oxidiser are considered in relation to the load limits for the operations at the Site. The expected destruction efficiency is greater than 99.99% for the new thermal oxidiser, from CEC Engineering; the engineering consultant engaged by Quantem.

This is in accordance with the operation of the existing thermal oxidiser which was installed in 2013 and was reported to have a destruction efficiency of 99.998% during commissioning. The commissioning report is provided in **Appendix A**. The assessment is detailed in **Section 4.5.1**.

The emissions from the oxidiser have been calculated by CEC Engineering based on a worst case, maximum load to the oxidiser with the 99.99% destruction efficiency.

2.3 Sources of Emissions

There are three existing discharge points, DP4, DP7, and DP9. The impact of emissions on local air quality was assessed based on the maximum emission rate for the proposed oxidiser TO-2, simultaneously with all emissions at worst case from existing discharge points from the EPL.

The dispersion of these emissions was modelled to assess the maximum predicted ground level concentrations against relevant assessment criteria, at the Site Boundary and at the nearest residential receptors.

2.3.1 Existing Oxidiser (DP4) and Proposed Oxidiser (TO-2)

CEC Engineering provided calculations to assess the worst-case scenario, the instantaneous maximum load of VOC including benzene being sent to the existing and proposed oxidiser. This calculation is provided attached in **Appendix G**.

Licence limits are not provided for some combustion products, sulfur dioxide. particulate matter, and carbon monoxide. The emission rate for sulfur dioxide was calculated by CEC based on the sulfur content of material sent to the oxidiser. This emission rate has been adopted for the purpose of

assessing worst case emission. The emission rate of other combustion products is calculated on the expected emission rate based on the peak gas flow rate. These emission rates are calculated from emission factors published by the National Pollutant Inventory (NPI). The calculation of the maximum emission rates is discussed in **Section 4.5.2**.

2.3.2 The Bitumen Combustor (DP7)

A previous air quality assessment was performed for emissions from the Site. The report is *Botany PMB and CRMB Project Air Quality Assessment*, which was prepared by GHD and dated 14 October 2020 (**Appendix B**). Emissions described in this report are also included and modelled to make sure that they are considered in the cumulative impact.

2.3.3 Vapour Recovery Unit (DP9)

Emissions from the vapour recovery unit were considered based on the maximum operational rate, four trucks loading simultaneously each at the maximum rate of 2,200 litres per minute, with vapour discharge at the EPL limit of 10 mg per litre. As a worst case situation it was assumed that all trucks were filled with vapour from unleaded petrol (ULP). The benzene fraction of the vapour was estimated from the ratio of benzene to total VOCs in the *NPI EET Manual for Fuel and Organic Liquid Storage*, Version 3.3 dated May 2012. According to Figure F.1 in NSW benzene can be expected to account for 0.4% of total VOCs in vapour from ULP.

It was assumed that total VOC concentrations are at the EPL limit, 10 mg per litre.

2.4 Dispersion Modelling

The predicted ground level concentrations at and beyond the facility boundary were modelled in accordance with the Approved Methods for Modelling and Assessment of Air Pollutants (‘Approved Methods) with the exception that AERMOD was used instead of AUSPLUME. The NSW Environment Protection Authority was consulted regarding the choice of the dispersion model and the advice was that AERMOD can be used in place of AUSPLUME provided the use can be justified as the more appropriate selection.

The dispersion modelling has been used to identify the potential air quality impacts in the vicinity of the site with additional focus on the nearest residential locations. The predicted maximum concentrations from the dispersion modelling have been used to assess potential impacts. The maximum benzene concentrations were also assessed at the fence-line of the Site to assess potential for off-site impacts.

3. REGULATIONS AND GUIDELINES

3.1 Protection of the Environment Operations Act 1997

The Protection of the Environment Operations Act 1997 (POEO) is a key piece of the environment protection legislation in New South Wales (NSW), which is administered by the NSW Environmental Protection Authority (NSW EPA).

Within the POEO, air pollution is a term defined as the emission into the air of any air impurity. The POEO provides the statutory framework for managing air emissions in NSW and requires that all necessary practicable means are used to prevent or minimise air pollution (NSW EPA 2014). Also, in accordance with the POEO, EPA-licenced activities must not emit offensive odour. Further, there are general provisions that apply to all premises which make it an offence for any person to undertake an activity that emits air pollution (including offensive odour) if the emission is caused by a failure to maintain or operate plant, or deal with materials in a proper and efficient manner.

3.2 Approved Methods for the Modelling and Assessment of Air Pollutants

The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016) ('Approved Methods') lists the statutory methods for modelling and assessing emission of air pollutants from stationary sources. The Approved Methods was released by the New South Wales Environment Protection Authority through the Department of Environment and Conservation. As this is a regulatory document, all stationary sources in NSW must be evaluated in accordance with the methods and criteria set forth in the Approved Methods.

Impact assessment criteria for individual toxic and odorous air pollutants have been extracted from section 7.2 of the Approved Methods. The criteria shown are based on the breakdown of emission estimates from both oxidisers that have been provided to PJRA.

The principal toxic air pollutants are defined on the basis whether they are carcinogenic, mutagenic, teratogenic, highly toxic or highly persistent in the environment. Benzene is listed as a principal toxic air pollutant.

It is stated in the Approved Methods that principal toxic air pollutants must be minimised to the maximum extent achievable through the application of best-practice process design and/or emission controls. Decisions with respect to achievability will have regard to technical, logistical and financial considerations. The control of benzene in air emissions will not change as a result of the proposed changes. The use of thermal oxidation for destruction of benzene from air emissions achieves control to the maximum extent achievable.

3.2.1 Air Quality Impact Assessment

There are two levels of impact assessment outlined in the Approved Methods.

- Level 1 – screening-level dispersion modelling technique using worst case input data
- Level 2 – refined dispersion modelling technique using site specific input data

The impact assessment levels are designed so that the impact estimates from the second level should be more accurate than the first. This means that, for a given facility, the result of a Level 1 impact assessment would be more conservative and less specific than the result of a Level 2 assessment.

4. SITE DESCRIPTION AND OPERATIONS

4.1 Site Location and Surrounding Land Use

The site is located in Port Botany which is approximately 11 km south of the Sydney's CBD, as shown in **Figure F1**. The site forms part of the Port Botany industrial area and is surrounded by heavy industrial uses. The nearest residential areas are located approximately 1.4 km south east of the site.

4.2 Zoning

The site is predominantly zoned industrial for Major Development (MD).

4.3 Topography

The topography of the site and the surrounding area is essentially flat and is situated at sea level. The topography of the site was interpreted from the Shuttle Radar Topography Mission, 1-second data file.

4.4 Meteorology

Data were obtained from the Bureau of Meteorology station 066037 (Sydney Airport) as it was the weather station nearest to the site. In accordance with the Approved Methods, the data were for a single year with over 90% of complete data, which in this case was 2017. Dispersion modelling was performed using meteorological data from observations at Sydney Airport for the 2017 year. The 2017 year was selected as it provided the most complete data set from the five most recent years available.

Wind roses produced from the meteorological data indicate that the predominant winds in Botany Bay are typically from the north west, north east and south. During winter winds are generally come from the west while summer tends to bring winds from the north east and south. The annual wind rose is displayed in Figure 1. The report entitled *AERMOD ready Meteorological data files for Port Botany – NSW* is provided in **Appendix C** and also provides wind roses to show seasonal variation.

It is noted that the predominant winds directions observed in the meteorological data are from the south, northwest and northeast. This is consistent with the predominant wind directions observed in the data provided from 1997 which were used in the assessment attached in **Appendix B**. Historic wind roses for observations from the weather station operated by the Bureau of Meteorology at Sydney Airport from April 1939 to August 2020 are provided as **Appendix D**. The morning (9am) and afternoon (3pm) show the same pattern for predominant wind directions as is observed in the meteorology for 1997 and from 2017. The wind speeds and directions used in this modelling appear to be consistent with historic observations.

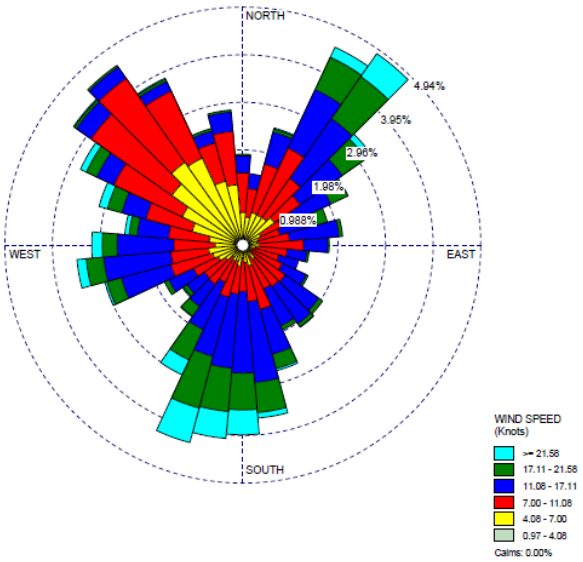


Figure 1 Wind Rose Plot

4.5 Description of Site Operations

The Site is operated under the Environment Protection Licence number 1048 (the EPL) issued by the New South Wales Environment Protection Authority (EPA). The operations at the Site typically involve the receival of product from seaborne tankers, bulk storage, and subsequent unloading to road tankers for distribution. However, some products including solvent mixtures of benzene, toluene and xylenes are received by road tanker for seaborne export. The Site is used for storage and distribution of hydrocarbon products.

Emissions from the operations at the Site result from storage in tanks and from truck loading. Emissions from the facility occur from the actions described. There are emissions from tank vents due to diurnal temperature changes from fixed roof tanks, referred as Standing Losses. There are emissions when vapour is displaced from the air in storage tank headspace during filling of a fixed roof vessel, referred to as Working Losses. There are also fugitive losses arising from leaks in the rim and deck of floating roof tanks. Truck loading generates vapour losses due to displacement of vapour from the headspace within the tanker trucks during filling.

There are three separate areas that constitute the Site as shown on **Figure F2**, attached. The three areas are located close to together but do not have a contiguous boundary. The three areas are referred to as Site A, Site B and Site C. Each section is used for the storage of different types of products. Site A is used for storage of bulk hydrocarbon chemicals, Site B is used for storage of bitumen and Site C is

used for storage of bulk fuels. All three areas of the Site are subject to the EPL and similar operations are performed at each of the areas of the Site.

To minimise the impact of residual emissions, the following control devices are in use at the Site:

- Site A
    - Thermal oxidiser which receives vapour from solvent tanks containing benzene, toluene, xylenes, and some other products such as methanol, ethanol; and
    - A carbon adsorption bed for handling truck loading and the remaining storage tank emissions.
- Site B
    - Bitumen combustor, a thermal oxidiser to treat vapours from storage and process vessels and for treatment of vapours from truck loading.
- Site C
    - Floating roof tanks are used for storage of unleaded petrol to eliminate Standing Losses; and
    - Vapour Recovery Unit (VRU) is used to capture emissions from truck loading.

A second thermal oxidiser is proposed to be installed at Site A to provide backup capacity for vapour control and for the disposal of liquid waste from the Site. It is used for control of emissions of chemicals such as, benzene, hexane, hexene and methanol.

The thermal oxidiser oxidises hydrocarbon chemicals, converting potentially harmful chemicals into carbon dioxide and water vapour. However, as the oxidation process involves combustion, there will be some generation of other combustion products such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), and particulate matter (PM).

The emissions from Site A which may contain benzene are treated by the existing thermal oxidiser. Therefore, there are no emissions of benzene from the carbon adsorption bed at Site A. There are some emissions of total VOCs from this location.

The carbon adsorption bed at Site A discharges from the Discharge Point (DP) which is described as DP2 on the EPL. The thermal oxidiser at Site A discharges emissions to air from DP4 as described in the EPL. The thermal oxidiser from Site B discharges from DP7 as described in the EPL. The VRU at Site C discharges emissions to air from DP9 as described in the EPL.

4.5.1 Site Emissions Limits

The operations at the site are undertaken in accordance with the EPL. The EPL provides a load limit for total emissions of benzene and total VOCs from the Site. These load limits are 3,000 kg of benzene and

25,000 kg of total VOCs per annum. Emissions are monitored and reported to EPA annually through the annual return. Emissions are also reported annually to the National Pollutant Inventory (NPI).

Emissions from the proposed thermal oxidiser will be counted in emissions from the site and will be included in the calculation of the load limit in the EPL and will be reported in emissions to the NPI.

It is estimated that an additional 360 tonnes of total VOCs will be added to the combined load of the existing and proposed thermal oxidisers at Site A. The expected destruction efficiency is for 99.99% removal of VOCs. Therefore, there is an expected increase of 36 kg per annum of total VOCs.

The liquid waste proposed to be sent to the new thermal oxidiser will not typically contain benzene. The benzene tanks do not collect slops for disposal.

The annual emissions for the most recent five years of operation are provided in **Table 1**. This shows that the addition of 70 kg of total VOCs emissions would not have had a material impact on the total emissions from the Site for the last five reporting periods.

The operation of the proposed thermal oxidiser will not result in a material increase in emissions of either benzene or total VOCs. Therefore, no change is proposed to the existing load limits in the EPL for the operation of the Site.

The only liquid containing any benzene that would be sent to the thermal oxidiser is liquid waste from the activated carbon beds, which would be collected during an upset condition during a shutdown of both thermal oxidisers and then fed of to the oxidisers once they are operational. For a conservative estimate of the maximum benzene emissions, this scenario has been included in the modelled benzene emissions from the new thermal oxidiser.

Table 1 Summary of last five years of emissions from Site

Year	Benzene	Total VOCs
Load Limit:	***3,000 kg***	***25,000 kg***
2015-16	9.4 kg	2,139 kg
2016-17	133.2 kg	4,327 kg
2017-18	7.8 kg	2,833 kg
2018-19	26.6 kg	15,751 kg
2019-20	26 kg	10,239 kg

4.5.2 Maximum Instantaneous Emissions

The EPL also contains emission limits for the maximum allowable concentrations that may be discharged from certain locations, referred to as discharge points (DPs) in the EPL. These are summarised in **Table 2**.

It is assumed that the proposed thermal oxidiser will be subject to the same concentration limits as the existing thermal oxidiser at Site A. To determine whether this could be expected to have an impact of the local air quality, an air quality impact assessment is provided in Section 5. This assessment assesses whether the maximum instantaneous discharge from the Site could adversely impact on local air quality.

Table 2 Summary of maximum emission concentrations from EPL

Discharge Point	Description	EPL Limits
DP2	Vent from the carbon adsorption bed in use at Site A	None
DP4	Discharge from the existing thermal oxidiser at Site A	350 mg/m^3 of NO_2 20 mg/m^3 of total VOC 1 mg/m^3 of benzene
DP7	Discharge from the bitumen plant combustor at the bitumen plant at Site B	350 mg/m^3 of NO_2 40 mg/m^3 of total VOC
DP9	Discharge from the vapour recovery unit at Site C	10 mg/L of total VOCs as n-propane*

* It is noted that a limit of 20 g/s is present in the current EPL. It is acknowledged that the lower limit described in note b) of licence condition L3.1 of the EPL should apply.

5. AIR QUALITY IMPACT ASSESSMENT

5.1 Previous Assessments

A previous air dispersion report was available regarding Quantem's facilities at Port Botany. The report was prepared by GHD and was titled *Report for Terminals Australia – Terminals Fuel Project 21/25548* (the GHD Report). An assessment of the cumulative impact of emissions assessed in the GHD Report in addition to the impacts modelled from the operation of the oxidisers is provided in Section 5.3.6.7 of this report.

An air quality impact assessment was performed for emissions from the bitumen plant combustor. This is *Botany PMB and CRMB Project Air Quality Assessment*, prepared by GHD dated 14 October 2020 (**Appendix B**).

The commissioning report for the thermal oxidiser at Site A (**Appendix A**) reported a destruction efficiency of 99.998%.

5.2 Sensitive Receptors

Sixteen sensitive receptors were taken into consideration in the modelling. These receptors were the closest existing receptors identified from a review of Nearmap Pty Ltd (Nearmap) aerial photography. The locations of these sensitive receptors are shown in **Figure F2**. The nearest sensitive receptor to the site is identified as an existing residence and is located approximately 1.36 km south east. **Table 3** displays the type of each receptor and its distance from the Site.

Fence line receptors were also situated around the property boundaries of Site A, Site B and Site C.

Table 3 Sensitive Receptors

Receptor Number	Receptor Type	Distance from site (km)	Direction
R01	Existing Residence	1.36	South East
R02	Council Building	1.48	South East
R03	Existing Residence	1.52	South East
R04	Existing Residence	1.52	North East
R05	Existing Residence	1.56	North East
R06	Existing Residence	1.69	North
R07	Existing Residence	1.71	North
R08	Existing Resident	1.79	North East
R09	Existing Residence	2.03	East
R10	Existing Residence	1.91	East
R11	Existing Residence	1.60	North East
R12	Public Sports Facility	1.87	East
R13	Existing Residence	1.88	East
R14	Existing Residence	1.93	East
R15	Existing Residence	2.02	North
R16	Existing Residence	2.29	North

5.3 Emissions Inventory

The sources of emissions from the Site are the two thermal oxidisers, DP4 and TO-2 (proposed) located on Site A, DP7 located on Site B and DP9 which is located on Site C. Emissions are modelled based on the maximum calculated emission rate calculated by CEC Engineering which is attached as **Appendix E**. It is also noted that the maximum calculated emission rates from CEC for the existing oxidiser exceed the emission rate measured in stack testing performed to demonstrate compliance with the existing Environment Protection Licence for the operations at the Site.

Fugitive losses from the storage and transfer of material at the Site were assessed in the report, *Botany Stage 5B Expansion, Air Quality Assessment,* August 2013. The conclusion of this report is that these emissions have a negligible potential to impact on local air quality. Therefore, the impact of such emissions has not been considered in this assessment.

5.3.1 Sources of Air Emissions

The sources of emission are the stack emissions from the VOC treatment system which consists of the existing thermal oxidiser on the site (DP4) and the proposed thermal oxidiser (TO-2) the bitumen combustor (DP7) and VRU (DP9).

Table 4 Source Emission Rates

	DP 4 (g/s)	TO-2 (g/s)	DP7 (g/s)	DP9 (g/s)
Benzene	0.00203	0.00203	0	0.0048
Carbon Monoxide	0.162	0.242	0.18	0
Nitrogen Dioxide	5.194	8.806	0.12	0
PM10	0.00142	0.021	0.016	0
Sulphur Dioxide	4.133	4.4	0.002	0

The basis for the calculated emission rates is shown in **Table 5.** The emission rates have been calculated either based on the calculated concentration at the maximum emission rate, or have been calculated based on the maximum gas usage rate with the emission factors from the NPI EET.

Table 5 Summary of inputs to calculated emission rates

	DP 4	Proposed Oxidiser	DP7 (g/s)	DP9
Flow Rate	18.87 m^3/hr	6.71 m^3/hr	14.18 m^3/hr	0.1467 m^3/hr
Flow Rate Source	CEC Calculation	CEC Calculation	GHD Assessment	Calculated based on worst case of four trucks loading

	DP 4	Proposed Oxidiser	DP7 (g/s)	DP9
				simultaneously at 2,200 lpm each.
Benzene	*Concentration* CEC Calculation	*Concentration* CEC Calculation	GHD Assessment	*Concentration* EPL limit of 10 mg/l 0.4% benzene concentration in vapour
Carbon Monoxide	*Emission rate* NPI EET based on maximum instantaneous gas consumption of 400 Nm^3/hr	*Emission rate* NPI EET Based on maximum instantaneous gas consumption of 598 Nm^3/hr	GHD Assessment	Not present – no combustion.
Nitrogen Dioxide	*Concentration* EPL limit 350 mg/m^3	*Concentration* POEO (Clean Air) Limit of 350 mg/m^3	GHD Assessment	Not present – no combustion.
PM10	*Emission rate* NPI EET based on maximum instantaneous gas consumption of 400 Nm^3/hr	*Emission rate* NPI EET Based on maximum instantaneous gas consumption of 598 Nm^3/hr	GHD Assessment	Not present – no combustion.
Sulphur Dioxide	*Concentration* CEC Calculation	*Concentration* CEC Calculation	GHD Assessment	Not present – no combustion.

5.3.2 Estimation of Air Emissions

The estimation of air emissions from the combustion system was undertaken by CEC Engineers from process data which were provided by Quantem. The data were calculated assuming worst case vapour loading to the thermal oxidisers. Data used for the bitumen combustor were taken from the GHD PMB and CRMB Air Quality Assessment Report and VRU data were supplied by Quantem.

Based on the process data provided by CEC Engineers, only concentrations of benzene and sulphur dioxide exceed the ground level assessment criteria within the stack. Other potential pollutants were below the ambient assessment criteria with zero dispersion. The impact of these is negligible because the in-stack concentrations are lower than the assessment criteria, therefore the dispersion of emissions of these other compounds were not modelled.

Additionally, dispersion of CO and PM_{10} were modelled at the request of Quantem. The natural gas maximum usage rate was used to estimate the emission rates from the combustion system. Using these peak rates of gas consumption, the National Pollution Inventory (NPI) emission factors were applied to estimate the emission rates of CO and PM_{10}.

The emission factors were obtained from the *NPI Emission Estimation Technique Manual for Combustion in Boilers, Version 3.6, 2011* (NPI Manual) for 30 MW or less, combustion system for natural gas. Using the NPI manual, the predicted emission rates for DP4 and TO-2 were then calculated using the following equation.

$$E_{(S)} = A \times EF_{(s)} \times (1 - CE)\text{Verification}$$

Annual emission testing reports for DP4 were also considered as part of the assessment. Quantem provided these reports to PJRA for the period 2013 - 2019. Upon review of the reports, it was noted that the emission rates observed for CO and NO_2 did not exceed the estimated emissions shown in Table 3, with one exception for NO_2 in April 2013. The reason for this exception is not known and is anomalous compared to the most recent nine measurements and is considered an outlier. Furthermore, benzene was reported to be below the detection limit in the emission testing reports and PM_{10} was not included as a specified parameter. Table 5 displays the results from the reports as provided by Quantem. The stack testing reports are provided in **Appendix F**.

Table 6 Sampled Emission Rates from DP4 in Emission Testing Reports

Sample Date	Benzene Emission Rate (g/s)	Sulfur Dioxode Emission Rate (g/s)	Carbon Monoxide Emission Rate (g/s)	Nitrogen Dioxide Emission Rate (g/s)
April 2013	<0.00018	2.6	0.19	1.1
August 2013	<0.0005	0.12	< 0.01	0.11
July 2013	<0.0005	0.065	< 0.01	0.08
May 2014	Not Detected	0.04	0.01	0.07
July 2015	Not Detected	0.128	0.02	0.11
December 2015	Not Detected	0.065	0.02	0.08
August 2016	<0.00017	Not Analysed	Not Analysed	0.32
May 2017	<0.00005	Not Analysed	0.003	0.08
April 2018	0.000075	Not Analysed	0.06	0.06
May 2019	<0.00008	Not Analysed	0.004	0.1
Modelled Emission Rate	**0.00203**	**4.133**	**0.162**	**5.194**
Calculation Notes for modelled emission rate	Calculated by CEC,	Calculated by CEC.	NPI Emission Estimation to give mass flow rate based on peak gas consumption.	Calculated from CEC flow rate, with the outflow concentration at the EPL Limit of 350 mg/m^3

It is noted that the emission rates modelled at the worst case scenarios provide a large over-estimate of the emissions that have been observed in analysis of samples from DP4. Therefore, the modelled emissions provide a conservative-high estimate of the emissions that are likely to be observed during normal operation of the Site.

5.4 Air Dispersion Modelling

Dispersion modelling was undertaken in accordance with the Approved Methods to predict the impact of discharges to air while DP4 and TO-2 are operating simultaneously with the DP7 and DP9 under local meteorological conditions.

5.4.1 Model Selection

The modelling has been undertaken in accordance with the Approved Methods with the exception that AERMOD was used instead of AUSPLUME. The NSW Environment Protection Authority was consulted regarding the choice of the dispersion model and the advice was that AERMOD can be used in place of AUSPLUME provided the use can be justified as the more appropriate selection.

The modelling prepared using AERMOD is better able to account for terrain factors and is recommended by the United States Environmental Protection Agency (USEPA) in place of the older AUSPLUME model. The AUSPLUME model was developed by the Environment Protection Authority Victoria, however it is no longer supported as the regulatory model in Victoria and the software is no longer updated. The use of AERMOD allows for consideration of terrain effects and provides an improvement over AUSPLUME for assessing potential impacts for small-scale, near-field dispersion modelling such as is the case in this situation.

The site is essentially at sea level and the topography surrounding the site is relatively flat. Examination of meteorological data indicated that calms occur less than 5% of the time. Based on these considerations, it was considered appropriate to use the regulatory approved AERMOD dispersion model version 9.9.0.

A comparison of three modelling programs, AUSPLUME, AERMOD, and TAPM demonstrated that AERMOD is preferable to AUSPLUME (Hurley, 2006). Although both AUSPLUME and AERMOD have some limitations with modelling in coastal scenarios, AERMOD was found to provide more accurate results than AUSPLUME. This was especially the case when looking at measuring the upper estimates of contaminant concentrations.

The use of a more complicated model such as TAPM or CALPUFF would provide more accurate results, however the margin of error using AERMOD is in the range of ~20%, compared to ~50% for

AUSPLUME. As a margin of error of 20% to the modelled maximum concentrations would not make a material difference to the outcome of the assessment, the use of TAPM or CALPUFF is not considered necessary.

5.4.2 Modelling Domain

A 9 km x 9 km grid was used with receptors placed 300 m apart and the centre of the grid located at the centre point of the site. Discrete receptors were also placed at existing residential receptors as described in Section 4.1 of this report. Fence line receptors were also positioned at property boundaries surrounding the processing equipment on Site A, B and C.

An additional 600m x 600m grid with receptors placed 30m apart was applied to the same centre point for the site. This was provided to assess whether there would be any impacts in close proximity to the site.

Topography was incorporated into the model using a digital elevation model with approximately 30 m resolution which has been gap filled. Since the terrain is relatively flat surrounding the site, the topographical resolution of the terrain was considered appropriate.

5.4.3 Dispersion

5.4.3.1 Climate Data

The nearest weather station operated by the Bureau of Meteorology (BOM) is at Sydney Airport, site number 066037. The station has been operated by BOM since 1929 and is located approximately 5 km north west of the site.

Daily 9 am and 3 pm weather data from the Sydney Airport BOM station were used to characterise the climate in the vicinity of the subject land. Wind roses produced from the meteorological data used for the dispersion modelling indicate that the winds are typically from the north west and north east.

5.4.3.2 Meteorological Input Files

The data file used for the AERMOD modelling was prepared by pDs Consultancy based on the observational data taken from weather stations operated by the BOM.

5.4.4 Model Input Parameters

In accordance with the Approved Methods the one-hour average concentrations were modelled so the results were consistent with the principal and individual toxic air pollutants assessment criteria.

Table 7 Summary of AERMOD Input Parameters

Model Input Parameters	
Meteorological Data	Obtained from Bureau of Meteorology at station 066037
Pollutant	Benzene, SO_2, CO, NO_2, PM_{10}
Deposition	None
Depletion	None
Dispersion	Rural
Averaging time	Hourly
Terrain	Flat & elevated
Gridded Receptors	9 km x 9km, 300m spacing 600m x 600m, 30m spacing
Discrete Receptors	14 houses located to the north, east and south 1 public sporting facility 1 council building 16 Fence line receptors (50m spacing) surrounding Site A 13 Fence line receptors (50m spacing) surrounding Site B 18 Fence line receptors (50m spacing) surrounding Site C

5.4.5 Source Input Parameters

A full listing of source input parameters used in the AERMOD simulations is provided in **Table 8.** The estimation of the emission rates utilised in the model was discussed in **Section 4.2.2.**

Table 8 Summary of Source Input Parameters for Dispersion Modelling Simulations

	DP4	Thermal Oxidiser 2 (TO-2)	DP7	DP9
Source Type	Point	Point	Point	Point
Source Height (m)	17.55	17.55	17.3	5.0
Inside Diameter	1.0	1.02	0.95	0.15
X co-ordinate (m)	335242	335239	335432	335652.
Y co-ordinate (m)	6239157	6239155	6238948	6239315
Exit Temperature (°C)	980	980	825	22
Gas Exit Velocity (m/s)	18.9	6.7	20.0	8.3
Gas Exit Flow Rate (m^3/s)	14.8	5.5	14.18	0.15

5.4.6 Results of AERMOD Simulations and Interpretations

In accordance with the Approved Methods, the emissions must be assessed against the assessment criteria. The impact assessment criteria for a 1-hour average period for benzene, sulphur dioxide, carbon monoxide and nitrogen dioxide are provided below as per the Approved Methods. The PM_{10} criterion is provided as a 24-hour average period.

- Benzene 0.029 mg/m^3 (Victorian Governments Gazette, 2001)
- Sulphur Dioxide 570 $\mu g/m^3$ (NHMRC, 1996)
- Carbon Monoxide 30 mg/m^3 (WHO, 2000)
- Nitrogen Dioxide 246 $\mu g/m^3$ (NEPC, 1998)
- PM_{10} 50 $\mu g/m^3$ (DoE, 2016)

5.4.6.1 Benzene

Table 9 100th Percentile predicted benzene concentrations at sensitive receptors

Receptor	GLC (mg/m^3)	% of Criterion	Location		Elevation (m)
			Easting	Northing	
R01	0.000153	0.5%	336600.77	6238834.97	15.84
R02	0.000110	0.4%	336586.90	6238481.55	17.74
R03	0.000108	0.4%	336632.12	6238499.78	17.24
R04	0.000125	0.4%	336342.33	6240219.80	15.50
R05	0.000117	0.4%	336190.89	6240393.45	16.32
R06	0.000127	0.4%	336018.25	6240670.08	11.27
R07	0.000117	0.4%	335958.68	6240705.42	10.51
R08	0.000139	0.5%	336817.93	6240016.59	24.76
R09	0.000110	0.4%	336977.39	6240187.57	18.33
R10	0.000137	0.5%	337077.67	6239774.93	28.96
R11	0.000129	0.4%	336541.84	6240114.49	16.18
R12	0.000153	0.5%	337156.16	6239436.87	21.88
R13	0.000165	0.6%	337153.68	6239115.58	16.57
R14	0.000108	0.4%	337164.39	6238909.43	20.12
R15	0.000093	0.3%	334375.19	6240986.80	4.18
R16	0.000072	0.2%	334102.67	6241129.35	4.98

The results of the dispersion modelling show there are no exceedances of the impact assessment criterion for benzene at any receptor. The highest concentration of benzene was 0.000165 mg/m^3 at Receptor 13, and this is 0.6% of the benzene impact assessment criterion of 0.029 mg/m^3.

For principal air toxics, impact assessment criteria should be applied at and beyond the boundary of the premises. Therefore, receptors at the facility boundary were added to the model inputs to predict benzene concentration at the facility boundary. The highest estimated concentration at the facility boundary was 0.0135 mg/m^3 at the northern boundary at Site C.

5.4.6.2 Sulphur Dioxide

Table 10 100th Percentile predicted SO_2 concentrations at sensitive receptors

Receptor	Ground level concentrations (µg/m³)	% of Criterion	Location		Elevation (m)
			Easting	Northing	
R01	34.42	6.0%	336600.77	6238834.97	15.84
R02	23.52	4.1%	336586.90	6238481.55	17.74
R03	23.30	4.1%	336632.12	6238499.78	17.24
R04	24.31	4.3%	336342.33	6240219.80	15.50
R05	24.97	4.4%	336190.89	6240393.45	16.32
R06	27.72	4.9%	336018.25	6240670.08	11.27
R07	25.57	4.5%	335958.68	6240705.42	10.51
R08	21.32	3.7%	336817.93	6240016.59	24.76
R09	21.07	3.7%	336977.39	6240187.57	18.33
R10	19.07	3.3%	337077.67	6239774.93	28.96
R11	24.83	4.4%	336541.84	6240114.49	16.18
R12	31.75	5.6%	337156.16	6239436.87	21.88
R13	35.14	6.2%	337153.68	6239115.58	16.57
R14	23.51	4.1%	337164.39	6238909.43	20.12
R15	20.17	3.5%	334375.19	6240986.80	4.18
R16	14.90	2.6%	334102.67	6241129.35	4.98

The predicted SO_2 peak concentration levels at each off-site receptor are shown in **Table 10.** There are no exceedances of the impact assessment criterion of 570 µg/m³ for sulphur dioxide at any of the receptors.

For a level 1 assessment, the existing background concentration of sulphur dioxide should be included. In accordance with the Approved Methods, the maximum background concentration of the pollutant is to be added to peak concentration levels at the maximum exposed off-site receptor for 100th percentile dispersion model prediction.

Ambient air quality data were obtained to determine the maximum background concentrations of sulphur dioxide. The closest station to the site that records ambient sulphur dioxide is located at Randwick approximately 7.5 km north of Quantem's facility and is operated by NSW EPA. Hourly average data were obtained for the 2017 calendar year and the maximum background concentration was determined to be 75 µg/m³ for SO_2.

Based on the results of the dispersion modelling, Receptor 13 is predicted to be the maximum exposed off-site receptor. The maximum background concentration was then added to the dispersion model prediction for Receptor 13, to give an impact of 110 µg/m^3, which is 20% of the impact assessment criterion of 570 µg/m^3.

5.4.6.3 Carbon Monoxide

Based on the modelling results there is no exceedance of the impact assessment criterion for CO at any receptor. As per the Approved Methods, background concentrations of CO must also be reported and included for the maximum exposed off-site receptor. The nearest ambient air quality station that measures background concentrations of CO is located in Chullora, NSW. Analysis of the data determined that the maximum ambient concentration was 2.16 mg/m^3.

Table 11 shows the predicted concentrations of CO at each off-site receptor. Based on the results, Receptor 2 is predicted to be the maximum exposed off-site receptor. The maximum background concentration was then added to the prediction to give an impact of 2.162 mg/m^3 approximately 7.2% of the impact assessment criterion of 30 mg/m^3.

Table 11 100th Percentile predicted CO concentrations at sensitive receptors

Receptor	Ground level concentrations (mg/m^3)	% of Criterion	Location		Elevation (m)
			Easting	Northing	
R01	0.00167	0.006%	336600.77	6238834.97	15.84
R02	0.00168	0.006%	336586.90	6238481.55	17.74
R03	0.00164	0.005%	336632.12	6238499.78	17.24
R04	0.00123	0.004%	336342.33	6240219.80	15.50
R05	0.00122	0.004%	336190.89	6240393.45	16.32
R06	0.00133	0.004%	336018.25	6240670.08	11.27
R07	0.00124	0.004%	335958.68	6240705.42	10.51
R08	0.00105	0.003%	336817.93	6240016.59	24.76
R09	0.00099	0.003%	336977.39	6240187.57	18.33
R10	0.00104	0.003%	337077.67	6239774.93	28.96
R11	0.00120	0.004%	336541.84	6240114.49	16.18
R12	0.00151	0.005%	337156.16	6239436.87	21.88
R13	0.00167	0.006%	337153.68	6239115.58	16.57
R14	0.00132	0.004%	337164.39	6238909.43	20.12
R15	0.00131	0.004%	334375.19	6240986.80	4.18
R16	0.00098	0.003%	334102.67	6241129.35	4.98

5.4.6.4 Nitrogen Dioxide

The predicted concentration levels at each off-site receptor are shown in **Table 12.** There are no exceedances of the impact assessment criterion of 246 µg/m^3 at any off-site receptor. Based on the modelling results, Receptor 13 is expected to be the maximum exposed off-site receptor with a modelled 100th percentile concentration of 56.51 µg/m^3.

Analysis of background concentrations was undertaken from data measured at Randwick and the maximum ambient concentration of NO_2 was determined to be 84.05 µg/m^3. To predict the total impact at Receptor 13, the highest background concentration was then added to the prediction at Receptor 13 to give an impact of 140.6 µg/m^3, approximately 57% of the impact assessment criterion for NO_2.

Table 12 100th Percentile predicted NO_2 concentrations at sensitive receptors

Receptor	Ground level concentrations (µg/m^3)	% of Criterion	Location		Elevation (m)
			Easting	Northing	
R01	53.66	21.8%	336600.77	6238834.97	15.84
R02	38.41	15.6%	336586.90	6238481.55	17.74
R03	37.51	15.2%	336632.12	6238499.78	17.24
R04	38.73	15.7%	336342.33	6240219.80	15.50
R05	39.52	16.1%	336190.89	6240393.45	16.32
R06	44.30	18.0%	336018.25	6240670.08	11.27
R07	40.58	16.5%	335958.68	6240705.42	10.51
R08	33.64	13.7%	336817.93	6240016.59	24.76
R09	33.41	13.6%	336977.39	6240187.57	18.33
R10	30.02	12.2%	337077.67	6239774.93	28.96
R11	39.78	16.2%	336541.84	6240114.49	16.18
R12	51.14	20.8%	337156.16	6239436.87	21.88
R13	56.51	23.0%	337153.68	6239115.58	16.57
R14	38.05	15.5%	337164.39	6238909.43	20.12
R15	32.17	13.1%	334375.19	6240986.80	4.18
R16	24.51	10.0%	334102.67	6241129.35	4.98

5.4.6.5 PM_{10}

There are no exceedances of the impact assessment criterion of 50 µg/m^3 for PM_{10} at any of the receptors. The predicted PM_{10} peak concentration levels at each off-site receptor are shown in **Table 13.** Based on the modelling results, Receptor 7 is expected to be the maximum exposed off-site receptor with a modelled 100th percentile concentration of 0.0426 µg/m^3.

Ambient air quality data were obtained to determine the maximum background concentrations of PM_{10} from Randwick. 24-hour average data were obtained for the 2017 calendar year and the maximum background concentration was determined to be 56.1 µg/m^3 for PM_{10}. The maximum ambient concentration was then added to the highest predicted emission at Receptor 7 to gauge the total impact of PM_{10} emissions. Based on the modelling results, it is considered that the predicted emission from both oxidisers would have negligible impact on the ambient concentrations of PM_{10}.

Table 13 100th Percentile predicted PM_{10} concentrations at sensitive receptors

Receptor	Ground level concentrations (µg/m^3)	% of Criterion	Location		Elevation (m)
			Easting	Northing	
R01	0.0271	0.05%	336600.77	6238834.97	15.84
R02	0.0253	0.05%	336586.90	6238481.55	17.74
R03	0.0234	0.05%	336632.12	6238499.78	17.24
R04	0.0255	0.05%	336342.33	6240219.80	15.50
R05	0.0333	0.07%	336190.89	6240393.45	16.32
R06	0.0421	0.08%	336018.25	6240670.08	11.27
R07	0.0426	0.09%	335958.68	6240705.42	10.51
R08	0.0231	0.05%	336817.93	6240016.59	24.76
R09	0.0197	0.04%	336977.39	6240187.57	18.33
R10	0.0234	0.05%	337077.67	6239774.93	28.96
R11	0.0229	0.05%	336541.84	6240114.49	16.18
R12	0.0238	0.05%	337156.16	6239436.87	21.88
R13	0.0279	0.06%	337153.68	6239115.58	16.57
R14	0.0195	0.04%	337164.39	6238909.43	20.12
R15	0.0217	0.04%	334375.19	6240986.80	4.18
R16	0.0192	0.04%	334102.67	6241129.35	4.98

5.4.6.6 Other VOCs

The emission calculations provided by CEC include calculated emissions of VOCs that can have an odour impact. These include butyl acrylate, ethanol, methanol, methyl methacrylate, and styrene. It is noted that the calculated concentrations in the stack under worst case operation do not exceed the ground level assessment criteria from the Approved Methods.

Therefore, it is therefore not necessary to assess the dispersion of the emissions of these VOCs. These emission concentrations are summarised in **Table 14.** The calculated concentrations are corrected to 1 atmosphere and 0°C.

Table 14 Other VOCs from CEC calculated emissions

Compound	Calculated DP4 mg/m^3	Calculated TO-2 mg/m^3	Assessment Criterion mg/m^3
Acetone	0.5357	0.3154	22
Ethanol	0.1320	0.0777	2.1
Methanol	0.5104	0.3005	3
Styrene	0.0005	0.0014	0.12
Methyl Methacrylate	0.0000	0.0000	0.12
Butyl Acrylates	0.0004	0.0011	0.1

These pollutants were below the ambient assessment criteria for odour impact within the oxidiser emissions. The impact of these emissions is negligible because the in-stack concentrations are lower than the assessment criteria at ground level. In view of this, the dispersion of emissions of these compounds was not modelled.

5.4.6.7 Cumulative Impact

The Quantem facility is predominantly used for the bulk storage of liquid fuels. As evident from aerial imagery, nearby industries are used for liquid storage purposes however the contents of the storage may consist of other liquids other than fuels.

The GHD Report (GHD 2016) identified only two other sites in the Port Botany industrial area that are both sources of emissions. The report estimated that the maximum predicted concentration of benzene beyond the site boundary was only 19% of the impact assessment criterion. It is stated in the report that other sites within the Port Botany industrial area would not be expected to add significant contribution of levels of benzene to the predicted concentrations.

The findings of this report support GHD's view as the maximum predicted off-site concentration of benzene is expected to be only 0.06% of the impact assessment criterion. Therefore, it is considered that the operations at the Site will have a negligible contribution to off-site benzene concentration.

6. CONCLUSIONS

The dispersion of emissions of benzene, carbon monoxide, sulphur dioxide, nitrogen dioxide and PM_{10} were modelled using licence limit for DP9 in EPA Licence 1048 and from the emission estimates provided by CEC Engineers and Peter J Ramsay & Associates.

The predicted ground level concentrations from the dispersion modelling of emissions show that the proposed addition of a second thermal oxidiser (TO-2) will not cause exceedances of the relevant impact assessment criteria at any sensitive receptors. The assessment was undertaken assuming a worst-case scenario of both thermal oxidisers, bitumen combustor and the VRU operating simultaneously, at maximum capacity, and worst-case ambient background concentrations from the nearest monitoring station.

Based on the predicted peak level concentrations, the maximum benzene concentration will be experienced at Receptor 13, approximately 1.88 km east from the site. It was predicted that benzene will peak at 0.000165 mg/m^3 at Receptor 13 which is approximately 0.6% of the impact assessment criterion when modelled at the licence limit. The cumulative benzene impact remains well below the assessment criterion at the most impacted receptor.

For sulphur dioxide, the maximum predicted concentration will also be experienced at Receptor 13. The predicted peak sulphur dioxide concentration is 110 $\mu g/m^3$ which includes the addition of background concentration which was obtained from NSW EPA ambient air quality data. The expected peak level concentration is approximately 20% of the impact assessment criterion.

In addition, the predicted peak level concentrations for carbon monoxide, nitrogen dioxide and PM_{10} are also at Receptor 13. As per the Approved Methods, the maximum ambient background concentration was added to the modelling result at Receptor 13 to gauge the overall impact of the emissions from the proposed combustion system. It is concluded that:

- The maximum carbon monoxide concentration will be experienced at Receptor 2 with a peak of 2.162 mg/m^3 approximately 7.2% of the impact assessment criterion.
- The maximum nitrogen dioxide concentration will be experienced at Receptor 13 with a peak of 140.6 $\mu g/m^3$, approximately 57% of the impact assessment criterion for NO_2.
- Based on the modelling results, it was considered that the predicted emission from both oxidisers would have negligible impact on the ambient concentrations of PM_{10}.

Although the use of gaussian dispersion models such as AUSPLUME or AERMOD are generally not preferred in coastal locations, the margin of error for the high concentration estimates is expected to be

around 20%. Given the modelled ground level concentrations this margin of error would not impact the outcome of this assessment and further dispersion modelling is not necessary.

The use of AERMOD was found to be preferable to AUSPLUME for modelling of emissions at the Site. The margin of error for assessing the predicted ground level concentrations by AERMOD is around 20% and is sufficiently accurate for the purposes of this impact assessment.

Emissions from the operation of the proposed thermal oxidiser, in addition to the existing air emissions from the Site, will not have unacceptable impact on the local air quality in the vicinity the Site nor at the nearest sensitive receptors.

The operation of the proposed thermal oxidiser will not cause a material increase to the total emissions of benzene or total VOCs form the Site. Therefore, no change to the existing load limits in the EPL is necessary.

7. REFERENCES

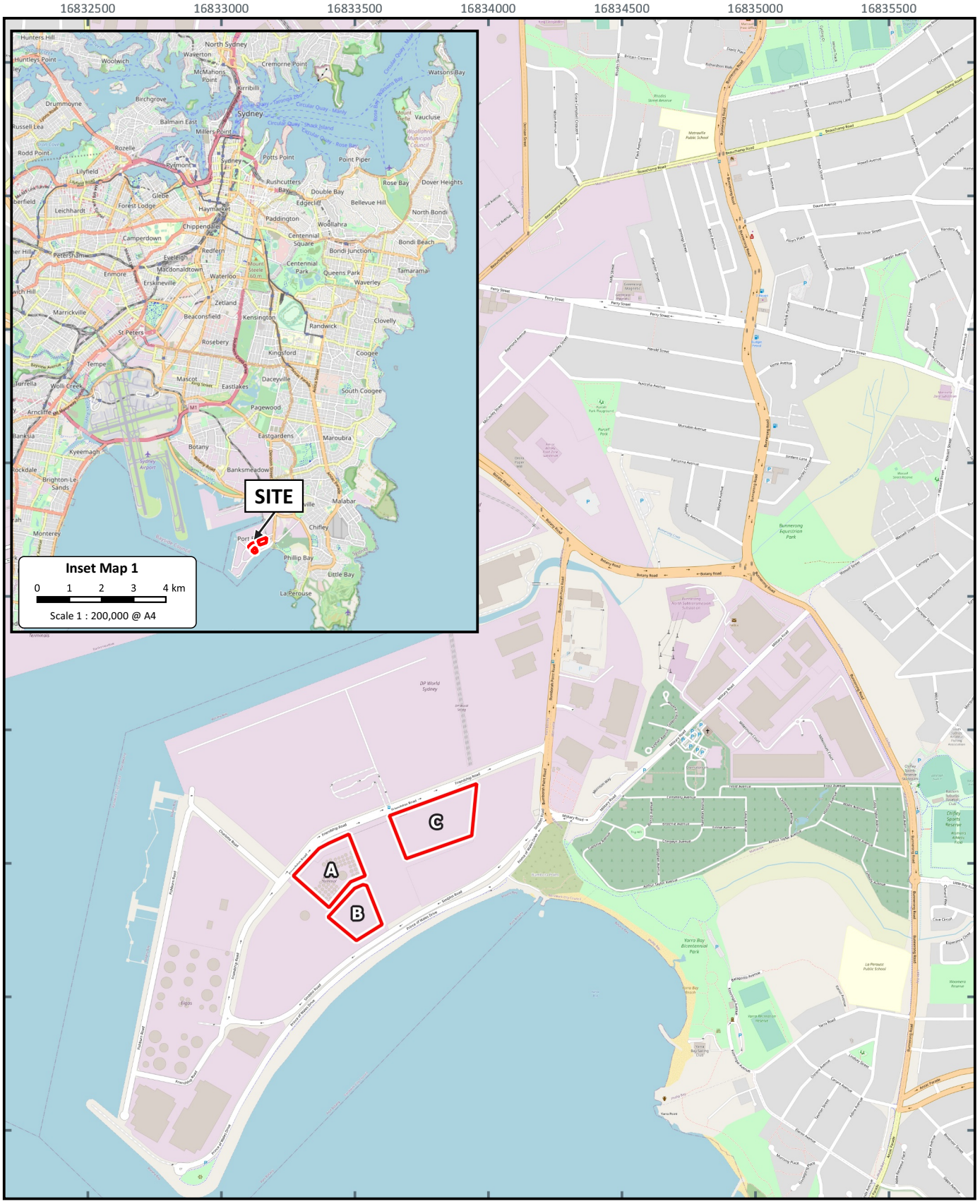
Hurley, 2006; *An Evaluation and Inter-Comparison of AUSPPLUME, AERMOD, and TAPM for Seven Field Datasets of Point Source Dispersion*, Peter J Hurley, CSIRO Marine and Atmospheric Research, Clean Air and Environmental Quality, 40, 45-50, 2006.





Figures

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PETER J RAMSAY & ASSOCIATES

LEGEND

Site Boundary
- Site A
- Site B
- Site C

LOCALITY MAP

Air Quality Impact Assessment

45 Friednship Road,
Port Botany NSW

Quantem Bulk Liquid Storage & Handling (Terminals Pty Ltd)

Figure **F1**

Project: 1033.1
Date: 05/02/2021
Revision: Rev01
Designed: TA
Drawn: AD
Reviewed: NW/TA

N

0 100 200 300 400 m

Main Map Scale 1: 20,000 @ A4

Coordinates: WGS84 / Pseudo-Mercato

Data Sources
Aerial Imagery - Nearmap Australia Ltd, photograph dated 26/09/2020.

File: P:\Projects\1033.1\Maps\Working\F1_Locality Map.qgz



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Project: 1033.1
Date: 11/02/2021
Revision: Rev02
Designed: TA
Drawn: AD
Reviewed: NW/TA

N

0 100 200 300 400 m

Main Map Scale 1: 12,000 @ A4

Coordinates: GDA94 / MGA 56

LEGEND

- Fenceline
  - Site A
  - Site B
  - Site C
- Fenceline Receptors
- Emission Sources
- Sensitive Receptors

Data Sources

Aerial Imagery - Nearmap Australia Ltd, photograph dated 26/09/2020

AIR DISPERSION MODELLING EMISSION SOURCES AND SENSITIVE RECEPTORS

Air Quality Impact Assessment

45 Friendship Road,
Port Botany NSW

Quantem Bulk Liquid Storage & Handling (Terminals Pty Ltd)

Figure
F2

File: P:\Projects\1033.1\Maps\Working\Working_20210211.qgz



PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL
Sources:4
Receptors:1512
Output Type: Concentration
Modelling Date: 10/02/2021

PETER J RAMSAY & ASSOCIATES

Project: 1033.1
Date: 11/02/2021
Revision: Rev03
Designed: TA
Drawn: AD
Reviewed: NW/TA

N

0 100 200 300 400 500 m

Main Map Scale 1: 20,000@ A4

Coordinates: GDA94 / MGA z56

LEGEND

Benzene Concentration
- 1.0
- 3.0
- 6.0

- Emission Sources
- Sensitive Receptors
- Fenceline
- Fenceline Receptors

Comments:
Benzene Criterion = 0.029 mg/m3 (1 hour averaging period) as per the Approved Methods.The contour lines that are displayed represent a percentage of the impact assessment criteria.
These percentages are as follows:
6.0 ug/m3 = 20%
3.0 ug/m3 = 10%
1.0 ug/m3 = 3%

EMISSION CONCENTRATION CONTOUR - BENZENE

Air Quality Impact Assessment

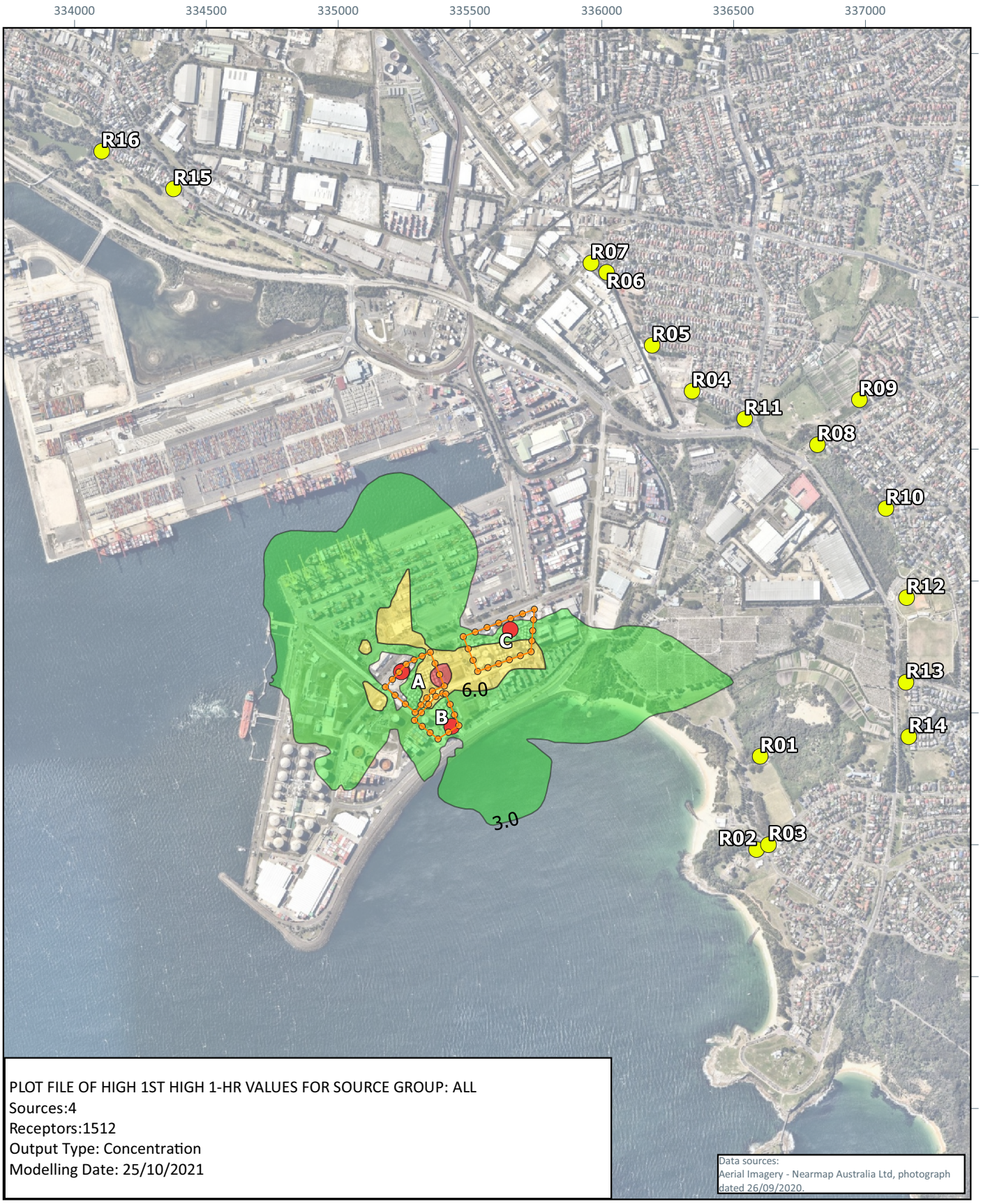
45 Friendship Road, Port Botany NSW 2036

Quantem Bulk Liquid Storage & Handling (Terminals Pty Ltd)

Figure **F3**

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File: P:\Projects\1033.1\Maps\Working\Working_20210211.qgz



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PETER J RAMSAY & ASSOCIATES

Project: 1033.1
Date: 25/10/2021
Revision: Rev03
Designed: TA
Drawn: AD
Reviewed: NW/TA

N

0 100 200 300 400 500 m

Main Map Scale 1: 20,000@ A4

Coordinates: GDA94 / MGA z56

LEGEND

CO Concentration
- 3.0
- 6.0
- 15.0

Emission Sources
Sensitive Receptors
Fenceline
Fenceline Receptors

Comments:
CO Criterion = 30 mg/m3 (1 hour averaging period) as per the Approved Methods. The contour lines that are displayed represent a percentage of the impact assessment criteria.
These percentages are as follows:
15 ug/m3 = 0.05%
6 ug/m3 = 0.02%
3 ug/m3 = 0.01%

EMISSION CONCENTRATION CONTOUR - CARBON MONOXIDE

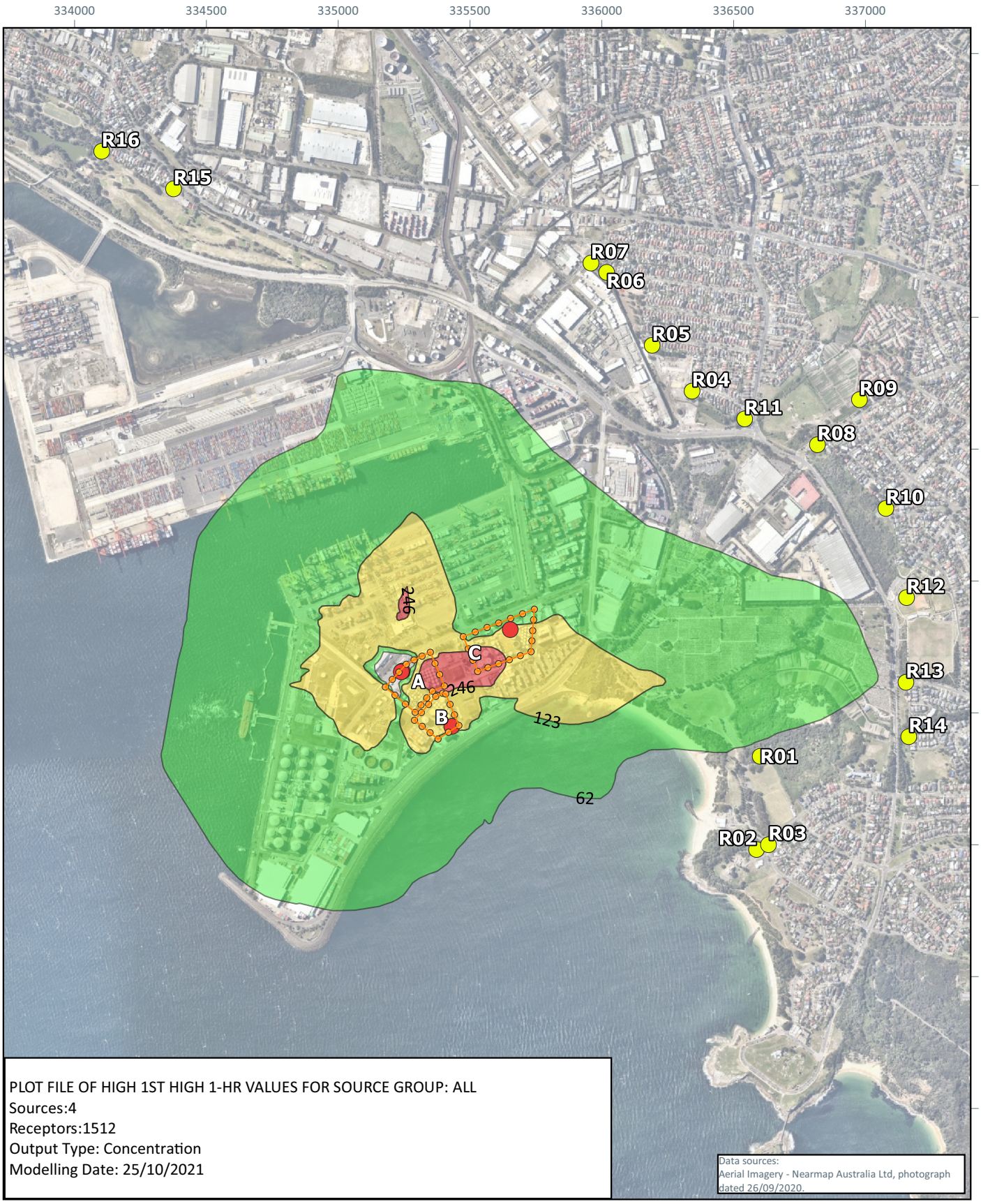
Air Quality Impact Assessment

45 Friendship Road, Port Botany NSW 2036

Quantem Bulk Liquid Storage & Handling (Terminals Pty Ltd)

Figure **F4**

File: P:\Projects\1033.1\Maps\Working\Working_20210211.qgz



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PETER J RAMSAY & ASSOCIATES

Project: 1033.1
Date: 25/10/2021
Revision: Rev03
Designed: TA
Drawn: AD
Reviewed: NW/TA

N

0 100 200 300 400 500 m

Main Map Scale 1: 20,000@ A4

Coordinates: GDA94 / MGA z56

LEGEND

NO2 concentration
- 62
- 123
- 246

- Emission Sources
- Sensitive Receptors
- Fenceline
- Fenceline Receptors

Comments:
NO2 Criterion = 246 ug/m3 (1 hour averaging period) as per the Approved Methods.The contour lines that are displayed represent a percentage of the impact assessment criteria.
These percentages are as follows:
246 ug/m3 = 100%
123 ug/m3 = 50%
62 ug/m3 = 25%

EMISSION CONCENTRATION CONTOUR - NITROGEN DIOXIDE

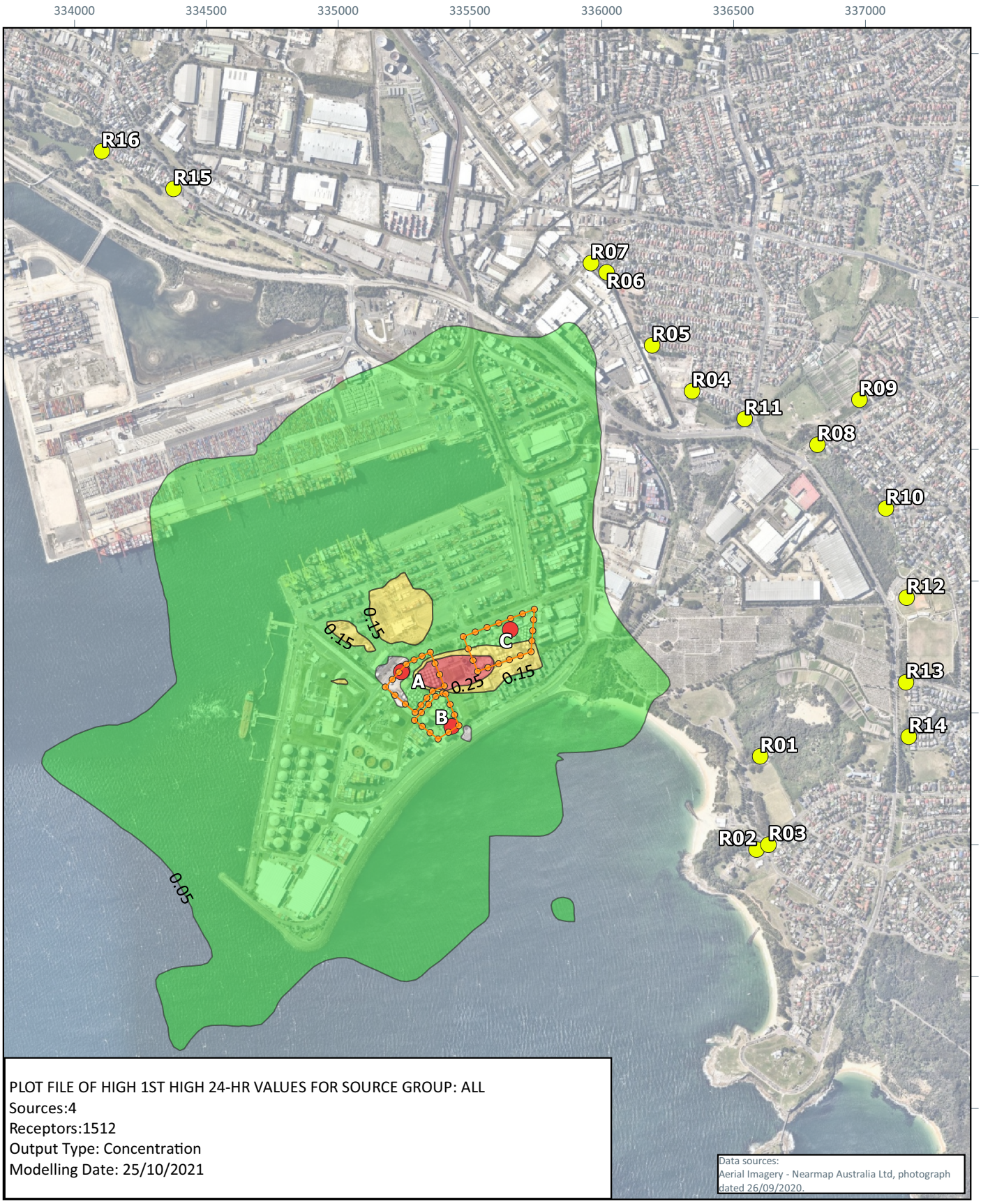
Air Quality Impact Assessment

45 Friendship Road, Port Botany NSW 2036

Quantem Bulk Liquid Storage & Handling (Terminals Pty Ltd)

Figure **F5**

File: P:\Projects\1033.1\Maps\Working\Working_20210211.qgz



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PETER J RAMSAY & ASSOCIATES

Project: 1033.1
Date: 25/10/2021
Revision: Rev03
Designed: TA
Drawn: AD
Reviewed: NW/TA

N

0 100 200 300 400 500 m

Main Map Scale 1: 20,000@ A4

Coordinates: GDA94 / MGA z56

LEGEND

PM10 Concentration
- 0.05
- 0.15
- 0.25

Emission Sources
Sensitive Receptors
Fenceline
Fenceline Receptors

Comments:
PM10 Criterion = 50 ug/m3 (24 hour averaging period) as per the Approved Methods.The contour lines that are displayed represent a percentage of the impact assessment criteria.
These percentages are as follows:
0.25 ug/m3 = 0.5%
0.15 ug/m3 = 0.3%
0.05 ug/m3 = 0.1%

EMISSION CONCENTRATION CONTOUR - PM10

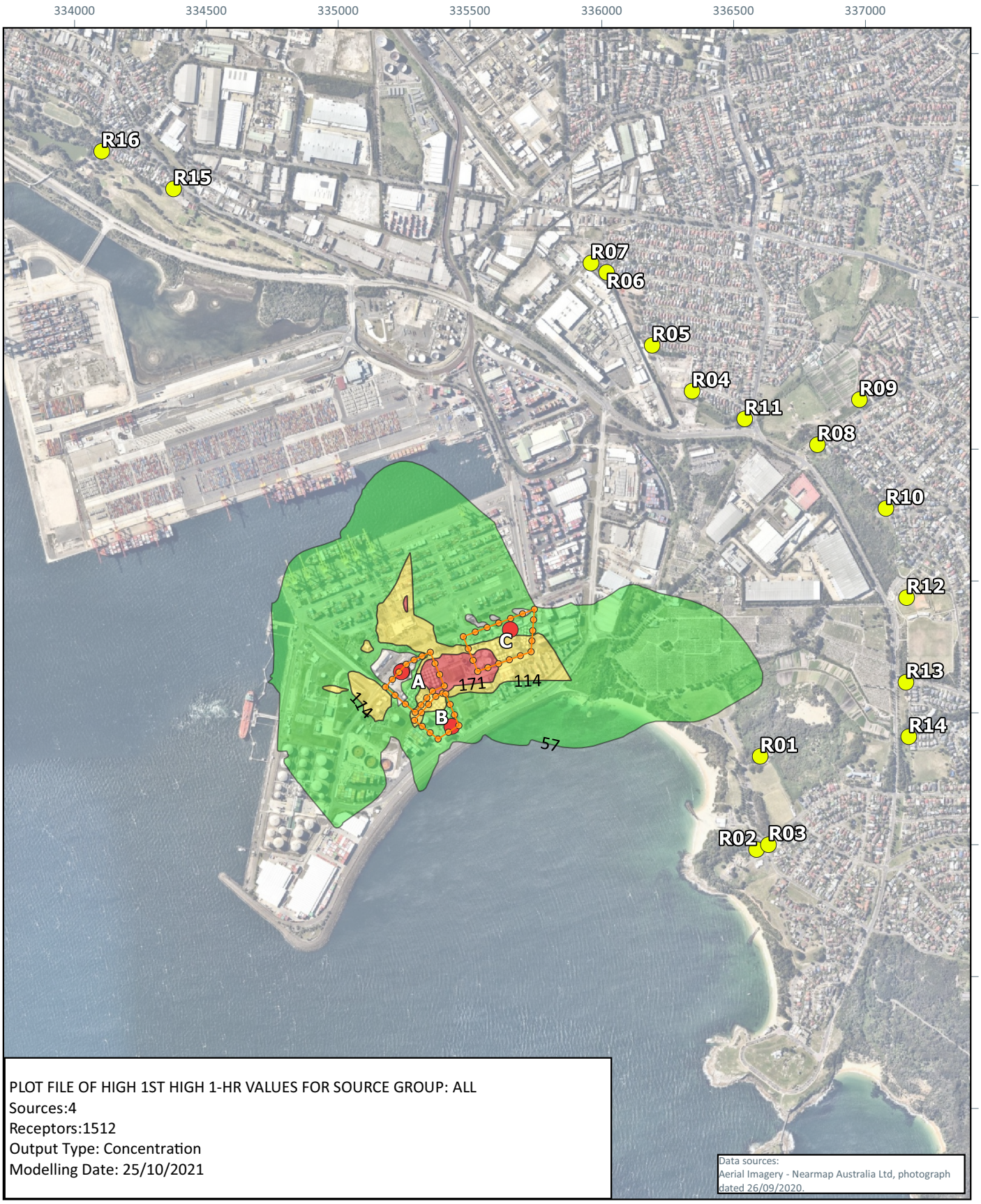
Air Quality Impact Assessment

45 Friendship Road, Port Botany NSW 2036

Quantem Bulk Liquid Storage & Handling (Terminals Pty Ltd)

Figure **F6**

File: P:\Projects\1033.1\Maps\Working\Working_20210211.qgz



PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL
Sources:4
Receptors:1512
Output Type: Concentration
Modelling Date: 25/10/2021

Data sources:
Aerial Imagery - Nearmap Australia Ltd, photograph dated 26/09/2020.

PETER J RAMSAY & ASSOCIATES

Project: 1033.1
Date: 25/10/2021
Revision: Rev03
Designed: TA
Drawn: AD
Reviewed: NW/TA

N

0 100 200 300 400 500 m

Main Map Scale 1: 20,000@ A4

Coordinates: GDA94 / MGA z56

LEGEND

SO2 Concentration
- 57
- 114
- 171

- Emission Sources
- Sensitive Receptors
- Fenceline
- Fenceline Receptors

Comments:
SO2 Criterion = 570 ug/m3 (1 hour averaging period) as per the Approved Methods.The contour lines that are displayed represent a percentage of the impact assessment criteria.
These percentages are as follows:
171 ug/m3 = 30%
114 ug/m3 = 20%
57 ug/m3 = 10%

EMISSION CONCENTRATION CONTOUR - SULFUR DIOXIDE

Air Quality Impact Assessment

45 Friendship Road, Port Botany NSW 2036

Quantem Bulk Liquid Storage & Handling (Terminals Pty Ltd)

Figure **F7**

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Appendix A

Commissioning Report for existing Thermal Oxidiser

Printed on Recycled Paper.

terminals pty ltd

ABN 87 000 348 407

gate b38, 45 friendship road
port botany nsw 2036
p.o. box 148 matraville nsw 2036

Phone (02) 9316 1900
Fax (02) 9316 9742

13th June 2013

Mr Greg Sheehy
Manager Sydney Industry
NSW EPA
PO Box 668
Parramatta NSW 2124

Dear Greg

Subject: **Terminals Licence 1048**
Condition Eight U1.4

Please find attached Final Report titled 'Benzene Vapour Emission Collection and Thermal Oxidiser Project' subtitled 'Final Report', June 2013, prepared by Geoff Millard.

This Final Report is submitted by Terminals to satisfy licence condition, U1.4 relating to compliance with PRP objectives by 31st May 2013 and report by 30 June 2013; implementing the thermal oxidiser project to reduce benzene emissions.

This report also demonstrates meeting the requirements of conditions U1.1, of section 8 of our licence 1048.

Please do not hesitate to contact me on 02 9316 1905 or 0414 604481 relating to any further queries.

Yours faithfully

Geoff Millard
National Safety & Environment Manager

Copies – by email:
Jacqueline Roberts, EPA
Andrew Hogg, State Manager TPL
Phil Jones, Operations Mgr TPL

TERMINALS PTY LTD

BENZENE VAPOUR EMISSION COLLECTION
and
THERMAL OXIDISER PROJECT
PORT BOTANY, NSW.

FINAL REPORT

JUNE 2013

Prepared by Geoff Millard



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APPENDICES

Appendix A	EPA Licence Pollution Studies and Reduction Programs
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Appendix D	Layout and general arrangement drawings 110010LAY-001 and thermal oxidiser vendor GA.
Appendix E	Advice from the EPA re thermal oxidiser destruction efficiency
Appendix F	BTX Ship Export Load for treatment; extracted from VECS Efficiency Report, dated April 2010.
Appendix G	Emission Testing Report by EML Air, dated April 2013.

1. INTRODUCTION

1.1. Scope of Report

Terminals Pty Ltd (Terminals) operates a bulk terminal facility in Port Botany, NSW. The facility has a NSW Environmental Protection Licence,1048.

Section 8, U1.4b of the Licence, Pollution Studies and Reduction Programs – Benzene Air Emission Reduction, details the final report requirements of the Pollution Reduction Program (PRP) for benzene. Specifically it requires a final report demonstrating how compliance with the PRP objectives (stated in U1.1) has been achieved. The report must include relevant sampling and analysis to demonstrate that all plant and equipment installed as part of the PRP is performing in accordance with the applicable design specifications and regulations. The objectives of the PRP are to:

a) *reduce air emissions of benzene and crude benzene products storage and transfers from the premises to ensure compliance with EPA relevant health-based impact assessment criteria for all relevant operating scenarios; and*

b) *to require the application of best-practice process design or emission controls to minimise the emissions of benzene to the maximum extent achievable that meets POEO Act 2010 (Clean Air) Regulation.*

This report demonstrates Terminals compliance with the requirements of condition U1.1. The PRP is detailed in Appendix A.

The report includes but is not limited to:

a) Design details, including performance specifications of all necessary process design, emission control and other measure required to ensure compliance with the PRP objectives set out in condition U1.1.

b) Relevant sampling and analysis to demonstrate compliance with design specification and licence condition; and

c) Reduced benzene emissions from storage and handling.

1.2. Background

The bulk storage facility at the Botany site stores and handles a range of flammable liquids including Benzene, Benzene Toluene Xylene (BTX) and Pygas, which generate Volatile Organic Compound (VOC) vapours, Hazardous Air Pollutant (HAP) vapours and odours.

These emissions are generally short term and sporadic in nature-not continuous. Currently the vapours generated from various bulk tanks and activities at the terminal are collected and diluted in an air sweep system, via an extraction fan, then directed to a carbon adsorption Vapour Emission Control System (VECS) before discharge to atmosphere. The system operates with limited effectiveness. There is minimal opportunity to improve the performance of the existing carbon beds.

To reduce emissions of Benzene/BTX from the terminals it is proposed to install a new dedicated vapour collection and emission control system for the Benzene, BTX and Pygas. The new system would use thermal oxidiser technology as the emissions control device.

Section 2 of this report covers the estimated benzene vapour loading generated from the various terminal operations and the estimated emission reduction efficiency required to meet NSW EPA requirements. This also provides the basis for the sizing of the collection system and specification of the thermal oxidiser.

Section 3 of this report contains the design details of the proposed new system.

Section 4 of this report covers the final commissioned details of what has been achieved.

2. BENZENE EMISSIONS

2.1 Source of Vapour

The following bulk tanks were nominated by Terminals as storing Benzene, BTX, and Pygas and two tanks for storing Butyl Acetate and Butanol. The bulk tanks are fixed roof, operate at low pressure and are nitrogen blanketed. These tanks were nominated by Terminals to be connected to the new vapour collection system and thermal oxidiser.

Tank Identification	Tank Volume m^3	Chemical stored
T202	830	Benzene
T203	830	Benzene
T204	1000	Benzene
T205	1000	Benzene
T223	300	Butyl Acetate
T261	160	Butanol

Note: All tanks storing benzene, BTX or Pygas were assumed to contain benzene as a worst case for estimating emissions.

The main potential vapour sources within the facility has been identified as:

- The bulk storage tanks, which are nitrogen blanketed, generate emissions when tank filling occurs;
- The bulk storage tanks also generate vapours when the vapours in the tank expand due to temperature increase during the day (diurnal breathing).
- These are generally an intermittent moderate flow and high concentration vapour source.
- During the filling of ships with BTX and/or Pygas for export, vapours are emitted which contain VOCs and air. These vapours are returned to the facility via extraction fan. These vapours are nitrogen inerted by injecting nitrogen into the vapour collection line so the oxygen concentration is below the Limiting Oxygen Concentration (LOC).

  This is generally an intermittent high flow and low-medium concentration vapour source.

  All emissions are VOC-nitrogen inerted.

A conservative approach was taken for estimating emissions from the tanks for the design basis. Tank T223 was assumed to contain methyl methacrylate instead of butyl acetate and T261 was assumed to contain benzene instead of butanol.

2.1.1 Design Vapour Loading

Basis of Vapour Loading Estimation

The new system has been designed to operate at worst case conditions.

The design basis was nominated by Terminals Pty Ltd, as follow:

- Benzene/BTX Tanks Maximum Breathing
- MMA Tank Breathing
- Truck Unloading (Tank Filling) Benzene / BTX maximum flowrate 60 m3 /hr
- Benzene/BTX Export – maximum flowrate 150 m3/ hr (normal 120 m3 /hr)
- Pygas Export – maximum flowrate 150m3 /hr (normal 120 m3 /hr)

Terminals Pty Ltd has nominated the worst case scenario would be filling 1 tank and 2 ship compartments at the same time.

The design basis assumes the other activities such as pigging and pressure test venting do not occur during maximum tank/ship loading and the rate would be controlled to within the rate of tank filling/ship loading. As such line pigging and venting has not been included below.

The basis for the worst case conditions for emissions is as follows:

Activity	Flowrate (m^3/hr)
Tank filling @ 60m^3/hr each (nominated) (only 1 tank at a time)	60
Tank diurnal breathing of tanks T202, 203, 204, 205, 223, 261 (calculated)	132
Ship filling @ 150 m^3/hr each (maximum) 120m^3/hr each (normal) (2 compartments at the same time (nominated)	240
Nitrogen injection inert flowrate during ship filling (calculated)	600
Total	1032

The worst case VOC emission rate for the proposed new system was calculated based on the above information.

Calculations by CEC Engineers for working losses and diurnal breathing from tanks are based on US EPA tank emission estimation method AP42. Worst case diurnal emissions are based on estimated vapour expansion factors and breathing assumed to occur over 3 hours. The vapour displaced during tank and ship filling is assumed to be saturated vapour at a maximum temperature of 30°C.

The concentrations for various reagents in the vent line can vary depending on what is happening in each tank, whether diurnal breathing is occurring, and whether other operations such as truck unloading and ship loading are in progress.

It is possible for the VECS unit to be receiving a mixture of solvents to solvent free nitrogen. It is possible to have saturated solvent being vented from a tank at the various concentrations depending on the temperature of the surface of the liquid in the tank.

As such the VECS systems must be designed for a worst case.

2.1.2 Maximum Design Vapour Loading

A worst case estimate of the major source and quantity of vapours which will be generated at the terminal are listed below. Benzene was used as the basis for determining emissions for the Benzene, BTX, and Pygas operations (except where otherwise noted as Methyl Methacrylate).
Hydrogen sulphide is present in the BTX. In addition an estimate of the hydrogen sulphide emissions was made, based on a worst case hydrogen sulphide concentration in the BTX vapour space of 4%, during ship loading. (This is based on vapour space tank testing of a bulk tank which recorded a maximum hydrogen sulphide concentration of 4%).

Inlet Stream Data

The maximum vapour loading and inlet stream data is summarised below.

Stream	Maximum rate	Comments
VOC-nitrogen maximum flowrate to thermal oxidiser (m^3/hr)	1032	Stream can vary from pure nitrogen to nitrogen and max. VOC/HAP concentration.
VOC-nitrogen maximum flowrate to thermal oxidiser (kg/hr) Benzene Flammable (MMA) Hydrogen Sulphide (H_2S) Total	 202.8 4.1 6.7 213.6	Calculated mass rate
Estimate total VOC mass rate to thermal oxidiser (kg/hr)	234.9	Calculated mass rate (+10% contingency)

2.2 Actual Benzene Emissions for Treatment

The highest benzene emission rate from the facilities occurs during the export of BTX to a ship with the ship's tanks vapour returning to the facility. The benzene emissions are higher during exporting of BTX compared to Pygas. The benzene concentration is 80 – 90% for BTX while the benzene concentration is approximately 50% for Pygas. Also the BTX transfer rates are slightly higher. Benzene load rates were measured in March 2010 during a BTX ship export and reported to the EPA via a report titled Vapour Emission Control Systems Efficiency Report, dated 30th April 2010. It found the peak benzene load rate for treatment was 6.4 g/sec (23 Kg/hour) towards the end of an export operation. Appendix F details the VEC efficiency table and EML test results from this report for reference.

This shows the actual benzene peak emission loads is approximately 10% of the TO capacity ie conservative capacity design will generate substantially greater residence time and in turn increased efficiency of destruction treatment.

3. DESIGN DETAILS

Preliminary Process Flow Diagrams

Overall a Process Flow Diagram (PFD) for the vapour collection system is included in Appendix B. The PFD details the process requirement for operations at the terminal which generate emissions that are to be collected in the VOC- nitrogen inerted stream. The thermal oxidiser will be sized and installed to handle 100% of the VOC- nitrogen inerted stream. Refer to drawing 110010PFD-001.

Preliminary Piping and Instrumentation Diagrams

Piping and Instrumentation Diagrams (P&ID's) for the collection system and thermal oxidiser detail the components and instrumentation of the new system. These are included in Appendix C. Refer to drawing 110010PID-001, 002 and vendor P&ID of the thermal oxidiser.

Layout and General Arrangement

Layout and general arrangement drawings of the proposed new vapour collection system and thermal oxidiser show the scope, extent and details of the proposed new system. Refer to Appendix D for layout and general arrangement drawings 110010LAY-001 and thermal oxidiser vendor GA.

3.1 Description

The Botany bulk storage facility stores a range of flammable chemicals including Benzene, BTX and Pygas. These chemicals generate volatile organic vapours, hazardous air pollutants and odours from the various operations at the facility including tank filling, ship filling, truck filling and diurnal breathing of tanks. These emissions are generally short term and sporadic in nature and are not continuous. Currently the vapours are directed to an existing carbon adsorption vapour emission collection system which operates with limited effectiveness.

A new vapour emission collection system is being proposed to collect vapours from various Benzene, BTX and Pygas operations. All emissions generated during tank filling, tank breathing and ship loading will be directed to a new thermal oxidiser via a vapour collection line and fan.

The vapour emission collection system will initially be designed to collect vapours from selected storage tanks and ships. The system will be designed to enable vapours from other tanks and other operations to be connected in the future.

The collected vapours will be nitrogen inerted below a safe oxygen level. In the case of the storage tanks nitrogen inerting takes place via the existing nitrogen blanketing system. In the case of ship loading nitrogen is injected into the vapour collection line.

The new vapour collection system will consist of the following major components.

a) New stainless steel vapour collection line.

b) Pressure control systems for the tank cluster vapour line and the ship loading vapour line.

c) Extraction fan in the vapour collection line.

d) Ancillary equipment items, control/isolation valves and instruments associated with collection piping.

e) Safety equipment, items and instruments associated with the collection piping (eg. detonation arrestors, oxygen meters, etc.).

f) New vapour diversion line to the existing carbon adsorption system. The vapour stream is diverted to the carbon adsorption system for treatment before discharge to atmosphere in the event the thermal oxidiser is unavailable to treat the vapours or the oxygen level is high in a particular stream.

g) Using existing dock line between wharf and Exchanger Pit Area 1 for vapour collection from ships.

h) Thermal oxidiser. This is a vertical gas fired unit. It has the following key components:

- A natural gas fired burner system to combust VOC and HAP vapours.
- Thermal oxidiser stack- 17.3 meters height
- Combustion air and quench air fans.
- EPA sample points for testing emissions from stack
- Access platform/s
- Pipework, fittings, valves and any other equipment required for operation of the thermal oxidiser.
- Structures, frames, platforms and access ways compliant with Australian codes and standards.
- Combustion management system in full compliance with AS 5601 and AS 3814.
- Motor control for all drives, junction boxes and field cabling to drives, as required
- Control system and instruments required for the safe and effective operations of the thermal oxidiser- includes dual temperature sensors on stack measuring stack gas temperature, dual oxygen analysers in stack measuring stack gas oxygen level.

3.2 Principle of Operation

The vapour collection system is controlled via the site wide PLC at the terminal. The thermal oxidiser is controlled by a dedicated PLC and burner management system. Critical interlocks are hardwired or through a PLC with a very high level of reliability.

3.2.1 Vapour Collection

There will be a new dedicated vapour collection system for the collection of vapours generated from the Benzene/BTX tanks and during ship filling. Refer to drawings 110010PID-001, 002, Appendix C.

Vapour from tanks during tank filling, diurnal breathing and ship filling shall be collected in a dedicated collection system. This will generally be a high concentration vapour stream. The basis of safety for collecting and transferring the flammable vapours shall be:

- The vapour stream shall be inerted with nitrogen to keep the oxygen concentration below the Limiting Oxygen Concentration (LOC).
- Oxygen analysers shall be installed at a specific location in the collection piping to continuously monitor the level of oxygen and ensure a safe level is being maintained. Emergency isolation shall occur if a high oxygen level is detected.
- Detonation arrestors will also be installed in specific locations to minimise the chance of the propagation of an incident.

The pressure vacuum vent (PRV) on each tank discharges into the tank cluster manifold of the inert collection system. The PRV discharges depending on the pressure in the tank. The pressure in the tank cluster manifold is maintained at nominally atmospheric pressure by a modulating valve and pressure transmitter.

During filling of the ship compartments the vapours from the ship are collected then transported to the inert collection system. To keep the oxygen concentration below the Limiting Oxygen Concentration nitrogen gas will also be injected into the line at the wharf. Pressure in the collection line for the wharf is maintained at nominally -2 kPag negative pressure by a modulating valve and pressure transmitter. A detonation arrestor is located on this line to prevent the propagation of a flame front.

The emissions from the various sources are collected in a dedicated nitrogen inerted rich VOC collection system. The flowrate and concentration of the inert stream will vary significantly depending on the activities being undertaken at the terminal and the prevailing weather conditions. For the majority of the time the flowrate of this stream will be very low or negligible. A skid mounted booster fan, will be provided to assist the transfer of the vapours and to ensure a minimum suction pressure is maintained in the collection system.

Oxygen analysers (2 off) shall be installed at a specific location in the collection piping to continuously monitor the level of oxygen and ensure a safe level is being maintained. If a high oxygen level is detected in the stream, the stream is put into an emergency diversion state. The stream shall be immediately isolated from the emission control device by closing isolation valves, the flowrate shall be reduced by reducing the speed of the fan and the stream shall be diverted to the emergency diversion duct by opening an isolation valve on the duct (the duct is to be connected to carbon VECS Stage III). The system shall have low point drains with sight glass for the collection of condensing vapours.

3.2.2 Thermal Oxidiser

The thermal oxidiser follows a predetermined start up sequence once the start is engaged. The combustion air blower purges the combustion chamber for a predetermined time. Once the purge cycle is complete the pilot is lit. The flame scanner confirms correct operation of the pilot. Once confirmed the gas burner is ignited and temperature of the unit begins to heat. When the operating temperature is attained the valves which isolate the benzene vapour stream are opened and the vapour blower is enabled, allowing then to start and control suction pressure in the collection pipework.

The temperature of the thermal oxidiser is controlled via regulation of the assist gas system and the quench air damper. If insufficient heating value is being provided by the vapour streams to maintain temperature then the assist gas will be added to maintain the temperature of the unit. If vapour loading is high the assist gas will stop and the air quench damper regulated to introduce additional air to maintain the temperature. Dual oxygen sensors in the stack will measure the oxygen content and adjust the combustion air to ensure an excess of oxygen is maintained.

3.3 Basis of Safety

The key design philosophy in transferring and destroying flammable vapours at the terminal is to design in such a manner to

a. Prevent an explosion from occurring in the first place and secondly
b. Prevent an explosion from propagating through the interconnected system

This has been achieved by including both active and passive safety features. These include

(i) Nitrogen blanketing of storage tanks and nitrogen inerting of vapours in the inert vapour collection system.

(ii) In line oxygen monitoring in the inerted vapour collection piping and automatic isolation of the stream to the thermal oxidiser if high oxygen is detected.

(iii) Flame/Detonation arrestors located in the vapour collection piping near the thermal oxidiser, on the suction of the fan, at the exchanger pit collecting vapours from the ships, and on the emergency line to the carbon to prevent propagation of a flame front.

(iv) Liquid catch pot in the vapour collection line. The catch pot at the thermal oxidiser contains high level switches and automatic isolation. This will eliminate the chance of sending flammable liquids to the thermal oxidiser.

There are no specific Australian codes or standards for flammable vapour piping which nominate minimum design pressures. Generally overseas experience and practice as well as German Inflammable liquid standard TRbF 100 recommends piping with a minimum nominal design pressure of PN 10 (1000 kPa) for handling flammable vapours. The basis is that piping with this minimum design pressure would withstand the short term pressure spike of an explosion and would not rupture. US practice is to specify vapour piping to conform to the Pressure Piping code B31.3-Process Piping. Based on the above information it was considered prudent to follow overseas practice and experience and design the flammable vapour piping with a minimum design pressure of 1000 kPa and follow Australian pressure piping codes.

The following design requirements for the collection system have been established in consultation with Terminals Pty Ltd.

(i) All flammable vapour lines shall be of Stainless Steel construction.

(ii) All piping handling flammable vapours shall be designed with a minimum design pressure of 1000 kPa and shall be designed, constructed and tested in accordance with AS 4041.

(iii) All flammable vapour lines shall have low point drains at each low point for removal of condensed vapours.

(iv) All piping shall be earthed and equi-potentially bonded as per AS 1020.

3.4 Thermal Oxidiser Performance Requirements

3.4.1 Destruction Efficiency and Stack Limits

Advice from the EPA has stated that the thermal oxidiser should have a minimum residence time of 0.3 seconds, an operating temperature above 760°C and a destruction efficiency of 99.99%. Refer to Appendix E for EPA advice letter.

The thermal oxidiser VOC destruction performance shall be such, as to limit the mass rate of VOC's at the outlet to less than that detailed below under the range of operating conditions detailed below:

- Minimum destruction efficiency of 99.99 % is required for all VOC/HAP input streams at maximum VOC/HAP load.
- Specific discharge limits for odour and toxic pollutants as detailed in Schedule 2 and 4 (Group 6) of the NSW Protection of the Environment Operations (Clean Air) Regulations 2010. Including discharge stack limits of:
    - Solid particles - 50 mg/m3
    - Nitrogen dioxide (NO2) or Nitric oxide (NO) - 350 mg/m3
    - VOC compounds - 20 mg/m3 VOC's
    - Hydrogen Sulphide (H2S) - 5mg/m3
    - Sulphuric acid mist or sulphur trioxide (SO3) - 100 mg/m3
    - Smoke - Ringelmann 1 or 20% opacity.

To achieve the destruction efficiency of 99.99% thermal oxidiser designers/suppliers have recommended a residence time of 1 second and an operating temperature above 980°C.

The EPA advice letter, in meeting the Environment Operations (Clean Air) Regulations 2010 including the requirements of Division 4 Group 6 treatment plants, is altered to dramatically improve the performance with the following characteristics.

- Minimum operating temperature - 980°C
- Minimum residence time - 1 sec

The thermal oxidiser vendor shall guarantee the thermal oxidiser supplied will destroy the incoming constituents to the degree required. Performance testing for adequate destruction efficiency shall be undertaken based on the nominated chemical constituents.

3.4.2 Start-up/Shutdown

Due to the nature of operations at the terminal and the proposed configuration of the system, the thermal oxidiser shall be capable of:

- Reaching full operating temperature from a shutdown state in 10-15 min.
- Frequent startup -shut downs (once everyday if shutdown at night).
- Suited to extended periods of shut down (typically up to 6 months)-future if a second backup unit is installed.
- Upon a TO trip/shutdown; vent feed streams are automatically diverted to existing activated carbon bed, known as VEC stage II located at southern end of site.

3.4.3 Hours of Operation

The thermal oxidiser shall be capable of operating continuously (approximately 8592 hrs/annum).

3.4.4 Turndown and Transient Response

The VOC inert stream flowrate shall vary from 0 - 1032 m3/hr. The thermal oxidiser shall be designed and sized to handle 0 - 1032 m3/hr of VOC inert stream.

The flow rate of the stream may vary suddenly. The thermal oxidiser shall be designed to handle the transient nature of operation of the flowrates.

The vendor shall specify the maximum turndown achievable with the system offered.

3.4.5 High Temperature Surfaces - Personnel Protection

All equipment items and surfaces running at temperatures in excess of 55°C shall be provided with suitable access restriction, shielding or insulation and lagging for personnel protection.

3.4.6 Exhaust Stack Height

The exhaust stack height shall be 17.3 m.

3.4.7 Noise

The noise level shall not exceed 85 dBA at 1 m from any equipment item.

3.4.8 Low NOx Burners

The burners specified in the thermal oxidiser shall be of the low NOx producing type.

3.4.9 Flue Gas Oxygen Sensor

A flue gas oxygen sensor shall be provided in the outlet stack of the thermal oxidiser. This shall monitor and control the oxygen concentration in the exit stack gases to ensure excess oxygen is always present.

3.4.10 EPA Sample Points

Sample and test points shall be provided on the thermal oxidiser stack in line with EPA requirements, to permit measuring and sampling of the stack gases.

3.4.11 Access Platform and Ladder

Access platform/s and ladder/s shall be provided, where required, to ensure good access for maintenance, monitoring and operation of the thermal oxidiser. This includes good access to the sample points and oxygen sensor.

3.4.12 Visual

No flame or smoke shall be visible from any position at ground level when the thermal oxidiser is operational.

The system shall not produce any visible flame glow or glare. Shielding shall be specified and supplied by the vendor if flame glare is considered a problem.

3.4.13 Sulphuric Acid Corrosion

Hydrogen sulphide (H2S) will be present in the vapour stream which will produce SO2 and SO3 during combustion. To prevent the chance of SO3/sulphuric acid condensing and creating corrosion problems the flue gas temperature and thermal oxidiser skin temperature shall be maintained above the dew point.

4. OPERATION & PERFORMANCE DETAILS

4.1 Project Commissioning

A comparison of the key milestone dates stated in the initial project plan compared with Progress Report status dated 30th November 2012 and the current status as of 17th May 2013 are tabulated below.

INITIAL PROJECT PLAN FOR U1.2		PROGRESS STATUS (30/11/12)	CURRENT STATUS (17/5/2013)
Activity	**Key Date**		
Project start	July 2011	Complete	Complete
Design	September 2011-June 2012	Completed by August/September 2012	Complete
Award contract for thermal oxidiser	December 2011	Completed - December 2011	Complete
Procurement	May – August 2012	Completed - June-September 2012	Complete
Installation	September - December 2012	Completed - 30th November 2012	Complete
Commissioning	October - December 2012	Scheduled December 2012 to January 2013	Complete – details below
Performance trials	January - February 2013	On schedule for January-February 2013	One set complete in April during BTX ship export.

4.2 Detailed Commissioning Plan and Implementation Milestones.

A comparison of the key milestone dates stated in the Progress Report compared with current status as of 17th May 2013 is tabulated below.

Activity	Completion Schedule (updated 7/12/2012)	Current Status (17/5/2013)
Piping and mechanical installation	30th November 2012 (Done)	Complete
Electrical / Instrument installation	30th November 2012 (Done)	Complete
Natural Gas connection	5th December 2012 (Done)	Complete
Check field works compared with P&IDs	Completed 23rd November 2012	Complete
Test instrument loops, alarms and safety trips	12th December 2012	Complete
Gas commissioning approval	14th December 2012	Complete
Cure combustor refractory	7th-12th December 2012 (Started)	Started on 6th December 2012 - Complete
Procedures developed training and competency assessment of operators.	November 2012 – January 2013. Note: Draft package for training and operation was completed by 21st November 2012	Complete
Test combustor on nitrogen gas via inert stream to combustor	21st December 2012	Completed trials with nitrogen on 7th December 2012. Also trials on butyl acetate tank with nitrogen to simulate a ship discharge peak load were completed on 7th December 2012.
Trial Benzene tanks and flammable tanks (stages I & II)	21st December 2012	Completed initial trials on BTX tanks over 12th to 14th February 2013.
Final Commissioning of benzene and flammable tanks (stages I & II)	15th January 2013	Final continuous (24/7) online treatment of the BTX tanks vapour occurred one at a time from 23rd April 2013 to 30th April 2013.

Activity	Completion Schedule (updated 7/12/2012)	Current Status (17/5/2013)
Commission next scheduled BTX/Pygas ship vapour return system to combustor	30th January 2013	Completed initial trial on simulated high nitrogen flow from wharf area to combustor on 4th February 2013. Completed first BTX ship vapour return system to combustor from 7th March 2013. Subsequently all BTX/Pygas ships vapour has been treated by the combustor since 7/3/2013 ie three ship exports over the last 3 months.
COMBUSTOR COMMISSIONED		Benzene emissions from tanks and ship exports have been fully commissioned and continuously online from 1st May 2013.

Commissioning stages overall have extended longer than expected due to technical and people difficulties. These are listed below in brief as future learnings. ie:

- Delay over the Christmas/holiday period due to the entire specialist commissioning team were not available over the festive season (for safety and control did not operate combustor unless a minimum number/skill level from specialist team on site monitoring combustor during daylight and shutting system down at night);
- Design issues with the combustion air fan and the quench air fan caused the gas usage rate to be more than 5 times the design rate; so cost unsustainable and significant increased greenhouse gas emissions until air fan controls modified;
- Benzene as a carcinogen meant any physical connecting vent piping from existing VEC system to combustor vent collection system had extra breathing apparatus respiratory protection for the workers. As this had to be physically changed each day before the combustor was shutdown at night other VOC tanks were trialled and logistics of resolving all issues before setting up all BTX tanks to combustor;
- The BTX tanks had to be separately nitrogen purged before coming onto the combustor as the nitrogen regulators to the tanks were found to be restricted leading to the tanks having high oxygen and in turn tripping the combustor feed (on high oxygen safety trip that prevents a flammable hazard in the collection pipelines) when being set up.

4.3 Thermal Oxidiser Sampling & Analysis.

On 17th April 2013; EML Air Pty Ltd sampled the TO vent stack for various analytes and conditions. This occurred towards the end of a BTX ship discharge and this coincides with the highest emission rate from the ship vapour return. The TO treated the BTX ship vapour return and Emission testing report from EML reported a benzene level below 0.043 mg/m3 and a benzene emission rate of < 0.00018 g/sec; indicatively approximately three orders of magnitude below the licence VOC criteria. The BTX ship export rate was estimated by inventory balance over time during the transfer operation and recorded as 153.5 m3/hour and found to be consistent during the export. Refer to Appendix G or EML Air report, titled Emissions Testing Report – April 2013.

The inlet stream to the TO was considered to be 7.7 g/sec based on the Vapour Emission Control Systems Efficiency Report, dated 30th April 2010 as covered in section 2.2 of 6.4 g/sec for a reported ship export rate of 127 m3/hour compared to this export rate of 153.5 m3/hr.

The TO destruction performance is evaluated using these two pieces of data; as tabulated below.

Description	Benzene inlet mass rate (g/sec)	Benzene outlet mass rate (g/sec)	Thermal Oxidiser Destruction Effectiveness (%)
BTX ship export	7.7	<0.00018	= (7.7 – 0.00018)/7.7 * 100 = 99.998

The TO destruction effectiveness is estimated at >99.99% based on one analysis and consistency with previous ship export load rate data. At this time, there were no other BTX tanks vapours being treated by the combustor. The data demonstrates compliance with design specification and licence condition, section 8, U1.4b. This should be verified by following sampling and analysis of TO vent planned for BTX ship exports during June and August.

4.4 Reduced Benzene Emissions

Estimated benzene emissions using Tanks and mass balance protocols as per our annual EPA Licence load based emission calculations methodology. With column estimating emissions of carbon bed adsorption destruction rate of 90% for all vented emissions over the five months. Also a column estimating actual emissions as a mixture with carbon bed treatment of tanks for four months and TO destruction effectiveness of conservatively 99.9% for one month plus last three BTX ship exports and both Pygas ship exports. This is tabulated below.

Description of conditions for first five months of 2013.	Benzene emission rate from sources (Kg).	Benzene emission rate to atmosphere using carbon beds (Kg) assuming only treatment for last five months.	Benzene emission rate to atmosphere using thermal oxidiser (Kg); when known to be online continuously.(ie does not count day trials before 1st May and only actual ship exports when used).	Reduced benzene emission from theoretical carbon bed treatment to actual mixture of carbon bed and TO for January to May 31st 2013; Kg
Tanks 202, 204 & 205 on BTX duty – diurnal breathing.	3,593	359	288	22
Unloaded 8,100 m^3 of BTX into these three tanks – working losses.	2,489	249	200	49
Ship exported 8,842 m^3 BTX – vapour return.	643	64	16.5	47.5
Ship exported 4,304 m^3 Pygas – vapour return.	374	37	0.4	36.6
TOTAL	4,592	459	304	155

Benzene emissions to atmosphere, over the first five months of 2013, have reduced to approximately 70% by using thermal oxidiser in conjunction with carbon bed compared with theoretical carbon bed treatment system even considering the TO system has only been commissioned fully since 1st May ie one month out of five. But TO has treated the emissions from five out of the six BTX/Pygas ship exports in 2013. The improvement factor for TO treatment is greater than 100 compared with the previous carbon bed treatment system. Overall the emission rate to atmosphere using the TO technology decreases by one thousand times when compared to having no treatment. This is conservatively based on 99.9% destruction effectiveness as TO performance is considered to be much greater taking into account the peak load rate is 10% of capacity providing substantially higher residence times; the design destruction rate of 99.99% and verification of >99.99% destruction effectiveness from one set of analytical data. At this rate the annual benzene emissions for the current licence period is expected to decrease from last years 1,041 Kg to 240 Kg; a substantial emission decrease.

5. CONCLUSION

Terminals have fully commissioned the Thermal Oxidiser and collection systems to continuous online (24/7) treatment of all site generated benzene emissions including BTX storage tanks, BTX unloading from road tankers, BTX ship exports as well as Pygas ship exports. Since February 2013; all BTX ships (three) and Pygas ship (two) vapours while filling the ships tanks were treated continuously by the TO. The BTX tanks vapours were treated by the TO starting with trials in February and resulting in final continuous online treatment of all three tanks by 1st May 2013. As a bonus other VOC tanks (two – butanol and butyl acetate) at stages I and II have also been connected to the TO for treatment providing lower emission rates. This complies with EPA licence condition, section 8, U1.4a ie 'by no later than 31 May 2013, implement all necessary process design, emission controls and other measures to ensure compliance with the PRP objectives set out in condition U1.1' covering reducing air emissions of benzene.

The main reasons for selecting a thermal oxidiser to replace the carbon beds are as follows:

- Meets the accepted emission requirements (current and foreseeable future) with very high emission reduction efficiencies.
- Best available technology for reduction of HAP and VOC emissions.
- Proven technology and relatively simple to operate.
- Flexible and able to handle sudden step changes, wide range of chemicals, stream concentrations and volumetric rates.
- Highly reliable and adaptable.
- Economically viable.
- Recovered HAP/VOC are appropriately disposed on site (no liquid waste to dispose off - site, such as with carbon beds).

The Thermal Oxidiser destruction effectiveness is estimated at >99.99% based on one analysis and consistency with previous ship export load rate data. The result demonstrates compliance with design specification and licence condition, section 8, U1.4b. This should be verified by following sampling and analysis of TO vent stack planned for BTX ship exports during June and August.

Benzene emissions to atmosphere, over the first five months of 2013, have reduced to 70% using thermal oxidiser in conjunction with carbon bed compared with theoretical carbon bed treatment system. The result is substantial when considering the TO system has only been commissioned fully since 1st May. The improvement factor is greater than 100 compared with the previous carbon bed treatment system. Overall the emission rate to atmosphere using the TO technology decreases by one thousand times when compared to having no treatment. This is conservatively based on 99.9% destruction effectiveness as TO performance is considered to be much greater taking into account the peak load rate is 10% of capacity providing substantially higher residence times; the design destruction rate of 99.99% and verification of >99.99% destruction effectiveness from one set of analytical data.

At this rate the annual benzene emissions for the current licence period is expected to decrease from last years 1,041 Kg to 240 Kg and following years to approximately 10 Kg; a substantial and significant emission reduction.

This report demonstrates compliance with EPA licence conditions U1.4 (a) and (b) as well as in turn condition U1.1.

Appendix A

EPA Licence Pollution Studies and Reduction Programs

8 Pollution Studies and Reduction Programs

U1 Benzene Air Emission Reductions

U1.1 The objectives of this PRP are to:

a) reduce air emissions of benzene and crude benzene products storage and transfers from the premises to ensure compliance with the NSW Environment Protection Authority (EPA) relevant health-based impact assessment criteria for all relevant operating scenarios; and

b) to require the application of best-practice process design or emission controls to minimise the emissions of benzene to the maximum extent achievable that meets the *Protection of the Environment Operations Act 2010 (Clean Air) Regulation.*

U1.2 **Project Plan**

By no later than 31 May 2012, the licensee must develop and submit to the Manager Sydney Industry, EPA, PO Box 668, Parramatta, NSW, 2124, a detailed Project Plan and Design Report demonstrating how the licensee will comply with the requirements of conditions U1.1 and U1.3.

The report must include, but need not be limited to:

a) design details, including performance specifications where applicable, of all necessary process design, emission controls and other measures required to ensure compliance with the PRP objectives set out in condition U1.1;

b) a clear demonstration that the process design, emission controls and other measures identified in U1.2a) are best practice;

c) a detailed project plan specifying how the timing requirements of condition U1.4 will be met, including dates for key design, construction, commissioning and other milestones; and

d) a proposed monitoring and maintenance regime for the proposed design, emission controls and other measures identified in U1.2 a).

U1.3 **Progress Report**

By 15 December 2012, the licensee must submit in writing to the *Manager Sydney Industry PO Box 668 Parramatta 2124*, a progress report demonstrating how the licensee has advanced towards completion of U1.4.

The report must include, but need not be limited to:

a) works already completed, timelines for remaining works, progress against key design and implementation milestones developed in U1.2a.

U1.4 **Implementation of all necessary process design emission controls**

The licensee must:

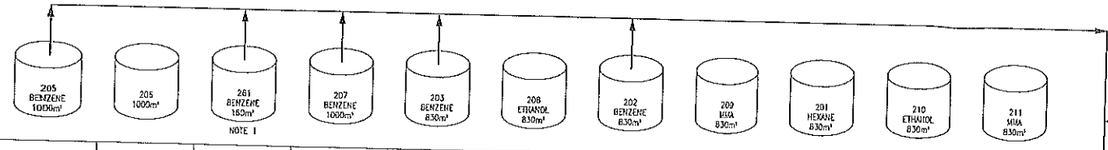
a) by no later than 31 May 2013, implement all necessary process design, emission controls and other measures to ensure compliance with the PRP objectives set out in condition U1.1; and

b) by no later than 30 June 2013, submit a report to the Manager Sydney Industry, EPA, PO Box 668, Parramatta, NSW, 2124, that clearly documents how compliance with the PRP objectives set out in condition U1.1 has been achieved. The report must include relevant sampling and analysis to demonstrate that all plant and equipment installed as part of the PRP is performing in accordance with the applicable design specifications and regulations.

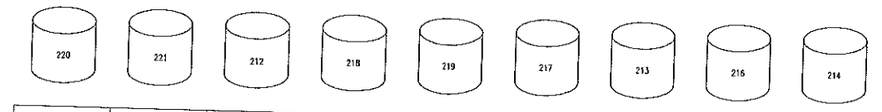
Appendix B

Process Flow Diagram (PFD)

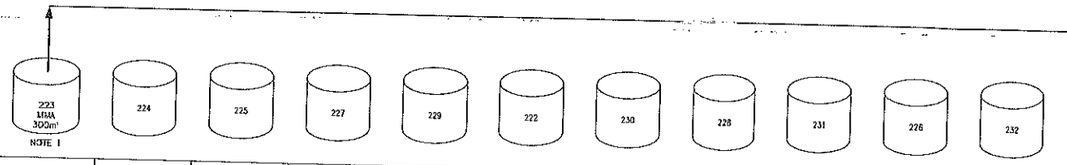
SCENARIO #9	• 100% BTX TANKS MAXIMUM BREATHING • TRUCK UNLOADING BTX • BTX EXPORT • PYGAS EXPORT • MMA TANK BREATHING



Filling rate	m³/hr	–	–	–	–	–	–	–	–	–	–	–
Diurnal emission rate	m³/hr	30	–	5	30	25	–	60	–	–	–	–
Emission concentration	kg/m³	0.49		0.49	0.49	0.49		0.49				



		–						
		–						

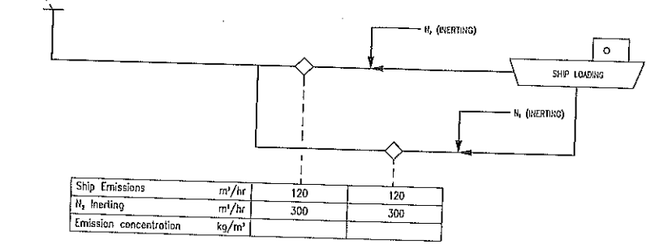


Filling rate	m³/hr	–									
Diurnal emission rate	m³/hr	16									
Emission concentration	kg/m³	0.25									

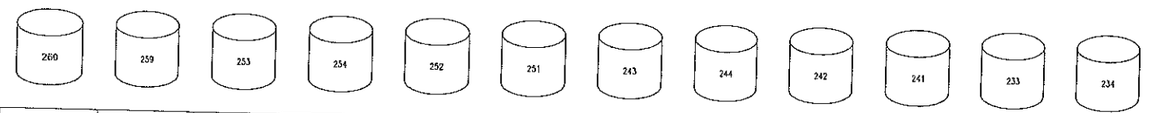
AREA 1

Emission rate	m³/hr	1032
Emission concentration	kg/m³	0.21

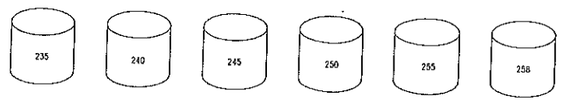
EXCHANGER PIT



Ship Emissions	m³/hr	120	120
N_2 Inerting	m³/hr	300	300
Emission concentration	kg/m³		

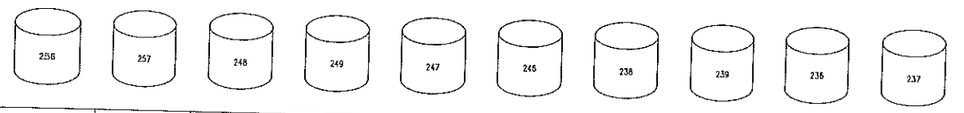


Filling rate	m³/hr	–								–		
Diurnal emission rate	m³/hr	–								–		
Emission concentration	kg/m³											

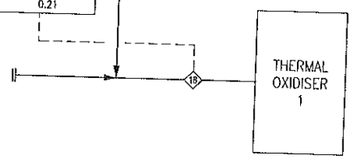


	–					
	–					

Emission rate	m³/hr	1032
Emission concentration	kg/m³	0.21



Filling rate	m³/hr			–		–		–	–		–
Diurnal emission rate	m³/hr			–		–		–	–		–
Emission concentration	kg/m³										



NOTE:

1. DIURNAL BREATHING BASED ON LARGER 830m³ TANK – CONSERVATIVE

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REV	DESCRIPTION	DATE	APP.
B	UPDATE		
A	INITIAL ISSUE	18/05/12	AB
		17/05/11	AB

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PROJECT
VAPOUR EMISSION COLLECTION AND THERMAL OXIDISER - BOTANY TERMINAL

TITLE
PFD
VAPOUR COLLECTION SYSTEM

SCALE	ORIGINAL SIZE
NTS	A1

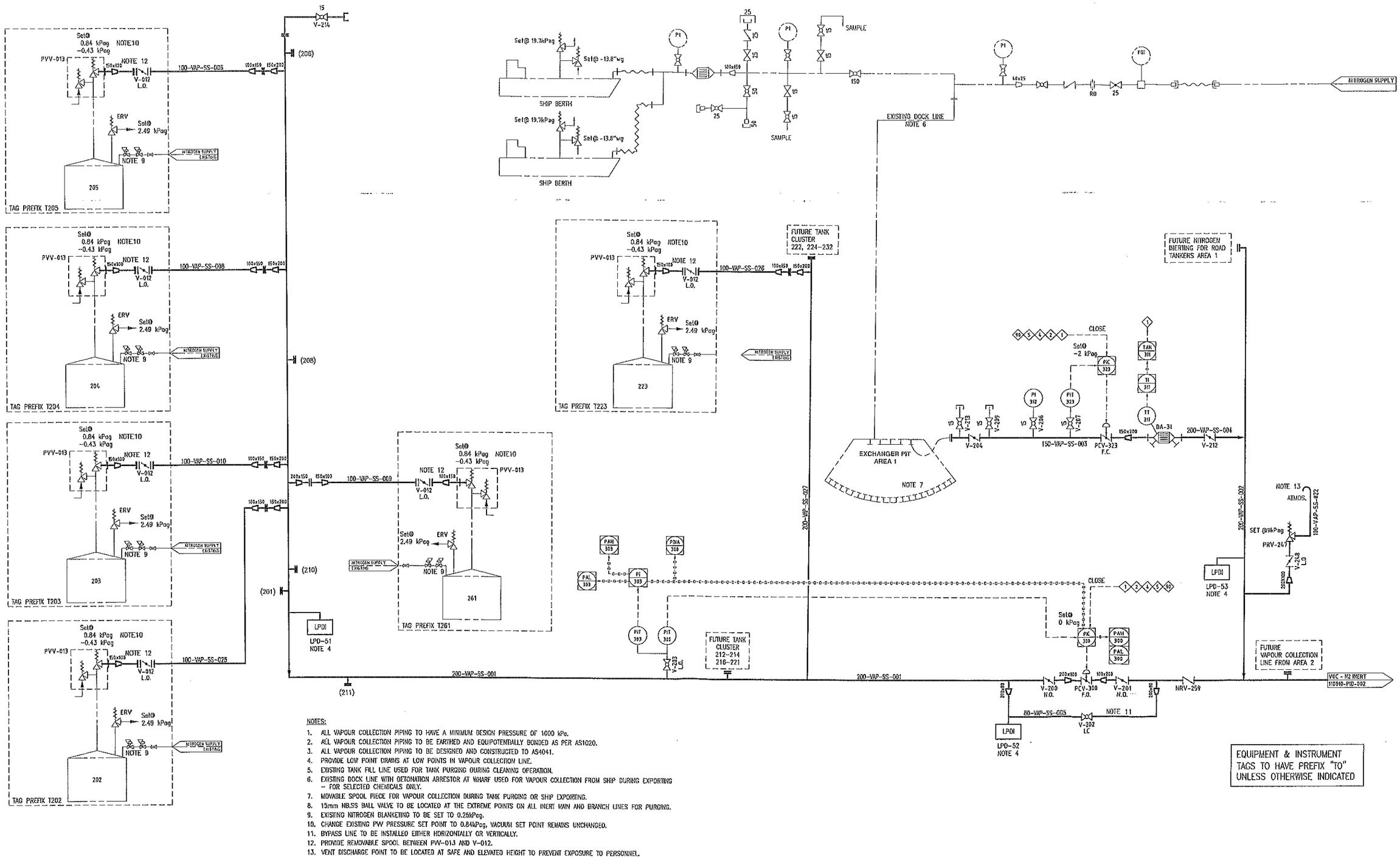
STATUS: PRELIMINARY ONLY

DRAWN	DATE	DESIGNED	DATE	APPROVED	DATE
AP	18/05/12	AB	18/05/12	-	-

PROJECT NO.	DRAWING NO.	REVISION
110010	PFD-001	B

Appendix C

P&IDs.



NOTES:

1. ALL VAPOUR COLLECTION PIPING TO HAVE A MINIMUM DESIGN PRESSURE OF 1000 kPa.
2. ALL VAPOUR COLLECTION PIPING TO BE EARTHED AND EQUIPOTENTIALLY BONDED AS PER AS1020.
3. ALL VAPOUR COLLECTION PIPING TO BE DESIGNED AND CONSTRUCTED TO AS4041.
4. PROVIDE LOW POINT DRAINS AT LOW POINTS IN VAPOUR COLLECTION LINE.
5. EXISTING TANK FILL LINE USED FOR TANK PURGING DURING CLEANING OPERATION.
6. EXISTING DOCK LINE WITH DETONATION ARRESTOR AT WHARF USED FOR VAPOUR COLLECTION FROM SHIP DURING EXPORTING – FOR SELECTED CHEMICALS ONLY.
7. MOVABLE SPOOL PIECE FOR VAPOUR COLLECTION DURING TANK PURGING OR SHIP EXPORTING.
8. 15mm NB.SS BALL VALVE TO BE LOCATED AT THE EXTREME POINTS ON ALL INERT MAIN AND BRANCH LINES FOR PURGING.
9. EXISTING NITROGEN BLANKETING TO BE SET TO 0.25kPag.
10. CHANGE EXISTING PVV PRESSURE SET POINT TO 0.84kPag, VACUUM SET POINT REMAINS UNCHANGED.
11. BYPASS LINE TO BE INSTALLED EITHER HORIZONTALLY OR VERTICALLY.
12. PROVIDE REMOVABLE SPOOL BETWEEN PVV-013 AND V-012.
13. VENT DISCHARGE POINT TO BE LOCATED AT SAFE AND ELEVATED HEIGHT TO PREVENT EXPOSURE TO PERSONNEL.

EQUIPMENT & INSTRUMENT TAGS TO HAVE PREFIX "TO" UNLESS OTHERWISE INDICATED

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REV	DESCRIPTION	DATE	APP.
E	MINOR UPDATES	24/04/12	FS
D	POST HAZOP CHANGES	16/03/12	AB
C	DESIGN REVIEW CHANGES	09/12/11	AB
B	GENERAL REVISIONS	16/09/11	AB
A	INITIAL ISSUE	12/05/11	AB

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PROJECT
VAPOUR EMISSION COLLECTION AND THERMAL OXIDISER - BOTANY TERMINAL

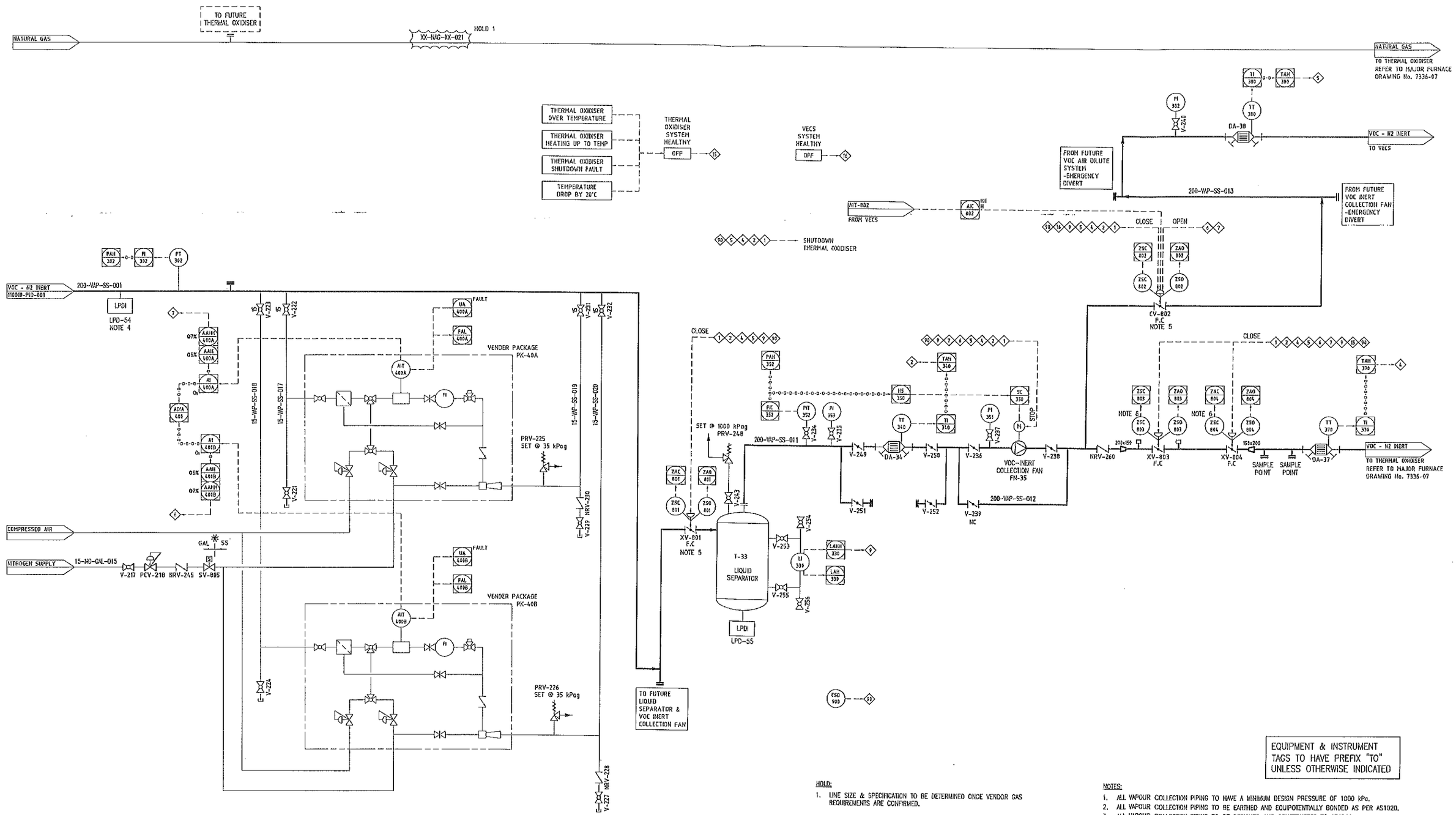
TITLE
PID
VOC INERT COLLECTION SYSTEM
AREA 1 TANKS

SCALE	ORIGINAL SIZE
NTS	A1

STATUS: ISSUED FOR REVIEW & APPROVAL

DRAWN	DATE	DESIGNED	DATE	APPROVED	DATE
YL	12/05/11	AB	12/05/11	FS	.

PROJECT NO.	DRAWING NO.	REVISION
110010	PID-001	E



EQUIPMENT & INSTRUMENT TAGS TO HAVE PREFIX "TO" UNLESS OTHERWISE INDICATED

HOLD:

1. LINE SIZE & SPECIFICATION TO BE DETERMINED ONCE VENDOR GAS REQUIREMENTS ARE CONFIRMED.

NOTES:

1. ALL VAPOUR COLLECTION PIPING TO HAVE A MINIMUM DESIGN PRESSURE OF 1000 kPa.
2. ALL VAPOUR COLLECTION PIPING TO BE EARTHED AND EQUIPOTENTIALLY BONDED AS PER AS1020.
3. ALL VAPOUR COLLECTION PIPING TO BE DESIGNED AND CONSTRUCTED TO AS4041.
4. PROVIDE LOW POINT DRAINS AT LOW POINTS IN VAPOUR COLLECTION LINE.
5. ACTUATED VALVES TO HAVE HIGH OPERATION INTEGRITY VALVES TO BE CONNECTED TO EMERGENCY POWER SUPPLY AND COMPRESSED AIR RESERVOIR TO ENABLE OPEN PATH TO CARBON ABSORPTION AS EMERGENCY OPTION.
6. HARDWIRED CLOSED VALVED STATUS SIGNAL TO BE PROVIDED TO THERMAL OXIDISER CONTROL SYSTEM.

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REV	DESCRIPTION	DATE	APP.
E	MINOR UPDATES	26/04/12	FS
D	POST HAZOP CHANGES	10/02/12	AB
C	DESIGN REVIEW CHANGES	05/12/11	AB
B	GENERAL REVISIONS	19/05/11	AB
A	INITIAL ISSUE	13/07/11	AB

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PROJECT: VAPOUR EMISSION COLLECTION AND THERMAL OXIDISER - BOTANY TERMINAL

TITLE: PID
VOC INERT COLLECTION SYSTEM
MAIN HEADER TO COMBUSTORS

SCALE	ORIGINAL SIZE
NTS	A1

STATUS: ISSUED FOR REVIEW & APPROVAL

DRAWN	DATE	DESIGN CHKD	DATE	APPROVED	DATE
YL	12/05/11	AB	12/05/11	FS	-

PROJECT NO.	DRAWING NO.	REVISION
110010	PID-002	E

REVISION A

DRAWING No 7336-07

ITEM	QTY	PART No	DESCRIPTION	MATERIAL SPEC	TOTAL WEIGHT	CATLT CODE	ORDER

MATERIAL LIST — CADFILE 733667 — DISK — TAPE

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COMBUSTION AIR FAN
FM 01
TP 50
PSL 02
PLC
I
TAH
NG SUPPLY
100 kPa
140 m³/hr
DN40
1
HV 01
TP 1
FE 01
TP 2
PCV 01
PSL 01
TP 3
OPSO SET kPa
TE 01
TAH 02
TE 02
PV
TIC
OP
SP
HMI AUTO
HMI INPUT
HMI MAN
FU
A/M
AFTER BURNER CHAMBER
AE 01
AT 01
LLA
AE 02
AT 02
PLC
LLA
<
STREAM 1 VOC/NITROGEN
STREAM 2 VOC/AIR
HMI AUTO
HMI INPUT
HMI MAN
FU
A/M
SP
PV
AIC
OP
ZSH 02
ZSL 02
TCV 02
BURNER
FS 01
BE 01
BE 02
BZ 01
BC 01
PLC
FS 01
HV 05
XV 09
XV 10
TP 30
TP 31
TP 32
PSH 03
PLC
DILUTION AIR FAN
VVVF
FM 02
>
OP
TIC
PV
SP
HMI INPUT
HMI MAN
A/M
FU
HMI AUTO
HV 04
TP 34
PCV 05
XV 11
XV 12
TP 35
TP 36
TP 37

REFERENCE DRAWINGS

Tolerances Unless Otherwise Noted
On dimensions: Machining / Fabrication
Up to 150: ±0.2 / ±1.0
Over 150 to 500: ±0.5 / ±1.0
Over 500: ±0.8 / ±1.5
All angles: ±½°
Drawing practice to AS1100
All dimensions in millimetres unless noted.
Minimum surface finish to be 6 u.m.a.
All machined surfaces to be 6 u.m.a.
THIRD ANGLE PROJECTION

REV	DATE	REVISIONS	W/O No	EQUIP. No.	W/S	BY	CHECKED	APPRVL
A	14.02.12	FOR APPROVAL	20155100	5159	ISSUE-1	TS		

Major MELBOURNE AUSTRALIA B1

TITLE VOC THERMAL OXIDISER P&I DIAGRAM

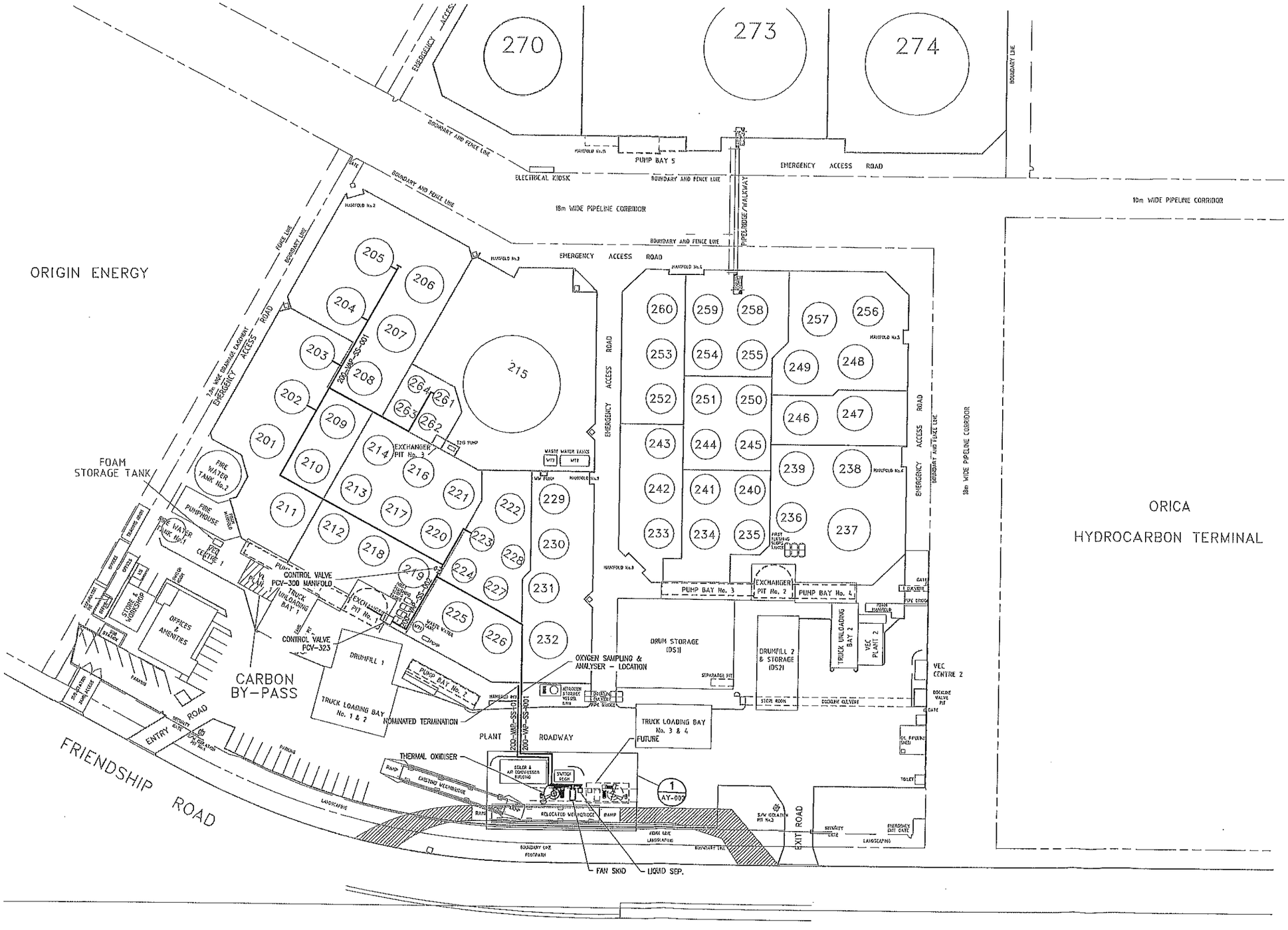
SHT 1 OF 1

DRAWN	DATE	SCALE	CHECKED	Q.O. APPROVAL	ENGINEER APPROVAL	DRAWING No	REVISION
TS	14/02/12	NTS				7336-07	A

PLOT DATE :-

Appendix D

Site Layout and general arrangement.



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REV	DESCRIPTION	DATE	APP.
D	POST HAZOP CHANGES	15/02/2012	AB
C	ROW WEIGHBRIDGE RELOCATED	20/11/2011	AB
B	GENERAL REVISIONS	28/10/2011	AB
A	INITIAL ISSUE	19/09/2011	AB

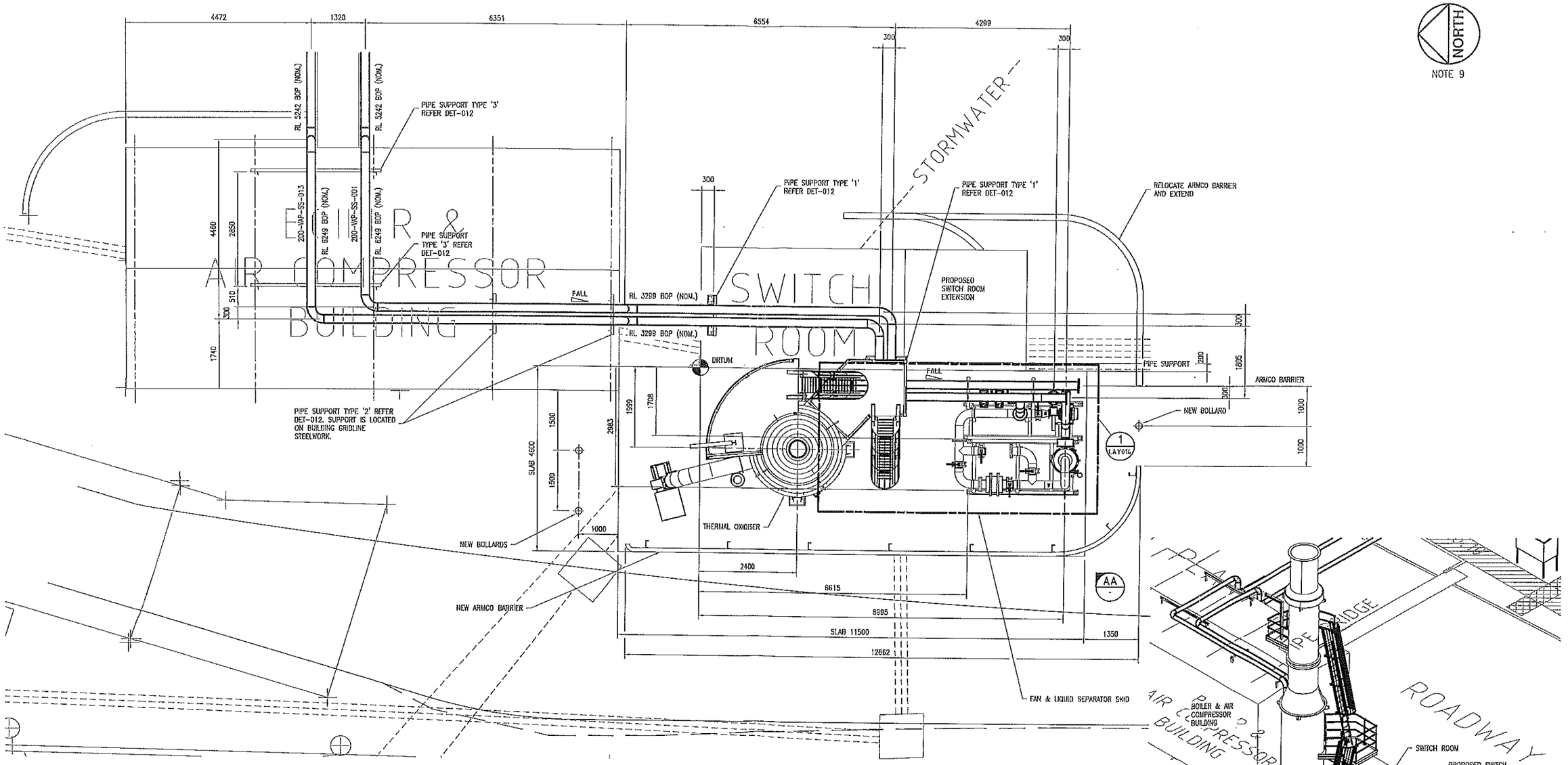
CEC ENGINEERS
PO Box 5230, Moreland West, VIC. 3055
T: (03) 9094 1789 F: (03) 9378 8671

CLIENT
TERMINALS PTY LTD
HEAD OFFICE
LEVEL 13 SUITE 1323
401 DOCKLANDS DRIVE
DOCKLANDS VIC 3008
TEL: (03) 9604 2900 FAX: (03) 9600 2870

PROJECT
VAPOUR EMISSION COLLECTION AND THERMAL OXIDISER - BOTANY TERMINAL

TITLE
CONCEPT LAYOUT
VOC INERT COLLECTION SYSTEM
AREA 1

SCALE 1:500				ORIGINAL SIZE A1	
STATUS PRELIMINARY ONLY					
DRAWN YL	DATE 19/09/2011	DESIGNED/CHKD AB	DATE 19/09/2011	APPROVED FS	DATE .
PROJECT NO. 110010		DRAWING NO. LAY-001		REVISION D	



GENERAL NOTES:

1. ALL VAPOUR COLLECTION PIPING TO HAVE A MINIMUM DESIGN PRESSURE OF 1000 kPa.
2. ALL VAPOUR COLLECTION PIPING TO BE EARTHED AND EQUIPOTENTIALLY BONDED AS PER AS1020.
3. ALL VAPOUR COLLECTION PIPING TO BE DESIGNED AND CONSTRUCTED TO AS4041.
4. ALL LEVELS SHOWN ARE NOMINAL FROM RELATIVE LEVEL DATUM RL000 AT NORTH-WEST CORNER OF SWITCH ROOM
5. CONTRACTOR SHALL CHECK & VERIFY ALL DIMENSIONS & LEVELS PRIOR TO COMMENCING ANY CONSTRUCTION/FABRICATION & NOTIFY TERMINALS OF ANY VARIATION
6. DUCT ROUTE IS INDICATIVE & SHALL BE CONFIRMED ON SITE WITH SUPERINTENDENT
7. PROVIDE EARTH STRAPS TO ALL FLANGES
8. PROVIDE INSULATING RUBBER SLEEVE AROUND DUCT AT EACH PIPE SUPPORT
9. NOMINATED SITE NORTH

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REV	DESCRIPTION	DATE	APP.
A	INITIAL ISSUE	03/04/2012	AB

CEC ENGINEERS
PO Box 5230, Moreland West, VIC. 3055
T: (03) 9094 1789 F: (03) 9378 8671

CLIENT: TERMINALS PTY LTD
HEAD OFFICE
LEVEL 13 SUITE 1323
401 DOCKLANDS DRIVE
DOCKLANDS VIC 3008
TEL: (03) 9604 2800 FAX: (03) 9600 2870

PROJECT: VAPOUR EMISSION COLLECTION AND THERMAL OXIDISER - BOTANY TERMINAL

TITLE: LAYOUT
THERMAL OXIDISER
AREA 1

SCALE	ORIGINAL SIZE
1:50	A1

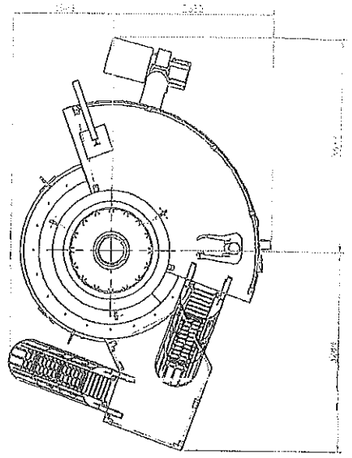
STATUS: ISSUED FOR REVIEW & APPROVAL

DRAWN	DATE	DESIGNED/CKD	DATE	APPROVED	DATE
YL	16/04/2012	AB	16/04/2012	FS	16/04/2012

PROJECT NO.	DRAWING NO.	REVISION
110010	LAY-013	A

REVISION D

DRAWING No P2603-01

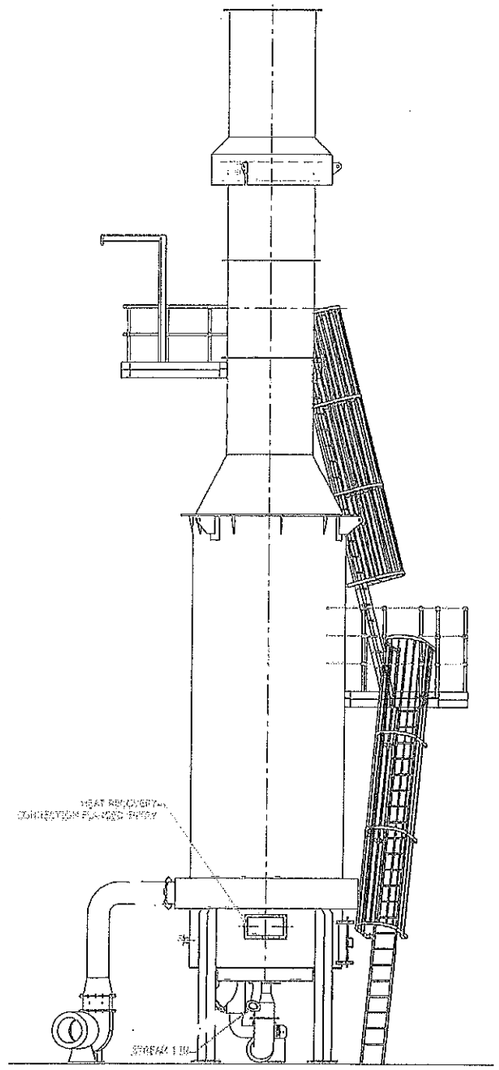


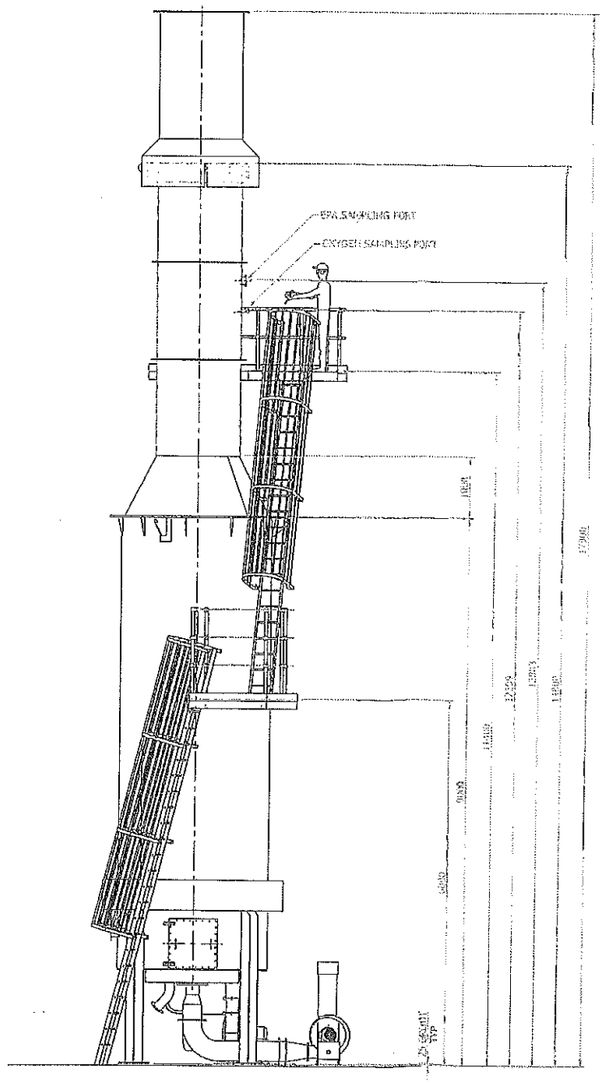
MATERIAL LIST

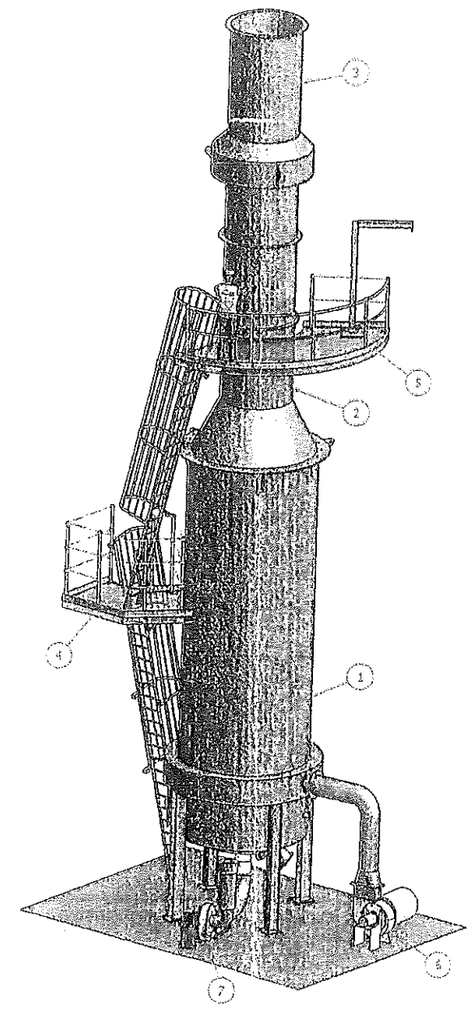
CASTLE DISK / TAPE P2603-01

ITEM	QTY	PART No.	DESCRIPTION	MATL SPEC.	WEIGHT	CAY.IT	ORDER
1	1		COMBUSTION CHAMBER		15606.0		
2	1		LOWER STACK		7945.0		
3	1		UPPER STACK		650.0		
4	1		PLATFORM, LADDER & HANDRAIL STAGE 1		1360.0		
5	1		PLATFORM, LADDER & HANDRAIL STAGE 2		1305.0		
6	1		DILUTION BLOWER & DUCTION		335.0		
7	1		COMBUSTION BLOWER & DUCTING		345.0		

ESTIMATED TOTAL WEIGHT = 25648 kg







3D ISOMETRIC VIEW

NOTE:-
DIMENSIONS AND DETAILS SHOWN ARE APPROXIMATE ONLY AND ARE SUBJECT TO MODIFICATION ON FINAL DESIGN

REFERENCE DRAWINGS

REV	DATE	REVISIONS	W/O No	EQUIP. No	W/S	BY	CHECKED	APPRVL
D	22/09/2011	PRELIMINARY	E104009		ISSUE-B	A.L.		

Tolerances (Unless otherwise noted)

Dia dimensions	Machining	Fabrication
Up to 150	±0.2	±1.0
Over 150 to 500	±0.5	±1.0
Over 500	±0.8	±1.5

All angles ±1/2°

Drawing practice to AS1100
All dimensions in millimetres u.g.o.
Minimum surface finish to be 6.3 U.N.O.
All machined surfaces to be 6.3 U.N.O.

THIRD ANGLE PROJECTION

Major MELBOURNE AUSTRALIA

B1

TITLE AFTERBURNER
GENERAL ARRANGEMENT

SHT 1 OF 1

DRAWN	DATE	SCALE	CHECKED	D.O. APPROVAL	ENGINEER APPROVAL	DRAWING No	REVISION
A.L.	19/09/2011	NTS				P2603-01	D

Appendix E

EPA Advice letter

NSW GOVERNMENT | Office of Environment & Heritage

Your reference
Our reference: DOC11/49621; EPL 1048
Our contact: Stuart Clark 9995 6835

Geoff Millard
National Safety and Environment Manager
Terminals Pty Ltd
PO Box 148
MATRAVILLE NSW 2036

Dear Mr Millard

I refer to the meeting held on 18 October 2011 between Stuart Clark and Kelsey Bawden of the Office of Environment and Heritage – Department of Premier and Cabinet ("OEH") and Terminals Pty Ltd ("Terminals") to discuss emission controls for Terminal's bulk liquid storage terminal located at 45 Friendship Road, Port Botany ("the Premises"), in particular in relation to the existing Benzene Toluene Xylene (BTX) and Pygas stores.

In relation to the emission of volatile organic compounds ("VOCs"), it is noted that they are currently controlled using activated carbon beds. The control system is designed so that emissions from storage tanks and road tanker filling are collected using a vapour ducting system and transferred to one of two activated carbon beds before discharging to atmosphere via an elevated vent stack. However, Terminals has requested that OEH provide guidance on the future management of VOCs from the Pygas storage at the Premises and the requirements of the afterburner for the asphalt plant.

Pygas Combustor

In relation to the storage and handling of volatile organic liquids, Part 6 of the *Protection of the Environment Operations (Clean Air) Regulation 2010* ("Clean Air Regulation") prescribes control equipment and procedures to minimise emissions of VOCs that are applicable to Terminals. Further, Part 5 of the Clean Air Regulation categorises emission control activities and equipment for controlling air impurities (including VOCs) into groups depending on the age of the activity or plant. This grouping has a bearing on the residence time, combustion temperature and destruction efficiency of the treatment plant.

Pursuant to Part 5 of the Clean Air Regulation, any new control equipment for emissions of VOCs would be categorised as a Group 6 treatment plant. However, as it is the intention of Terminals to divert vapour from the BTX and Pygas storage from the existing carbon absorption beds to a new combustor system, the combustor is not taken to be a Group 6 treatment plant by virtue of Clause 33(1) of the Clean Air Regulation. Clause 33(1) of the Clean Air Regulation states:

(1) An emission unit is taken to belong to Group 6 if:

(a) the emission unit is in Group 1, 2, 3, 4 or 5 and is altered as a result of:

(i) the modification of development consent under section 96 (2) of the Environmental Planning and Assessment Act 1979 pursuant to an application made on or after 1 September 2005, or

PO Box 668 Parramatta NSW 2124
Level 7, 79 George St Parramatta NSW 2150
Tel: (02) 9995 5000 Fax: (02) 9995 6900
ABN 30 841 387 271
www.environment.nsw.gov.au

(ii) the variation of the licence for the plant, and

(b) the effect of the alteration is that there is an increase in the emission of air impurities, or a change in the nature of the air impurities emitted or the intensity with which air impurities are emitted, from the plant of which the emission unit forms part, or to which it is attached.

By diverting the emissions from the BTX and Pygas storage to the combustor emissions will be dramatically reduced, thus the alteration Clause 33(1) of the Clean Air Regulation, would be applied. However the OEH expected licence conditions would require the combustor to meet the following minimum residence time and combustion temperature parameters:

- The time between an air impurity entering and exiting the afterburner is more than 0.3 seconds residence time;
- The temperature for the combustion of an air impurity by the afterburner is greater than 760°C
- The minimum destruction efficiency is 99.99%.

Bitumen Combustor
Based on the information provided by Terminals Pty Ltd, the following minimum design parameters are acceptable and are recommended to be applied to the combustor to control emissions from the proposed asphalt plant:

- Temperature >= 760°
- Residence time >= 0.5 seconds
- Maximum VOC concentration at combustor outlet = 40 mg/Nm^3
- Maximum NO_x concentration at combustor outlet = 350 mg/Nm^3

I trust that the above is sufficient to proceed with further discussions in relation to the management of VOCs emissions at the premises. Should you wish to discuss the contents of this letter and the expected licence conditions, please contact Stuart Clark on 9995 6835.

Yours sincerely

2/11/11

GREG SHEEHY
Manager Sydney Industry
Environment Protection and Regulation
Office of Environment and Heritage
Department of Premier and Cabinet

Appendix F

BTX Ship Export Load for treatment extracted from VECS Efficiency Report, dated April 2010.

TERMINALS PTY LTD
PORT BOTANY

VAPOUR EMISSION CONTROL SYSTEMS EFFICIENCY REPORT

Prepared by Geoff Millard
30th April 2010

VEC EFFICIENCIES BASED ON BENZENE

								Wtd Average over 16.9 hours Kg/hr	Estimated Emissions to DECCW Kg/hr	Benzene emission rate used for July 2008 modelling Kg/hr
STAGE 1										
Run No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**			
Sampling Hour	3	6	8	10	12	14	16			
Inlet, g/sec	0.21	0.27	1.1	0.74	1.9	3.1	3.8	5.21	7.18	2.6
Outlet, g/sec	0.016	0.032	0.049	0.013	0.046	0.079	0.099	0.16	0.718	0.26
Weighted hours	4.1	2.3	2	2	2	2	2.5			
Efficiency	92	88	96	98	98	97	97	97		
STAGE 3										
Run No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**			
Sampling Hour	3	6	8	10	12	14	16			
Inlet, g/sec	0.14	0.15	0.35	0.48	0.71	0.83	2.6	2.59	7.18	2.6
Outlet, g/sec	0.0062	0.024	0.065	0.013	0.089	0.094	0.27	0.27	0.718	0.26
Weighted hours	4.1	2.3	2	2	2	2	2.5			
Efficiency	96	84	81	97	87	89	90	90		
Benzene percentage to saturated vapour equilibrium from ship's tanks.#	2.7	3.3	11.3	9.5	20.3	30.6	49.9	17.0		

based on mass balance compared to inlet rate. ie. Flow rate $m^3/hr \times \frac{\text{vapour pressure}}{\text{atmos pressure}} \times \text{Benzene\%} \times \frac{\text{molecular weight}}{\text{ideal gas volume per mol}} = (0.21 + 0.14) \times \frac{3600\ kg}{1000\ hr}$ for run 1.

Where flow rate is $127m^3/hr$ average and overall transfer of $2152m^3$.
Vapour pressure /atmos pressure is 1.535/14.7 = 0.104
Molecular weight is 78 Kg/kg mol.
Ideal gas volume is $22.4m^3$ per kgmol.

EML AIR PTY LTD ABN 98 006 878 342
PO Box 466, Canterbury, Victoria 3126
Telephone(03) 9836 1999 • Facsimile(03) 9830 0670
Email Address: emlair@eml.com.au
Web Address: www.eml.com.au

Our reference: **N85424**

27 April 2010

Terminals Pty Ltd
Gate B38, 45 Friendship Rd
PORT BOTANY NSW 2036

Attention Mr Geoff Millard

PORT BOTANY PLANT

Emission Testing Report - MARCH 2010

Tests were performed at the request of Terminals Pty Ltd to determine emissions to air as detailed below;

Test Summary		
Location	**Test Date**	**Test Parameters***
VEC 1 - Inlet - Run 1	30 March 2010	Speciated volatile organic compounds
VEC 1 - Inlet - Run 2	30 March 2010	Speciated volatile organic compounds
VEC 1 - Inlet - Run 3	31 March 2010	Speciated volatile organic compounds
VEC 1 - Inlet - Run 4	31 March 2010	Speciated volatile organic compounds
VEC 1 - Inlet - Run 5	31 March 2010	Speciated volatile organic compounds
VEC 1 - Inlet - Run 6	31 March 2010	Speciated volatile organic compounds
VEC 1 - Inlet - Run 7	31 March 2010	Speciated volatile organic compounds
VEC 1 - Outlet - Run 1	30 March 2010	Speciated volatile organic compounds
VEC 1 - Outlet - Run 2	30 March 2010	Speciated volatile organic compounds
VEC 1 - Outlet - Run 3	31 March 2010	Speciated volatile organic compounds
VEC 1 - Outlet - Run 4	31 March 2010	Speciated volatile organic compounds
VEC 1 - Outlet - Run 5	31 March 2010	Speciated volatile organic compounds
VEC 1 - Outlet - Run 6	31 March 2010	Speciated volatile organic compounds
VEC 1 - Outlet - Run 7	31 March 2010	Speciated volatile organic compounds
VEC 2 - Inlet - Run 1	30 March 2010	Speciated volatile organic compounds
VEC 2 - Inlet - Run 2	30 March 2010	Speciated volatile organic compounds
VEC 2 - Inlet - Run 3	31 March 2010	Speciated volatile organic compounds
VEC 2 - Inlet - Run 4	31 March 2010	Speciated volatile organic compounds
VEC 2 - Inlet - Run 5	31 March 2010	Speciated volatile organic compounds
VEC 2 - Inlet - Run 6	31 March 2010	Speciated volatile organic compounds
VEC 2 - Inlet - Run 7	31 March 2010	Speciated volatile organic compounds
VEC 2 - Outlet - Run 1	30 March 2010	Speciated volatile organic compounds
VEC 2 - Outlet - Run 2	30 March 2010	Speciated volatile organic compounds
VEC 2 - Outlet - Run 3	31 March 2010	Speciated volatile organic compounds
VEC 2 - Outlet - Run 4	31 March 2010	Speciated volatile organic compounds
VEC 2 - Outlet - Run 5	31 March 2010	Speciated volatile organic compounds
VEC 2 - Outlet - Run 6	31 March 2010	Speciated volatile organic compounds
VEC 2 - Outlet - Run 7	31 March 2010	Speciated volatile organic compounds

* Flow rate, velocity, temperature and moisture were determined unless otherwise stated.

NATA
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Please refer to the following pages for results, plant operating conditions, test methods, quality assurance / quality control information and definitions.

Aaron Davis BSc LLB (Hons)
NATA Signatory
cs doc:n85424.doc

Melissa Reddan BAppSc
NATA Signatory

NATA
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RESULTS

Date	30/03/2010	**Client**	Terminals Pty Ltd	
Report	N85424	**Stack ID**	VEC 1 - Inlet - Run 1	
Licence No.	-	**Location**	Port Botany	**State** NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	450	0.159 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Centrifugal fan	3 D
Upstream disturbance	Change in diameter	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.8	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	12	12
Volumetric flow rate, discharge, m³/s	2	2
Volumetric flow rate (wet NTP), m³/s	1.8	1.8
Volumetric flow rate (dry NTP), m³/s	1.8	1.8
Mass flow rate (wet basis), kg/hour	8300	8300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			1915-2015		1915-2015	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.072	0.13	0.066	0.12	0.078	0.14

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			1915-2015		1915-2015	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.00069	<0.0012	<0.0008	<0.0014	<0.00058	<0.001
Benzene	0.12	0.21	0.11	0.19	0.13	0.23
Toluene	0.0074	0.013	0.0069	0.012	0.0078	0.014
Butyl acetate	0.0041	0.0072	0.0032	0.0056	0.0049	0.0087

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Buloxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate,
Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	30/03/2010	**Client**	Terminals Pty Ltd	
Report	N85424	**Stack ID**	VEC 1 - Inlet - Run 2	
Licence No.	-	**Location**	Port Botany	**State** NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	450	0.159 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Centrifugal fan	3 D
Upstream disturbance	Change in diameter	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.8	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	12	12
Volumetric flow rate, discharge, m³/s	2	2
Volumetric flow rate (wet NTP), m³/s	1.8	1.8
Volumetric flow rate (dry NTP), m³/s	1.8	1.8
Mass flow rate (wet basis), kg/hour	8300	8300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			2200-2300		2200-2300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.093	0.16	0.096	0.17	0.09	0.16

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			2200-2300		2200-2300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.0008	<0.0014	<0.0011	<0.0019	<0.00051	<0.0009
Benzene	0.15	0.27	0.16	0.28	0.15	0.26
Toluene	0.0095	0.017	0.0096	0.017	0.0094	0.017
Butyl acetate	0.0033	0.0058	0.0023	0.0041	0.0042	0.0074

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 1 - Inlet - Run 3		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	450	0.159 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Centrifugal fan	3 D
Upstream disturbance	Change in diameter	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.8	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	12	12
Volumetric flow rate, discharge, m³/s	2	2
Volumetric flow rate (wet NTP), m³/s	1.8	1.8
Volumetric flow rate (dry NTP), m³/s	1.8	1.8
Mass flow rate (wet basis), kg/hour	8300	8300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0000-0100		0000-0100	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.37	0.66	0.35	0.62	0.4	0.7

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0000-0100		0000-0100	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.00069	<0.0012	<0.00069	<0.0012	<0.00069	<0.0012
Benzene	0.64	1.1	0.6	1.1	0.68	1.2
Toluene	0.024	0.042	0.02	0.035	0.028	0.049
Butyl acetate	0.0024	0.0042	0.0017	0.0031	0.003	0.0053

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd	
Report	N85424	**Stack ID**	VEC 1 - Inlet - Run 4	
Licence No.	-	**Location**	Port Botany	**State** NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	450	0.159 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Centrifugal fan	3 D
Upstream disturbance	Change in diameter	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.8	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	12	12
Volumetric flow rate, discharge, m³/s	2	2
Volumetric flow rate (wet NTP), m³/s	1.8	1.8
Volumetric flow rate (dry NTP), m³/s	1.8	1.8
Mass flow rate (wet basis), kg/hour	8300	8300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0200-0300		0200-0300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.24	0.43	0.26	0.47	0.22	0.39

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0200-0300		0200-0300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.0007	<0.0012	<0.00071	<0.0013	<0.00069	<0.0012
Benzene	0.42	0.74	0.45	0.8	0.38	0.67
Toluene	0.015	0.027	0.016	0.029	0.014	0.025
Butyl acetate	0.0012	0.0022	0.0015	0.0027	0.00091	0.0016

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate,
Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 1 - Inlet - Run 5		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	450	0.159 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Centrifugal fan	3 D
Upstream disturbance	Change in diameter	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.8	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	12	12
Volumetric flow rate, discharge, m³/s	2	2
Volumetric flow rate (wet NTP), m³/s	1.8	1.8
Volumetric flow rate (dry NTP), m³/s	1.8	1.8
Mass flow rate (wet basis), kg/hour	8300	8300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0400-0500		0400-0500	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.62	1.1	0.67	1.2	0.58	1

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0400-0500		0400-0500	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.0013	<0.0024	<0.0015	<0.0026	<0.0012	<0.0021
Benzene	1.1	1.9	1.1	2	1	1.8
Toluene	0.035	0.062	0.041	0.073	0.028	0.05

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Bulyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 1 - Inlet - Run 6		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	450	0.159 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Centrifugal fan	3 D
Upstream disturbance	Change in diameter	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.8	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	12	12
Volumetric flow rate, discharge, m³/s	2	2
Volumetric flow rate (wet NTP), m³/s	1.8	1.8
Volumetric flow rate (dry NTP), m³/s	1.8	1.8
Mass flow rate (wet basis), kg/hour	8300	8300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0600-0700		0600-0700	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	1	1.8	1.1	1.9	1	1.8

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0600-0700		0600-0700	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.0015	<0.0027	<0.0016	<0.0027	<0.0015	<0.0027
Benzene	1.8	3.1	1.8	3.2	1.7	3.1
Toluene	0.063	0.11	0.063	0.11	0.062	0.11

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 1 - Inlet - Run 7		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	450	0.159 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Centrifugal fan	3 D
Upstream disturbance	Change in diameter	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.8	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	12	12
Volumetric flow rate, discharge, m³/s	2	2
Volumetric flow rate (wet NTP), m³/s	1.8	1.8
Volumetric flow rate (dry NTP), m³/s	1.8	1.8
Mass flow rate (wet basis), kg/hour	8300	8300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0800-0830		0800-0830	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	1.3	2.2	1.2	2.1	1.3	2.3

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0800-0830		0800-0830	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.0046	<0.0081	<0.0061	<0.011	<0.0031	<0.0054
Benzene	2.2	3.8	2.1	3.7	2.2	4
Toluene	0.073	0.13	0.079	0.14	0.067	0.12

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate,
Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	30/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 1 - Outlet - Run 1		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	10 D
Upstream disturbance	Bend	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.9	
Gas molecular weight, g/g mole	28.7 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	15	15
Volumetric flow rate, discharge, m³/s	1.8	1.8
Volumetric flow rate (wet NTP), m³/s	1.7	1.7
Volumetric flow rate (dry NTP), m³/s	1.7	1.7
Mass flow rate (wet basis), kg/hour	7900	7900
Velocity difference, %	1	1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			1920-2020		1920-2020	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.0061	0.01	0.0067	0.011	0.0055	0.0092

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			1920-2020		1920-2020	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.00028	<0.00046	<0.00025	<0.00041	<0.00031	<0.00051
Benzene	0.0096	0.016	0.011	0.018	0.0084	0.014
Toluene	0.0015	0.0024	0.0014	0.0024	0.0015	0.0025

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	30/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 1 - Outlet - Run 2		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	10 D
Upstream disturbance	Bend	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.9	
Gas molecular weight, g/g mole	28.7 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	15	15
Volumetric flow rate, discharge, m³/s	1.8	1.8
Volumetric flow rate (wet NTP), m³/s	1.7	1.7
Volumetric flow rate (dry NTP), m³/s	1.7	1.7
Mass flow rate (wet basis), kg/hour	7900	7900
Velocity difference, %	1	1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			2200-2300		2200-2300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.012	0.02	0.015	0.025	0.0084	0.014

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			2200-2300		2200-2300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.00025	<0.00042	<0.00019	<0.00031	<0.00032	<0.00053
Benzene	0.019	0.032	0.025	0.043	0.013	0.022
Toluene	0.0017	0.0028	0.0015	0.0026	0.0018	0.003

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Bulyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd	
Report	N85424	**Stack ID**	VEC 1 - Outlet - Run 3	
Licence No.	-	**Location**	Port Botany	**State** NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	10 D
Upstream disturbance	Bend	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.9	
Gas molecular weight, g/g mole	28.7 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	15	15
Volumetric flow rate, discharge, m³/s	1.8	1.8
Volumetric flow rate (wet NTP), m³/s	1.7	1.7
Volumetric flow rate (dry NTP), m³/s	1.7	1.7
Mass flow rate (wet basis), kg/hour	7900	7900
Velocity difference, %	1	1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0000-0100		0000-0100	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.018	0.03	0.019	0.032	0.016	0.027

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0000-0100		0000-0100	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.0004	<0.00066	<0.00044	<0.00073	<0.00036	<0.0006
Benzene	0.029	0.049	0.032	0.053	0.027	0.045
Toluene	0.0023	0.0038	0.0025	0.0042	0.002	0.0034

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate,
Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 1 - Outlet - Run 4		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	10 D
Upstream disturbance	Bend	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.9	
Gas molecular weight, g/g mole	28.7 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	15	15
Volumetric flow rate, discharge, m³/s	1.8	1.8
Volumetric flow rate (wet NTP), m³/s	1.7	1.7
Volumetric flow rate (dry NTP), m³/s	1.7	1.7
Mass flow rate (wet basis), kg/hour	7900	7900
Velocity difference, %	1	1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0200-0300		0200-0300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.0053	0.0089	0.0055	0.0091	0.0051	0.0086

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0200-0300		0200-0300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.00035	<0.00059	<0.00034	<0.00057	<0.00036	<0.00061
Benzene	0.0076	0.013	0.0078	0.013	0.0073	0.012
Toluene	0.0021	0.0036	0.0022	0.0036	0.0021	0.0035

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MiBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 1 - Outlet - Run 5		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	10 D
Upstream disturbance	Bend	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.9	
Gas molecular weight, g/g mole	28.7 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	15	15
Volumetric flow rate, discharge, m³/s	1.8	1.8
Volumetric flow rate (wet NTP), m³/s	1.7	1.7
Volumetric flow rate (dry NTP), m³/s	1.7	1.7
Mass flow rate (wet basis), kg/hour	7900	7900
Velocity difference, %	1	1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0400-0500		0400-0500	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.018	0.03	0.019	0.032	0.016	0.027

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0400-0500		0400-0500	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.00066	<0.0011	<0.00063	<0.0011	<0.00068	<0.0011
Benzene	0.027	0.046	0.031	0.051	0.024	0.04
Toluene	0.0047	0.0079	0.0034	0.0058	0.006	0.01

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate,
Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 1 - Outlet - Run 6		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	10 D
Upstream disturbance	Bend	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.9	
Gas molecular weight, g/g mole	28.7 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	15	15
Volumetric flow rate, discharge, m³/s	1.8	1.8
Volumetric flow rate (wet NTP), m³/s	1.7	1.7
Volumetric flow rate (dry NTP), m³/s	1.7	1.7
Mass flow rate (wet basis), kg/hour	7900	7900
Velocity difference, %	1	1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0600-0700		0600-0700	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.029	0.048	0.03	0.051	0.027	0.046

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0600-0700		0600-0700	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.00071	<0.0012	<0.00069	<0.0012	<0.00074	<0.0012
Benzene	0.047	0.079	0.05	0.083	0.044	0.074
Toluene	0.0049	0.0082	0.0047	0.0079	0.0051	0.0086

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd	
Report	N85424	**Stack ID**	VEC 1 - Outlet - Run 7	
Licence No.	-	**Location**	Port Botany	**State** NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	10 D
Upstream disturbance	Bend	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.9	
Gas molecular weight, g/g mole	28.7 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	15	15
Volumetric flow rate, discharge, m³/s	1.8	1.8
Volumetric flow rate (wet NTP), m³/s	1.7	1.7
Volumetric flow rate (dry NTP), m³/s	1.7	1.7
Mass flow rate (wet basis), kg/hour	7900	7900
Velocity difference, %	1	1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0800-0830		0800-0830	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.037	0.062	0.035	0.058	0.039	0.066

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0800-0830		0800-0830	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.0014	<0.0023	<0.0014	<0.0024	<0.0013	<0.0022
Benzene	0.059	0.099	0.053	0.089	0.065	0.11
Toluene	0.0081	0.014	0.0099	0.017	0.0062	0.01

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Bulyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Bulylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	30/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 2 - Inlet - Run 1		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Bend	3 D
Upstream disturbance	Centrifugal fan	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.5	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	9.5	9.5
Volumetric flow rate, discharge, m³/s	1.2	1.2
Volumetric flow rate (wet NTP), m³/s	1.1	1.1
Volumetric flow rate (dry NTP), m³/s	1.1	1.1
Mass flow rate (wet basis), kg/hour	5300	5300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			1915-2015		1915-2015	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.075	0.085	0.089	0.1	0.061	0.069

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			1915-2015		1915-2015	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.0016	<0.0018	<0.00069	<0.00078	<0.0025	<0.0028
Benzene	0.12	0.14	0.15	0.17	0.096	0.11
Toluene	0.01	0.012	0.007	0.0079	0.014	0.016
Heptane	-	-	0.0014	0.0016	<0.0025	<0.0028

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, *m*+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	30/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 2 - Inlet - Run 2		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Bend	3 D
Upstream disturbance	Centrifugal fan	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.5	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	9.5	9.5
Volumetric flow rate, discharge, m³/s	1.2	1.2
Volumetric flow rate (wet NTP), m³/s	1.1	1.1
Volumetric flow rate (dry NTP), m³/s	1.1	1.1
Mass flow rate (wet basis), kg/hour	5300	5300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			2200-2300		2200-2300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.077	0.087	0.084	0.094	0.071	0.08

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			2200-2300		2200-2300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.00077	<0.00087	<0.00081	<0.00092	<0.00074	<0.00083
Benzene	0.13	0.15	0.14	0.16	0.12	0.13
Toluene	0.0084	0.0094	0.0078	0.0088	0.0089	0.01

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd	
Report	N85424	**Stack ID**	VEC 2 - Inlet - Run 3	
Licence No.	-	**Location**	Port Botany	**State** NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Bend	3 D
Upstream disturbance	Centrifugal fan	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.5	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	9.5	9.5
Volumetric flow rate, discharge, m³/s	1.2	1.2
Volumetric flow rate (wet NTP), m³/s	1.1	1.1
Volumetric flow rate (dry NTP), m³/s	1.1	1.1
Mass flow rate (wet basis), kg/hour	5300	5300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0000-0100		0000-0100	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.2	0.23	0.22	0.25	0.21	0.24

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0000-0100		0000-0100	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.00069	<0.00078	<0.00058	<0.00065	<0.0008	<0.00091
Benzene	0.31	0.35	0.32	0.36	0.3	0.33
Toluene	0.01	0.011	0.0094	0.011	0.011	0.012
Hexane	0.0033	0.0037	0.0033	0.0038	0.0033	0.0037
2-Methylhexane	0.068	0.077	0.07	0.079	0.066	0.075
2,3-Dimethylpentane	0.0017	0.0019	0.0017	0.0019	0.0016	0.0019
Heptane	0.0087	0.0098	0.0092	0.01	0.0082	0.0093
Methylcyclohexane	0.0026	0.003	0.0027	0.0031	0.0025	0.0028

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd	
Report	N85424	**Stack ID**	VEC 2 - Inlet - Run 4	
Licence No.	-	**Location**	Port Botany	**State** NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Bend	3 D
Upstream disturbance	Centrifugal fan	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.5	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	9.5	9.5
Volumetric flow rate, discharge, m³/s	1.2	1.2
Volumetric flow rate (wet NTP), m³/s	1.1	1.1
Volumetric flow rate (dry NTP), m³/s	1.1	1.1
Mass flow rate (wet basis), kg/hour	5300	5300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0200-0300		0200-0300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.25	0.28	0.26	0.29	0.24	0.27

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0200-0300		0200-0300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.0016	<0.0018	<0.0016	<0.0019	<0.0015	<0.0017
Benzene	0.42	0.48	0.43	0.49	0.41	0.46
Toluene	0.018	0.021	0.02	0.023	0.016	0.018
Heptane	0.0038	0.0043	0.0042	0.0047	0.0035	0.0039

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate,
Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 2 - Inlet - Run 5		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Bend	3 D
Upstream disturbance	Centrifugal fan	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.5	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	9.5	9.5
Volumetric flow rate, discharge, m³/s	1.2	1.2
Volumetric flow rate (wet NTP), m³/s	1.1	1.1
Volumetric flow rate (dry NTP), m³/s	1.1	1.1
Mass flow rate (wet basis), kg/hour	5300	5300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0400-0500		0400-0500	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.37	0.42	0.39	0.44	0.35	0.39

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0400-0500		0400-0500	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.0021	<0.0024	<0.0016	<0.0019	<0.0026	<0.003
Benzene	0.63	0.71	0.66	0.75	0.59	0.66
Toluene	0.023	0.026	0.022	0.025	0.025	0.028
Heptane	0.0038	0.0042	0.0043	0.0048	0.0032	0.0037
Methylcyclohexane	-	-	0.0017	0.0019	<0.0026	<0.003

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 2 - Inlet - Run 6		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Bend	3 D
Upstream disturbance	Centrifugal fan	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.5	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	9.5	9.5
Volumetric flow rate, discharge, m³/s	1.2	1.2
Volumetric flow rate (wet NTP), m³/s	1.1	1.1
Volumetric flow rate (dry NTP), m³/s	1.1	1.1
Mass flow rate (wet basis), kg/hour	5300	5300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0600-0700		0600-0700	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.43	0.48	0.44	0.49	0.42	0.47

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0600-0700		0600-0700	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.0013	<0.0015	<0.001	<0.0011	<0.0016	<0.0018
Benzene	0.73	0.83	0.75	0.85	0.71	0.8
Toluene	0.025	0.028	0.024	0.028	0.026	0.029
Heptane	-	-	0.0012	0.0013	<0.0016	<0.0018

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	31/03/2010	**Client**	Terminals Pty Ltd	
Report	N85424	**Stack ID**	VEC 2 - Inlet - Run 7	
Licence No.	-	**Location**	Port Botany	**State** NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	400	0.126 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	2 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Bend	3 D
Upstream disturbance	Centrifugal fan	2 D
No. traverses & points sampled	2	12
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.5	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	9.5	9.5
Volumetric flow rate, discharge, m³/s	1.2	1.2
Volumetric flow rate (wet NTP), m³/s	1.1	1.1
Volumetric flow rate (dry NTP), m³/s	1.1	1.1
Mass flow rate (wet basis), kg/hour	5300	5300
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0800-0830		0800-0830	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	1.4	1.5	1.3	1.5	1.4	1.6

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0800-0830		0800-0830	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.0028	<0.0031	<0.0028	<0.0032	<0.0027	<0.0031
Benzene	2.3	2.6	2.2	2.5	2.4	2.7
Toluene	0.056	0.063	0.059	0.067	0.053	0.059
2-Methylhexane	0.07	0.079	0.072	0.082	0.067	0.076
Heptane	0.0076	0.0086	0.0074	0.0083	0.0079	0.0089
Methylcyclohexane	0.004	0.0045	0.0038	0.0043	0.0042	0.0047

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate,
Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	30/03/2010	Client	Terminals Pty Ltd	
Report	N85424	Stack ID	VEC 2 - Outlet - Run 1	
Licence No.	-	Location	Port Botany	State NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	320	0.0804 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Junction	2 D
Upstream disturbance	Junction	4 D
No. traverses & points sampled	2	8
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the downstream disturbance but is greater than or equal to 1D
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.7	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	17	17
Volumetric flow rate, discharge, m³/s	1.3	1.3
Volumetric flow rate (wet NTP), m³/s	1.2	1.2
Volumetric flow rate (dry NTP), m³/s	1.2	1.2
Mass flow rate (wet basis), kg/hour	5800	5800
Velocity difference, %	<1	<1

VOC's (as n-Propane) Totals	Average		Test 1 1915-2015		Test 2 1915-2015	
Sampling time	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.0052	0.0063	0.0049	0.006	0.0055	0.0067

VOC's (speciated)	Average		Test 1 1915-2015		Test 2 1915-2015	
Sampling time	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.0003	<0.00037	<0.00031	<0.00038	<0.00029	<0.00035
Benzene	0.0051	0.0062	0.0048	0.0059	0.0053	0.0065
Toluene	0.001	0.0012	0.00084	0.001	0.0012	0.0014
2-Methylhexane	0.0038	0.0047	0.0036	0.0044	0.0041	0.005
Methylcyclohexane	0.00038	0.00047	0.00034	0.00042	0.00042	0.00051

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	30/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 2 - Outlet - Run 2		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	320	0.0804 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Junction	2 D
Upstream disturbance	Junction	4 D
No. traverses & points sampled	2	8
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the downstream disturbance but is greater than or equal to 1D
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.7	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	17	17
Volumetric flow rate, discharge, m³/s	1.3	1.3
Volumetric flow rate (wet NTP), m³/s	1.2	1.2
Volumetric flow rate (dry NTP), m³/s	1.2	1.2
Mass flow rate (wet basis), kg/hour	5800	5800
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			2200-2300		2200-2300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.012	0.015	0.012	0.015	0.012	0.015

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			2200-2300		2200-2300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.00038	<0.00047	<0.00038	<0.00046	<0.00038	<0.00047
Benzene	0.02	0.024	0.019	0.024	0.02	0.025
Toluene	0.0018	0.0023	0.0021	0.0026	0.0016	0.0019

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	31/03/2010	Client	Terminals Pty Ltd	
Report	N85424	Stack ID	VEC 2 - Outlet - Run 3	
Licence No.	-	Location	Port Botany	State NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	320	0.0804 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Junction	2 D
Upstream disturbance	Junction	4 D
No. traverses & points sampled	2	8
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the downstream disturbance but is greater than or equal to 1D
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.7	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	17	17
Volumetric flow rate, discharge, m³/s	1.3	1.3
Volumetric flow rate (wet NTP), m³/s	1.2	1.2
Volumetric flow rate (dry NTP), m³/s	1.2	1.2
Mass flow rate (wet basis), kg/hour	5800	5800
Velocity difference, %	<1	<1

VOC's (as n-Propane) Totals	Average		Test 1		Test 2	
Sampling time			0000-0100		0000-0100	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.033	0.041	0.033	0.04	0.034	0.042

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0000-0100		0000-0100	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.00033	<0.0004	<0.00033	<0.0004	<0.00032	<0.0004
Benzene	0.053	0.065	0.052	0.064	0.054	0.067
Toluene	0.0017	0.002	0.0014	0.0017	0.0019	0.0024
2-Methylhexane	0.0049	0.006	0.005	0.0061	0.0048	0.0059
Heptane	0.00044	0.00054	0.00046	0.00057	0.00042	0.00051
Methylcyclohexane	0.00035	0.00043	0.00034	0.00042	0.00036	0.00044

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 2 - Outlet - Run 4		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	320	0.0804 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Junction	2 D
Upstream disturbance	Junction	4 D
No. traverses & points sampled	2	8
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the downstream disturbance but is greater than or equal to 1D
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.7	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	17	17
Volumetric flow rate, discharge, m³/s	1.3	1.3
Volumetric flow rate (wet NTP), m³/s	1.2	1.2
Volumetric flow rate (dry NTP), m³/s	1.2	1.2
Mass flow rate (wet basis), kg/hour	5800	5800
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0200-0300		0200-0300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.007	0.0086	0.0074	0.0091	0.0067	0.0082

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0200-0300		0200-0300	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.00067	<0.00082	<0.00066	<0.00081	<0.00069	<0.00084
Benzene	0.011	0.013	0.011	0.014	0.01	0.012
Toluene	0.0023	0.0028	0.0024	0.0029	0.0022	0.0026

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 2 - Outlet - Run 5		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	320	0.0804 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Junction	2 D
Upstream disturbance	Junction	4 D
No. traverses & points sampled	2	8
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the downstream disturbance but is greater than or equal to 1D
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.7	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	17	17
Volumetric flow rate, discharge, m³/s	1.3	1.3
Volumetric flow rate (wet NTP), m³/s	1.2	1.2
Volumetric flow rate (dry NTP), m³/s	1.2	1.2
Mass flow rate (wet basis), kg/hour	5800	5800
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0400-0500		0400-0500	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.042	0.051	0.038	0.047	0.045	0.055

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0400-0500		0400-0500	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.00076	<0.00093	<0.00073	<0.00089	<0.00079	<0.00096
Benzene	0.072	0.089	0.066	0.081	0.079	0.097
Toluene	0.0013	0.0015	0.0015	0.0019	0.001	0.0012

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate,
Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	31/03/2010	**Client**	Terminals Pty Ltd		
Report	N85424	**Stack ID**	VEC 2 - Outlet - Run 6		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	AD/SC/SW				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested emission testing to determine VOC removal efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	320	0.0804 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Junction	2 D
Upstream disturbance	Junction	4 D
No. traverses & points sampled	2	8
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the downstream disturbance but is greater than or equal to 1D
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.7	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	17	17
Volumetric flow rate, discharge, m³/s	1.3	1.3
Volumetric flow rate (wet NTP), m³/s	1.2	1.2
Volumetric flow rate (dry NTP), m³/s	1.2	1.2
Mass flow rate (wet basis), kg/hour	5800	5800
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0600-0700		0600-0700	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.044	0.054	0.043	0.053	0.045	0.056

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0600-0700		0600-0700	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit[1]	<0.00059	<0.00073	<0.00059	<0.00073	<0.00059	<0.00072
Benzene	0.077	0.094	0.075	0.092	0.079	0.097
Toluene	0.0018	0.0022	0.002	0.0024	0.0016	0.002

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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Date	31/03/2010	**Client**	Terminals Pty Ltd	
Report	N85424	**Stack ID**	VEC 2 - Outlet - Run 7	
Licence No.	-	**Location**	Port Botany	**State** NSW
EML Staff	AD/SC/SW			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested emission testing to determine VOC removal efficiency.			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	320	0.0804 m²
Sampling port size, number & depth	2 x 1" BSP	
Access & height of ports	Ground level	1 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Junction	2 D
Upstream disturbance	Junction	4 D
No. traverses & points sampled	2	8
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

The sampling plane is too near to the downstream disturbance but is greater than or equal to 1D
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
The discharge is assumed to be composed of dry air and moisture
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.7	
Gas molecular weight, g/g mole	28.8 (wet)	29.0 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)
	Test 1	Test 2
Gas Flow Parameters		
Temperature, K	296	296
Velocity at sampling plane, m/s	17	17
Volumetric flow rate, discharge, m³/s	1.3	1.3
Volumetric flow rate (wet NTP), m³/s	1.2	1.2
Volumetric flow rate (dry NTP), m³/s	1.2	1.2
Mass flow rate (wet basis), kg/hour	5800	5800
Velocity difference, %	<1	<1

VOC's (as n-Propane)	Average		Test 1		Test 2	
Totals Sampling time			0800-0830		0800-0830	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Total	0.13	0.16	0.12	0.15	0.13	0.16

VOC's (speciated)	Average		Test 1		Test 2	
Sampling time			0800-0830		0800-0830	
	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s	Concentration g/m³	Mass Rate g/s
Detection limit(1)	<0.0013	<0.0016	<0.0013	<0.0016	<0.0013	<0.0016
Benzene	0.22	0.27	0.22	0.27	0.22	0.27
Toluene	0.0048	0.0059	0.004	0.0049	0.0056	0.0069

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Pentane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Terminals Pty Ltd's records for complete process conditions.

TEST METHODS

Unless otherwise stated, the following methods meet the requirements of the NSW Department of Environment, Climate Change & Water (as specified in the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales,* January 2007). All sampling and analysis was performed by EML Air, NATA accreditation number 2732, unless otherwise specified.

Parameter	NSW Test Method	Reference Method	Uncertainty	NATA Accredited	
				Sampling	Analysis
Sample Plane Criteria	TM-1	AS 4323.1	-	✓	NA
Flow rate, temperature and velocity	TM-2	USEPA 2	not specified	✓	NA
Moisture content	TM-22	USEPA Alt-008	not specified	✓	✓
Speciated volatile organic compounds (VOC's)	TM-34	USEPA 18	not specified	✓	✓

AS – Australian Standard
USEPA – United States Environmental Protection Agency
TM - Test Method

DEVIATIONS

Speciated volatile organic compounds (VOCs)

Due to the uncertainty of concentrations of the compounds of interest to be encountered during sampling, adsorbent tubes were not 'spiked' with the compounds of interest prior to sampling. This deviation was agreed with Terminals Pty Ltd prior to sampling.

QUALITY ASSURANCE / QUALITY CONTROL INFORMATION

EML Air Pty Ltd is accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources (Accreditation number 2732). Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for EML Air at NATA's website www.nata.asn.au.

EML Air is accredited to Australian Standard 17025 – General Requirements for the Competence of Testing and Calibration Laboratories. Australian Standard 17025 requires that a laboratory have a quality system similar to ISO 9002. More importantly it also requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Quality Assurance Manager.

A formal Quality Control program is in place at EML Air to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

DEFINITIONS

The following symbols and abbreviations may be used in this test report:

NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
BSP	British standard pipe.
NA	Not applicable
D	Duct diameter or equivalent duct diameter for rectangular ducts.
<	Less than.
>	Greater than.
≥	Greater than or equal to.
~	Approximately.

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Appendix G

Emission Testing Report by EML Air dated April 2013.

EML AIR PTY LTD ABN 98 006 878 342
Melbourne (Head Office)
PO Box 466, Canterbury, Victoria 3126
427 Canterbury Road, Surrey Hills, Victoria 3127
T. +61 3 9836 1999 F. +61 3 9830 0670
E. emlair@emlair.com.au W. www.emlair.com.au

Our reference: N90851

7 May 2013

Terminals Pty Ltd
PO Box 148
MATRAVILLE NSW 2036

Attention Mr Geoff Millard

PORT BOTANY PLANT

Emission Testing Report - APRIL 2013

Tests were performed at the request of Terminals Pty Ltd to determine emissions to air as detailed below;

Test Summary		
Location	Test Date	Test Parameters*
Benzene Combuster	17 April 2013	Total particulate matter, speciated volatile organic compounds (VOC's) including benzene, hydrogen sulfide, sulfur dioxide, nitrogen oxides, carbon monoxide, carbon dioxide, oxygen

* Flow rate, velocity, temperature and moisture were determined unless otherwise stated.

Please refer to the following pages for results, plant operating conditions, test methods, quality assurance / quality control information and definitions.

Heath Thatcher DipAppSc
Client Manager
jw doc:n90851.doc

Zac Xavier BSc BEng
Managing Director

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RESULTS

Date	17/04/2013	Client	Terminals Pty Ltd	
Report	N90851	Stack ID	Benzene Combustor	
Licence No.	-	Location	Port Botany	State NSW
EML Staff	HT			
Process Conditions	Please refer to client records.			
Reason for testing:	Client requested testing to determine emissions to air			

Sampling Plane Details		
Sampling plane dimensions (mm) & area	1300	1.33 m²
Sampling port size, number & depth	4" Flange (x2)	
Access & height of ports	Fixed ladder	12.5 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit cone	2 D
Upstream disturbance	Change in diameter	5 D
No. traverses & points sampled	2	16
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

Flow to Combustor - 670 m³/hr. Online temperature ~990°C
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.7	
Gas molecular weight, g/g mole	29.2 (wet)	29.4 (dry)
Gas density at NTP, kg/m³	1.30 (wet)	1.31 (dry)
Gas Flow Parameters		
Temperature, K	1305	
Velocity at sampling plane, m/s	15	
Volumetric flow rate, discharge, m³/s	20	
Volumetric flow rate (wet NTP), m³/s	4.3	
Volumetric flow rate (dry NTP), m³/s	4.2	
Mass flow rate (wet basis), kg/hour	20000	
Velocity difference, %	<1	

Isokinetic	Results	
Sampling time	1045-1205	
	Concentration mg/m³	Mass Rate g/s
Total particulate matter	<0.83	<0.0035

Hydrogen Sulfide	Results	
Sampling time	1105-1205	
	Concentration mg/m³	Mass Rate g/s
Hydrogen sulfide	<0.0039	<0.000016

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Date	17/04/2013	Client	Terminals Pty Ltd		
Report	N90851	Stack ID	Benzene Combustor		
Licence No.	-	Location	Port Botany	State	NSW
EML Staff	HT				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested testing to determine emissions to air				

Gases	Average		Minimum		Maximum	
Sampling time	1025-1125		1025-1125		1025-1125	
	Concentration mg/m³	Mass Rate g/s	Concentration mg/m³	Mass Rate g/s	Concentration mg/m³	Mass Rate g/s
Nitrogen oxides (as NO_2)	260	1.1	68	0.29	440	1.9
Sulfur dioxide	630	2.6	<5.7	<0.024	1200	5.1
Carbon monoxide	44	0.19	11	0.047	210	0.87
	Concentration %		Concentration %		Concentration %	
Carbon dioxide	6.6		5.6		7	
Oxygen	5.6		4.3		6.8	

VOC's (as n-Propane)	Results	
Sampling time	1045-1145	
	Concentration mg/m³	Mass Rate g/s
Total	<0.041	<0.00017

VOC's (speciated)	Results	
Sampling time	1045-1145	
	Concentration mg/m³	Mass Rate g/s
Detection limit[1]	<0.043	<0.00018
Benzene	<0.043	<0.00018

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

NATA

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PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Terminals Pty Ltd's records for complete process conditions.

Testing was performed during benzene ship discharge operations to provide peak load rate between 1045 and 1210 on Wednesday, 17th April 2013

TEST METHODS

Unless otherwise stated, the following methods meet the requirements of the NSW Office of Environment and Heritage (as specified in the Approved Methods *for the Sampling and Analysis of Air Pollutants in New South Wales, January 2007).* All sampling and analysis was performed by EML Air unless otherwise specified. Specific details of the methods are available upon request.

Parameter	NSW Test Method	Reference Method	Uncertainty*	NATA Accredited	
				Sampling	Analysis
Sample Plane Criteria	TM-1	AS 4323.1	-	✓	NA
Flow rate, temperature and velocity	TM-2	USEPA 2	8%, 2%, 7%	✓	NA
Moisture content	TM-22	USEPA 4	8%	✓	✓
Sulfur dioxide	TM-4	USEPA 6C	12%	✓	✓
Hydrogen sulfide	TM-5	USEPA 11	not specified	✓	✓
Nitrogen oxides (NO_x)	TM-11	USEPA 7E	12%	✓	✓
Particulate matter	TM-15	AS 4323.2	5%	✓	✓
Carbon dioxide	TM-24	USEPA 3A	13%	✓	✓
Oxygen	TM-25	USEPA 3A	13%	✓	✓
Speciated volatile organic compounds	TM-34	USEPA 18	19%	✓	✓

* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

AS – Australian Standard
USEPA – United States Environmental Protection Agency
TM - Test Method

QUALITY ASSURANCE / QUALITY CONTROL INFORMATION

EML Air Pty Ltd is accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources (Accreditation number 2732). Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for EML Air at NATA's website www.nata.asn.au.

EML Air is accredited to Australian Standard 17025 – General Requirements for the Competence of Testing and Calibration Laboratories. Australian Standard 17025 requires that a laboratory have a quality system similar to ISO 9002. More importantly it also requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Quality Assurance Manager.

A formal Quality Control program is in place at EML Air to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

NATA

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DEFINITIONS

The following symbols and abbreviations may be used in this test report:

NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
BSP	British standard pipe
NA	Not applicable
D	Duct diameter or equivalent duct diameter for rectangular ducts
<	Less than
>	Greater than
≥	Greater than or equal to
~	Approximately





Appendix B

Botany PMB and CRMB Project Air Quality Assessment, prepared by GHD 14 October 2020

Printed on Recycled Paper.

Puma Energy Australia

Botany PMB and CRMB Project
Air Quality Assessment

October 2020

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Appendix B – ETC sampling report

Appendix C – Air Noise Environment sampling report

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Appendix E – Chemical odour level calculations

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Appendix G – Meteorological analysis

1. Introduction

1.1 Overview

Puma Energy Australia (Puma Energy) propose to commission a new Polymer Modified Bitumen (PMB) and Crumbed Rubber Modified Bitumen (CRMB) production facility at the existing Terminals Pty Ltd (Terminals) facility located in Botany Bay ('the proposal').

Puma Energy have engaged GHD Pty Ltd (GHD) to undertake an assessment of cumulative operational air quality impacts associated with the proposal. This report provides an updated air quality assessment of the site, which includes the existing Terminals bitumen import and dispatch facility and additional emission sources associated with the proposal.

1.2 Project description

Puma Energy currently operates a bitumen import, storage and distribution facility located within Port Botany in New South Wales. The bitumen facility primarily stores and loads out C170 and C320 grades of bitumen and has the capability to oxidise these grades to higher viscosities as required.

Puma Energy purchased the BP bitumen business including formulas for the Olexobit range of PMB for which Puma has now found a ready market. In order to meet the PMB market (a significant quantity of which is centred on NSW) a new PMB manufacturing facility is required in NSW. The proposal aims to meet this PMB demand.

A narrative functional description and process flow diagram which provides a detailed description of proposal operations is attached as Appendix A.

An overview of the intended operation and key functions of the proposal is summarised below:

- Receipt, storage, handling and transfer of polymer binder or other solid bitumen modifiers
- Blending of polymer/modifiers, C170 bitumen and Extract Oil to produce PMB
- Blending of crumbed rubber, C170 Bitumen
- PMB sampling and storage
- CRMB sampling and storage
- Transfer of PMB/CRMB between tanks
- Load out of PMB/CRMB to the existing road gantry.

The proposal comprises of the following main systems and equipment:

- 1 x 50T heated/insulated blend tank including high sheer mixer/shredder for the manufacture of all PMB/CRMB grades
- 2 x 100T heated and insulated storage tanks complete with mixers to hold finished PMB/CRMB
- 1 x 50T heated and insulated Extract oil storage tank
- 1 x 100T heated and insulated buffer tank for the storage of C170 grade bitumen – this tank is required to cover periods when bitumen from the existing facility is not available (e.g. during tank ship discharges). Base grade C170 bitumen will be transferred from the main facility using the existing transfer pumps and heat exchangers
- Heating for the PMB facility – The existing site hot oil heaters are rated at 2 x 3000 KW – the PMB plant heating required is relatively small therefore utilizing the existing heaters

should be possible. Heat metering will be required to enable additional gas usage to be monitored

- Hot oil circulation for both tank heating and tracing in the PMB area will utilise the existing pumps
- Venturi and hopper system to facilitate the controlled additional of material into the flowing stream of bitumen
- Loading and transfer pumps
- Homogeniser – 1 x 60T/hr capacity
- PMB loading capability – Propose to use existing gantry and loading arms with product line tie in located as close to the loading arm as possible
- Sour gas system linked to all tanks. A vapour incinerator already exists which generally runs well below its design capacity as the existing plant normally generates much lower gas volumes. The vapour combustor is capable of handling the additional vapour flow generated by the PMB plant but may require production scheduling at times when the existing blowing plant is producing maximum vapour flow.

1.3 Scope

The scope of the air quality assessment included the following tasks:

- Desktop review of site plans, aerial photography, proposed operations and sensitive receptors within the study area
- Review of available ambient air quality monitoring data, to gain an understanding of existing air quality in the vicinity of the proposal. Ambient pollutant levels were sourced from data recorded at Department of Planning, Industry and Environment ambient monitoring stations located in the local area.
- Preparation of an emissions inventory to estimate operational air quality emissions from the proposal and neighbouring Terminals site
- Calculation of a concentration/design criterion metric to rank air quality emissions constituents based on source
- Preparation of a meteorological data file (using meteorology from Sydney Airport AWS) for use in dispersion modelling
- Dispersion modelling using the AUSPLUME model to predict worst-case impacts from the proposal
- Preparation of this report

1.4 Limitations

This report: has been prepared by GHD for Puma Energy Australia and *may only be used and relied on by Puma Energy Australia for the purpose agreed between GHD and the Puma Energy Australia as set out in section 1.3 of this report.*

GHD otherwise disclaims responsibility to any person other than Puma Energy Australia arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.5 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Puma Energy Australia and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.5 Assumptions

The following major assumptions were used in this assessment:

- Details of all operational activities likely to produce air quality emissions were provided by Puma Energy
- Tank dimensions (diameter, height, capacity), layout, and bitumen flowrates were provided by Puma Energy
- The rate of sulfur addition during PMB batch mixing and the corresponding hydrogen sulphide production rate was provided by Puma Energy
- Emissions to air were estimated based on measurements taken at similar facilities scaled to the production rates of the proposal.

2. Existing environment

2.1 Location

The site is located within the Port Botany Industrial area, along Simblist Road and will be an extension of the existing Terminals Site B. Other industries surrounding the site include Origin Energy, Qenos and Tyne Container Services. The site location (shown in yellow) and the existing Terminals site (shown in blue) is depicted in Figure 2-1.

The nearest residential receptors potentially affected by air quality emissions from the site are the residential dwelling approximately 1.7 km to the east across Yarra bay.

2.2 Sensitive receptors

Sensitive receptors were selected based off examination of aerial photography. The location and approximate distance of each sensitive receptor from the proposal is provided in Table 2-1.

Table 2-1 Sensitive receptor location and description

Receptor	Approximate distance from the proposal (m)	X Coordinate (m)	Y Coordinate (m)
Philip bay residential area	1,700	336637	6238499
Yarra Bay Bicentennial Park	1,500	336464	6238600
Yarra Recreation reserve	1,700	336665	6238646
Botany cemetery	1,250	336042	6239209
Matraville residential area	2,000	336552	6240093
Botany residential area	2,150	334344	6240977



Paper Size A4

0 62.5 125 250 375 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Terminal Site B
- Puma Energy Site
- Sensitive receivers

Puma Energy Australia
Botany PMB Project

Job Number 21-27357
Revision A
Date 23 Aug 2018

Site location and sensitive areas

Figure 2-1

\\ghdnet\ghd\AU\Sydney\Projects\21\27357\GIS\Maps\Deliverables\21_27357_Z001_SiteLocation.mxd

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Data source: Aerial Imagery: Sixmaps Created by:ppandey

2.3 Background pollutant concentrations

The Department of Planning, Industry and Environment (DPIE) operate ambient air quality monitoring stations in selected areas around NSW. The nearest stations to the site are the Randwick and Earlwood monitoring stations.

An analysis of background pollutant concentration at both stations for the last five complete calendar years (2015 – 2019) is provided in Table 2-2. It should be noted that background PM_{10} is considered high and exceeds the assessment criteria for most years (refer Section 3 for details regarding assessment criteria). Further discussion regarding selection of background PM_{10} concentrations is provided below.

Table 2-2 Background pollutant concentration analysis

Pollutant	Averaging period	Randwick monitoring station					Earlwood monitoring station				
		2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
SO_2 ($\mu g/m^3$)	1 hour maximum	81.2	89.1	76.0	55.0	76.0	-	-	-	-	-
	24 hour maximum	10.5	7.9	21.0	10.5	13.1	-	-	-	-	-
	Annual average	2.4	2.3	2.7	2.7	2.6	-	-	-	-	-
NO_2 ($\mu g/m^3$)	1 hour maximum	80.8	82.7	77.1	75.2	95.9	99.6	80.8	126.0	94.0	114.7
	Annual average	15.9	15.1	12.8	12.4	12.2	14.8	18.1	20.3	19.2	19.3
CO (mg/m^3)	1 hour maximum	-	-	-	-	-	1495.0	-	-	-	-
PM_{10} ($\mu g/m^3$)	24 hour maximum	77.4	44.1	56.1	95.5	127.7	66.5	42.9	59.8	86.5	129.4
	Annual average	18.6	18.0	19.2	21.2	24.1	17.2	17.6	18.0	19.8	23.0

Note: '-' indicates that the pollutant was not monitored at that station during that year

To conservative assess potential worst-case cumulative pollutant concentrations, the maximum recorded pollutant concentration from both Randwick and Earlwood monitoring stations was adopted as the background concentration for use in this assessment with the exception of PM_{10}. Background 24 hour PM_{10} concentrations exceed the assessment criteria (refer Section 3 for details regarding assessment criteria) at both monitoring stations for years 2015, 2017, 2018 and 2019. The only year where recorded background concentrations comply with the assessment criteria is 2016. Therefore to provide a meaningful cumulative assessment (where criteria exceedances are not sorely due to high background concentrations) background PM_{10} concentrations were selected from the worst case monitoring station for 2016.

The adopted background pollutant concentration used in this assessment are provided in Table 2-3.

Table 2-3 Adopted background pollutant concentrations

Pollutant	Averaging period	Adopted background concentration	Percentage of assessment criteria (%)
SO_2 (µg/m^3)	1 hour maximum	89.1	15.6%
	24 hour maximum	21.0	9.2%
	Annual average	2.7	4.5%
NO_2 (µg/m^3)	1 hour maximum	126.0	51.2%
	Annual average	20.3	32.8%
CO (mg/m^3)	1 hour maximum	1495.0	5.0%
PM_{10} (µg/m^3)	24 hour maximum	44.1	88.2%
	Annual average	18.0	71.8%

3. Air quality criteria

3.1 Criteria overview

To determine the compliance status of the proposal, individual air pollutants were assessed against the impact assessment criteria at the site boundary and at sensitive receptors where appropriate.

3.2 Pollutant assessment criteria

Impact assessment criteria was taken from the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2016) (the Approved Methods) and is summarised in Table 3-1.

Sulfur dioxide (SO_2) emissions were assessed at the nearest sensitive receptor in accordance with the Approved Methods. All other air quality pollutants were assessed at and beyond the site boundary using the relevant averaging period and respective assessment criteria percentile. Compliance with the impact assessment criteria at the site boundary would also result in compliance at the nearest sensitive receptors.

Table 3-1 Summary of air quality criteria in NSW (EPA, 2016)

Pollutant	Averaging period	Percentile	Concentration (µg/m^3)[1]
PM_{10}	24 hour	100th	50
	Annual	100th	25
Carbon monoxide (CO)	1 hour	100th	30000
	8 hour	100th	10000
Nitrogen dioxide (NO_2)	1 hour	100th	246
	Annual	100th	62
Sulfur dioxide (SO_2)	10 minutes	100th	712
	1 hour	100th	570
	24 hour	100th	228
	Annual	100th	60
Benzene	1-hour	99.9th	29
Toluene	1-hour	99.9th	360
Xylene	1-hour	99.9th	190
Trimethyl-benzene	1-hour	99.9th	2200
Total PAH (as benzo[a]pyrene)	1-hour	99.9th	0.4

[1] The assessment criteria for some pollutants was converted from milligrams per metre cubed (mg/m^3) to micrograms per metre cubed (µg/m^3)

Pollutant	Averaging period	Percentile	Concentration (µg/m^3)[1]
Chloromethane	1-hour	99.9th	1900
Acetone	1-hour	99.9th	22000
Ethyl Benzene	1-hour	99.9th	8000

3.3 Odour assessment criteria

The Approved Methods defines odour assessment criteria and specifies how they should be applied in dispersion modelling to assess the likelihood of nuisance impact arising from the emission of odour.

Odour impact is a subjective experience and has been found to depend on many factors, the most important of which are the:

- **F**requency of the exposure
- **I**ntensity of the odour
- **D**uration of the odour episodes
- **O**ffensiveness of the odour
- **L**ocation of the source.

These factors are often referred to as the FIDOL factors.

The odour assessment criteria is defined to take account of two of these factors (**F** is set at 99th percentile; **I** is set at from 2 to 7 odour units (OU)). The choice of assessment criteria has also been made to be dependent on the population of the affected area, and to some extent it could be said that population is a surrogate for location – so that the **L** factor has also been considered. The relationship between the criteria odour level **C** to affected population **P** is given below:

$$C = [\log P\text{-}4.5] \div \text{-}0.6 \qquad \text{equation 1}$$

Table 3-2 lists the values of C for various values of affected populations as obtained using equation 1.

Table 3-2 Odour criteria for the assessment of odour (EPA, 2016)

Population of affected community	Odour performance criteria (nose response odour certainty units at 99th percentile[2])
Single Residence (≤ ~2)	7
~ 10	6
~ 30	5
~ 125	4
~ 500	3
Urban (≥~2,000)	2

The criteria assumes that 7 OU at the 99th percentile would be acceptable to the average person, but as the number of exposed people increases there is a chance that sensitive

[2] This is a prediction of the odour level that may occur 1% of the time, or one hour in one hundred. Odour performance criteria are designed to be precautionary, so that impacts on sensitive receivers can be minimised.

individuals would be encountered. The criteria of 2 OU at the 99th percentile is considered to be acceptable for large populations (more than 2,000 people).

The criteria have also been specified at an averaging time of nominally 1 second. The choice of the short averaging time recognises that the human nose has a response time of less than 1 second, so that modelling of odour impact should allow for the short-term concentration fluctuations in an odour plume due to turbulence.

As the AUSPLUME dispersion model (used in this assessment) cannot predict concentrations for a 1 second average, a ratio between the 1 second peak concentration and 60 minute average concentration has been applied. This is known as the peak to mean ratio (PM60). PM60 is a function of source type, stability category and range (that is, near or far-field), and values are tabulated in the Approved Methods.

3.3.1 Adopted odour assessment criteria

The most stringent project specific odour assessment criteria of 2 OU was selected for the assessment.

4. Emissions inventory

4.1 Emissions overview

The following section outlines the emission sources and emission rates of the Puma Energy proposal used in this assessment. Emissions from the nearby Terminals bitumen storage facility were included to provide a cumulative assessment of potential worst-case air quality impacts.

4.2 Puma emission rates summary

Emissions to air from the Puma site arise from several operations to be conducted at the facility, namely:

- Bitumen transfers to and from storage/mix tanks – Inflowing bitumen displaces tank headspace vapour (headspace vapour contains air pollutants including Volatile Organic Compounds (VOCs) and Polycyclic Aromatic Hydrocarbons (PAHs)) which is then ducted and treated in an existing purpose-built combustor unit operated by Terminals
- Sulfur addition during PMB batching mixing – Foul air exhaust from the mixer containing higher hydrogen sulphide (H_2S) concentrations will be ducted to the combustor.

Emission rates

Emission rates from bitumen transfers to and from storage/mix tanks were calculated based on measured pollutant concentrations within the headspace of bitumen tanks at similar facilities and Puma Energy's maximum proposed bitumen flowrates. The pollutant headspace samples were analysed for odour, VOCs and PAHs.

Emissions from PMB tanks was estimated based on sampling of tank headspace concentrations undertaken by Emission Testing Consultants (ETC, 2006) at two similar facilities (sampling report attached as Appendix B). Emissions from CRMB tanks was estimated based on sampling of CRMB tank headspace undertaken by Air Noise Environment (2020) at Puma Energy's Pinkenba facility (sampling report attached as Appendix C).

As the bitumen storage tanks may be used for both PMB or CRMB, the maximum emission rate for PMB and CRMB was adopted for all tanks (refer Table 4-1). This is a conservative approach to predict maximum potential impacts.

Puma Energy advised that a maximum bitumen transfer rate of 80 m^3/h from storage to mixing tanks would occur during operation. This maximum value was adopted for use in this assessment.

During PMB batch mixing, sulfur is added resulting in exhaust air from the mixer containing significantly higher hydrogen sulphide concentrations. Hydrogen sulphide is a highly odorous gas with potential to cause adverse odour impacts. To reduce odour emissions, the exhaust gas is ducted to the combustor for treatment prior to release. During combustion, hydrogen sulphide is converted into sulfur dioxide based on the following equation:

$$2\,H_2S + 3\,O_2 \rightarrow 2\,SO_2 + 2\,H_2O$$

For modelling purposes, a 100% conversion rate of hydrogen sulphide into sulfur dioxide has been assumed.

Sulfur dioxide emissions from the combustor were calculated based on hydrogen sulphide flowrate data from an experimental run undertaken at Bulwer provided by Puma (provided in Appendix F). The Bulwer charts were for 25 T batches, as Puma are intending to run 50 T batches the measured flowrates were double. To predict the maximum 10 minute averaged sulfur dioxide concentration the maximum 1 minute hydrogen sulphide flowrate (2 x 7.85 kg/h)

for the Bulwer plant was modelled as a constant 24 hour emission rate. To predict the maximum 1 hour average sulfur dioxide concentration, the 1 hour averaged hydrogen sulphide flowrate (2 x 6.08 kg/h) was modelled as a constant 24 hour emission rate.

The Bulwer charts shows the measured hydrogen sulphide production rate immediately after sulfur was added during the mixing process. This addition of sulfur significantly increases the hydrogen sulphide production rate for approximately an hour. The maximum onsite hydrogen sulphide production rate occurs during this period. It is understood that a maximum of four mixing loads (additions of sulfur) will occur per day. Sulfur dioxide emissions were modelled to occur 24 hours a day, 7 days a week despite only occurring a maximum of four hours per day. This accounts for worst case sulfur dioxide dispersion. Consequently, the sulfur dioxide emission rate used to predict ground level concentrations will only occur a maximum of four hour per day resulting in a conservative sulfur dioxide assessment.

The combustor is assumed to achieve a 99% emissions removal of all pollutants. Emissions rates from combustor (PMB/CRMB storage and mixing tank headspace) are provided in Table 4-1.

It should be noted that sulfur is not added during CRMB batch mixing and therefore hydrogen sulphide production and corresponding sulfur dioxide emissions during CRMB batch mixing are significantly lower than those during PMB batch mixing.

However it was conservatively assumed that worst case sulfur dioxide emissions (that would only occur PMB batch mixing) occurred from both PMB and CRMB tanks.

4.3 Terminals emission rate summary

Emissions to air from the Terminals site arise from several operations at the facility, namely:

- Ship unloading to the main storage tanks – displaced headspace vapour is ducted and treated in the purpose-built combustor unit
- Road tanker loading from the day tanks – displaced headspace vapour is directed to the combustor
- Foul air exhaust from the oxidation columns is highly odorous; and mitigation is achieved by ducting it to the combustor, and
- Products of combustion from one natural gas fired hot oil heaters and the combustor. The system can only handle one hot oil heater in operation during the ship unloading. This is the period where air borne emissions are maximised.

Emission rates

A maximum ship unloading rate of 400 m^3/h and a road tanker loading rate of 2x80 m^3/h (160 m^3/h) has been used with the ETC analysis of bitumen headspace pollutant concentration (provided in Appendix B) to determine the maximum constituent emission rates.

The measured flow rate and constituent concentrations given in the newEQ report (provided in Appendix D) were used to determine the constituent emission rates from the oxidation column exhausts that is input to the combustor. Odour was not sampled, however the inferred 'chemical' odour level was determined as shown in Appendix E.

Emissions from combustion within the combustor and the hot oil heaters were calculated using the *National Pollutant Inventory Emissions Estimation Technique Manual for Combustion in Boilers (2011)*. Combustor and hot oil heater energy usage was provided by Terminals. It was assumed that the combustor operated at its maximum design capacity (16.6 GJ/hr).

The sulfur dioxide emissions rate were conservatively calculated from the hydrogen sulphide flowrate assuming 100% conversion of hydrogen sulphide to sulfur dioxide. Sulfur dioxide is also an odorous gas and has been assessed against its ground level concentration criteria. 1% of the hydrogen sulphide has been assumed to contribute to odour from this source as per the next paragraph.

The combustor is assumed to achieve a 99% emission removal of all pollutants, but it is more likely up to 99.9% or higher. Emissions rates from combustor (ship unloading and road tanker loading) are provided in Table 4-1. Emission rates from combustion products within the hot oil heaters and combustor are provided in Table 4-2.

Table 4-1 Emission rates – PMB/CRMB and mixing tank headspace, tanks and road tankers headspace, and oxidation column emissions vented via combustor with 99% removal

Emission source	Odour Emission rate[a] (OUm^3/s)	Total PAH (Bap equi.) (g/s)	Trimethyl – benzene[a] (g/s)	Xylene (g/s)	Toluene (g/s)	Benzene (g/s)	Chloromethane (g/s)	Acetone (g/s)	Ethyl Benzene (g/s)	Sulfur Dioxide (g/s)
Puma										
PMB and mixing tank headspace	39[a]	0.0000000016[a]	0.000019[a]	0.000017[a]	0.000015[a]	0.000014[a]				8.19[c]
CRMB and mixing tank headspace[f]	47	0[g]	0.0000012	0.000039	0.0000073	0.0000015			0.0000015	0.00052
Adopted maximum for Puma Site	47	0.0000000016	0.000019	0.000039	0.000015	0.000014			0.0000015	8.19
Terminals										
Tank and road tanker headspace[b]	273	0.000000011	0.00014	0.00012	0.00011	0.00010				0.013
Oxidation column[d]	3470[e]		0.0000015	0.0000022	0.00000	0.0000020	0.0000018	0.00044	0.00000050	0.083

a. Emission rate calculated from Appendix B constituent concentration and maximum expected ship unloading and road tanker loading rate (0.022 m^3/s)
b. Emission rate calculated from Appendix B constituent concentration and maximum expected ship unloading and road tanker loading rate (0.16 m^3/s)
c. Calculated from 1 minute maximum hydrogen sulphide flowrate (4.4 g/s) (Used to predict 10 minute averaged Sulphur dioxide concentration)
d. Emission rates calculated from Appendix D
e. Odour level was determined as per Appendix E
f. Emission rate calculated from Appendix C constituent concentration and maximum expected ship unloading and road tanker loading rate (0.022 m^3/s)
g. Below detection limit

Table 4-2 Emission rates – Combustion emissions from the burners in the hot oil heaters and combustor

Pollutant	Emissions Factor (kg/GJ)	Terminals combustor emission rate[b] (g/s)	Hot oil heater emission rate[c] (g/s)
Carbon Monoxide	0.041	0.18	0.15
Nitrogen Dioxide[a]	0.027	0.12	0.10
PM_{10}	0.0036	0.016	0.014
PAHs	0.00000031	0.0000014	0.0000012
Sulfur Dioxide	0.00054	0.0024	0.0020

a. Assuming 20% of NOx is NO_2
b. Combustor energy usage of 16 GJ/hr (maximum design capacity)
c. Hot oil heater maximum energy usage of 13.5 GJ/hr

4.4 Ranking of emission constituents with respect to compliance

An emission metric was calculated for all constituents (except odour and sulfur dioxide) to determine which pollutant constituent had the least margin of compliance from each source. The metric was calculated for pollutants originating from tank headspace (mixing tank headspace, ship and tanker unloading and road tanker loading, refer Table 4-3) and for pollutants originating from combustion in the hot oil heater and combustor (refer Table 4-4).

The metric is calculated as the constituent emissions rate divided by the design criteria multiplied by 100.

Table 4-3 Ranking of pollutants (PMB/CRMB and mixing tank headspace/ship and tanker unloading/road tanker loading)

Pollutant	Mass Rate (g/s)	Design Criteria (mg/m^3)	Metric	Metric (% of total)
Toluene	0.00012	0.36	0.035	6.6
Xylene	0.00016	0.19	0.085	16.3
Trimethyl-benzene	0.00016	2.2	0.0071	1.4
Total PAH	0.000000012	0.0004	0.0031	0.6
Benzene	0.00011	0.029	0.39	74.8
Chloromethane	0.0000018	1.9	0.00010	0.02
Acetone	0.00044	22	0.0020	0.4
Ethyl Benzene	0.0000020	8	0.000025	0.005

Table 4-3 identifies benzene as the worst-case pollutant originating from tank headspace with respect to potential non-compliance. Hence, provided the dispersion modelling of benzene emissions show that compliance with assessment criteria is met, then all other constituents will also comply with increased margins.

Table 4-4 Ranking of pollutants (combustion products from hot oil heaters and combustor)

Pollutant	Mass Rate (g/s)	Design Criteria (mg/m^3)	Metric	Metric (% of total)
Carbon monoxide	0.34	100	0.3	0.2
Nitrogen dioxide	0.22	0.246	89.3	59.5
PM_{10}	0.030	0.05	59.0	39.3
PAHs	0.0000025	0.0004	0.6	0.4
Sulfur dioxide	0.0044	0.57	0.8	0.5

Table 4-4 identifies nitrogen dioxide as the worst-case pollutant originating from combustion in the hot oil heater and combustor with respect to potential non-compliance. Hence, provided the dispersion modelling of nitrogen dioxide emissions show that compliance with assessment criteria is met, then all other constituents will also comply with increased margins.

5. Meteorology

5.1 Meteorology overview

The complex interaction between synoptic scale and mesoscale meteorology determines the general weather conditions in the NSW coastal region.

Westerly high-pressure regions are the primary synoptic scale influence in NSW, however variation is apparent on a seasonal basis. These aforementioned high-pressure cells move north during autumn and winter, from a typical location across southern NSW during summer, resulting in predominantly westerly winds. These autumn and winter prevailing conditions differing greatly to the easterlies experienced in the summer months; spring shows similar atmospheric attributes to autumn and winter.

Mesoscale land-sea contrasts result in the generation of the afternoon sea breeze particularly during the summer months, and nocturnal katabatic drainage flows are also apparent from areas of higher topography particularly during cold and clear winter months (from the west in the Botany Bay region). Other terrain-induced flows and land breeze events are also evident dependent upon location, onset timing and overarching meteorological conditions.

Meteorological data from Sydney airport for 1997 was obtained previously by GHD and utilised within this assessment. This file has been used extensively for this site (including approval as part of an EIA) and others nearby for a number of years. Appendix G shows that hourly averages for the wind speed and wind direction have been generated, which meets USEPA guidelines. Appendix G also shows the seasonal variation in the mixing height which meets the requirements of NSW Approved Methods.

With regards to inter-annual variability, EPA NSW Approved Methods, Section 4.2 states that at least one year of site-specific meteorological data is used. Given Sydney Airport is located approximately 5 km northwest of the facility this dataset is therefore considered to be site-representative meteorology for the Port Botany site.

EPA Victoria generally require 5 years of meteorological data to be used, however they also accept one year of modelling where site specific data has been used in the generation of the met file (which is the case here). EPA Victoria have also relaxed to one year of data where the worst case model result is less than 20% of assessment criterion (which is also the case here – see Section 7).

Wind speed and atmospheric stability were examined with respect to flow direction to investigate typical flow regimes and directions of poor dispersion.

The P/G stability category scheme is a six level categorisation of atmospheric stability, with three unstable levels (A, B and C), one neutral level (D) and two stable levels (E and F). Atmospheric stability is an important factor in the dispersion of emissions to air, and the incidence of stable conditions (when dispersion is poor) will define the directions of maximum toxicity impact.

Accordingly, the all hours wind and stability roses for the data set are illustrated below in Figure 5-1 and Figure 5-2.

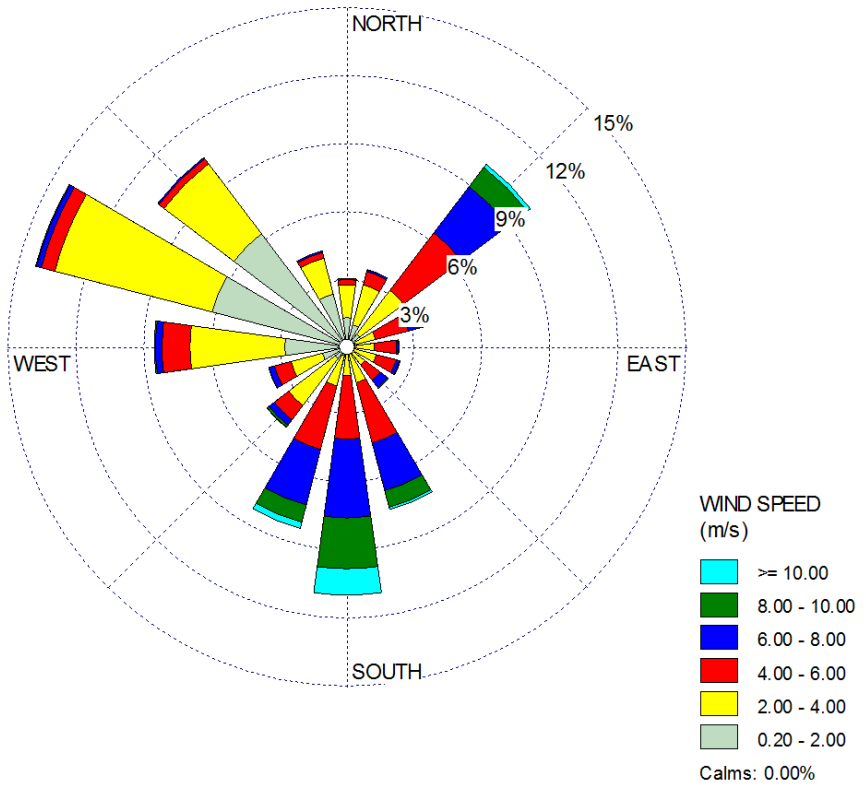


Figure 5-1 Wind rose for Sydney Airport, all hours

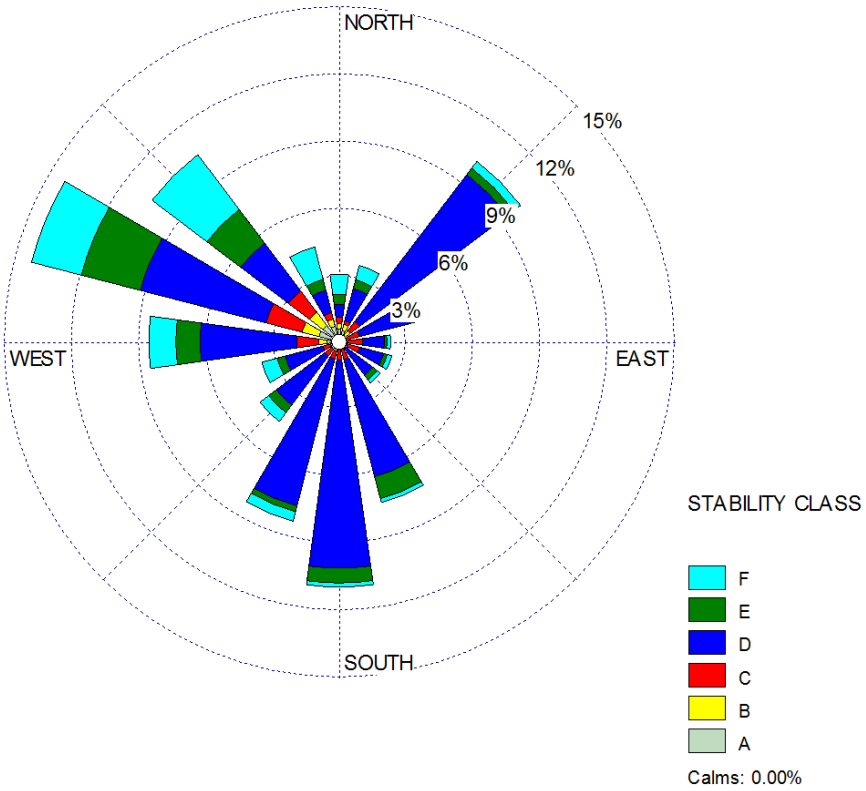


Figure 5-2 Stability rose for Sydney Airport, all hours

5.2 All hours wind rose

The pattern of wind climate is readily shown by means of a wind rose. The annual average wind rose formed from the Sydney Airport meteorological data is illustrated in Figure 5-1 and this is considered representative of the site.

Three dominant wind regimes are evident: north-westerly, north-easterly and southerly. Wind speeds are significantly higher in the north-easterly and southerly flows when compared to north-westerly conditions. It is apparent that north-westerly wind speeds are predominantly 0.5 – 3.6 m/s whereas the remaining dominant flow regimes display values of predominantly 3.6 – 11.1 m/s.

As discussed earlier southerly and easterly component winds are dominant during the summer months whereas the westerly flow components are more typical of winter conditions.

5.3 All hours stability rose

The pattern of atmospheric stability at the site is readily shown by means of a stability rose. The annual average stability rose formed from the Sydney Airport meteorological data is illustrated in Figure 5-2.

It is apparent that the dominant directions of poor dispersion (stability categories E and F) are from the west and northwest. These directions reflect the nocturnal cool air drainage flows in the Sydney basin. This directional dominance is similar to the wind rose whereby these westerly azimuths were identified as the dominant wind flow regime during winter months.

It is therefore evident that stable westerly flows are the meteorological conditions representing worst-case atmospheric (poor) dispersal. However, the quantity of sensitive receptors to the east of the facility is reduced due to the proximity of the South Pacific Ocean and as such potential large-scale impact in the region is tempered.

5.4 Seasonal meteorology

5.4.1 Seasonal wind patterns

It is apparent from Figure 5-3 that spring, autumn and winter show distinctive westerly flows; with reduced frequency north-easterly and southerly winds in the case of spring and autumn.

This contrasts with summer where the westerlies present in the other three seasons are reduced markedly in frequency together with an increase in frequency of the southerly and north-easterly components.

Summer shows the highest mean wind speed (4.8 m/s) whereas the remaining seasons show a value considerably lower (3.1 to 4.0 m/s).

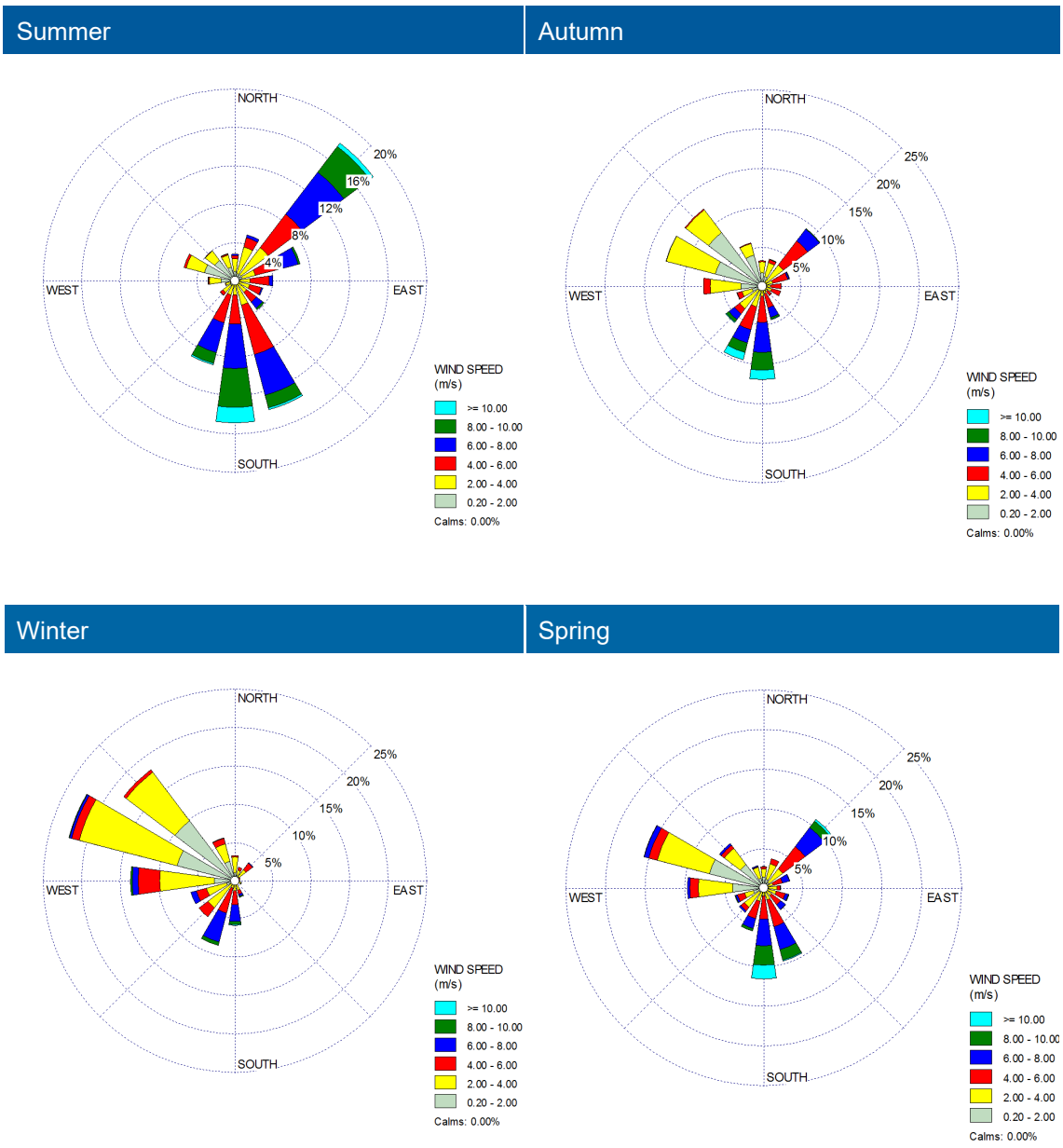


Figure 5-3 Seasonal wind roses, Sydney Airport

5.4.2 Seasonal stability patterns

It is apparent that the dominant directions of poor dispersion in Figure 5-4 (stability categories E and F) display a seasonal variation. The dominant direction of poor dispersion drainage flows during spring, autumn and winter is to the east and southeast (~10 to 15% occurrence), and this is aligned with the predominantly westerly winds at such times of the year. A southerly and north-easterly wind direction component showing stable conditions is also evident for spring and autumn albeit of a reduced frequency – these directions indicating poor dispersion towards the north and southwest.

Summer displays a reduced frequency of stable categories E and F (~7% occurrence) with dominance from the south and northeast – this change in directional dominance reflecting the increased number of easterlies.

It is evident that stable westerly flows are the meteorological conditions representing worst-case atmospheric (poor) dispersal predominantly during the spring, summer and winter seasons.

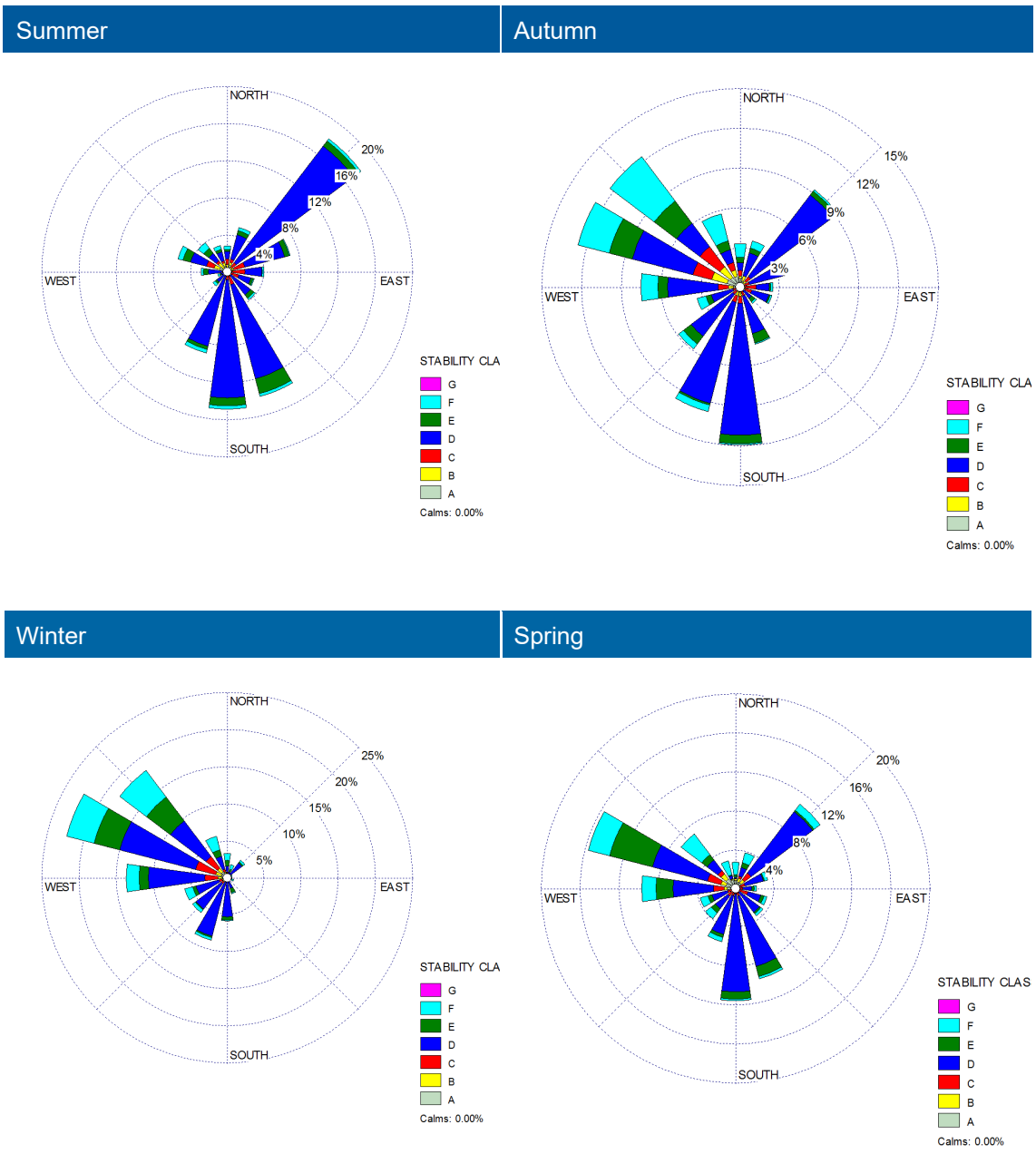


Figure 5-4 Seasonal stability roses, Sydney Airport

6. Air quality assessment

6.1 Assessment overview

Dispersion modelling was conducted in accordance with the Approved Methods to predict the maximum ground level concentrations resulting from emissions to air from the proposal. The predicted ground level concentrations were assessed against the air quality assessment criteria.

This section describes selection of the dispersion model, model input, air quality design criteria and model scenarios.

6.2 Dispersion modelling

The plume dispersion model AUSPLUME (version 6.0) is the model approved by the Approved Methods for predicting the effects of industrial emissions on air quality. This model is a steady-state Gaussian plume model that can be used to predict off-site pollutant concentrations for a wide variety of sources. Features of the model include: ability to model building downwash (the effect of buildings in causing a plume to be brought down to ground level); area, line and volume sources; plume rise as a function of downwind distance; arbitrary orientation of sources; and terrain adjustment. AUSPLUME was selected as the appropriated dispersion model for use in this assessment.

6.3 Model Configuration

AUSPLUME was configured to represent the sources in the proposed bitumen storage facility and make best use of the measured emissions and meteorological data.

Emissions from the combustor stack and hot oil heater stack were modelled as point sources. Building wake effects were included, with characteristic storage tank dimensions determined by inspection of a plan of the site and the Building Profile Input Program (BPIP) module within the AUSPLUME model was used to generate the characteristic dimensions for each 10-degree wind-directional arc. For wind directions where the potential for building wake influences were considered significant by AUSPLUME, the PRIME building wake algorithm is used to provide a conservative estimate of ground level concentrations.

Key components of the model configurations are summarised below:

- Ground level concentrations were predicted over a 2 km square Cartesian receptor grid, centred over the site with a grid resolution of 50 m;
- Averaging period of 1 hour was selected for all pollutants. An additional run using an average period of 10 minute was conducted for sulfur dioxide;
- Given that Port Botany is relatively flat and the model domain of interest is confined to the near-field (eg. site boundary), the effects of terrain on dispersion were considered negligible and were not included in this assessment;
- Irwin's "Urban" wind profile exponents were used;
- Horizontal dispersion was parameterised according to equations for the Pasquill-Gifford curves; and
- A roughness height of 0.8 m was used to represent the site.
- A peak to mean factor of 2.3 was applied to the one hour averaged predicted odour concentrations to account for a one second averaged impact

6.4 Emissions source configuration

Dispersion model was undertaken to predict pollutant concentrations from the worst case operational scenario. The scenario assumed all activities with potential to release emissions to air would occur simultaneously. The scenario contained emissions from:

- the unloading of bitumen from the ship
- the transfer of bitumen into the PMB/CRMB mixing tanks (including the addition of sulfur during PMB batch mixing and resulting emissions) and
- the loading of bitumen into two road tankers.

The headspace emissions from the ship unloading and road tanker loading were ducted to the Terminals combustor. The headspace emissions from the transfer of bitumen into the PMB/CRMB mixing tanks and addition of sulfur were additionally ducted to the same Terminals combustor. The hot oil heater was located near the Terminals combustor. The modelled source parameters and location are presented in Table 6-1.

It is understood that the combustor is often operated below is maximum design capacity, resulting in lower combustion product emissions (calculated in Table 4-2) and a lower exhaust flowrate. To account for worst case operating conditions, pollutants have been modelled with their corresponding worst case stack properties. Pollutants from tank and road tanker headspace (emission rates shown in Table 4-1) have been model to exit the combustor stack at a more realistic flowrate of 8 m^3/s which results in a lower velocity and poorer dispersion. Combustion products (emission rates shown in Table 4-2) have been modelled to occur at the combustors maximum design capacity with a flowrate of 14 m^3/s. This results in the maximum production of combustion products.

Table 6-1 Model source parameters

Parameter	Terminals		
Source	Combustor		Hot oil heater
Co-ordinates (x,y) UTM (m)	335432, 6238948		335438, 6238959
Stack height (m)	17.3		10
Stack diameter (m)	0.95		0.7
Exhaust discharge velocity (m/s)	11.3[a]	20[b]	15
Flow rate (m^3/s)	8[a]	14[b]	5.8
Exhaust discharge temperature (ºC)	825		200

a. Flowrate and velocity used to model tank and road tanker headspace pollutants (corresponds with worst case measured minimum flows that may lead to maximum emissions)
b. Flowrate and velocity used to model combustion products from the combustor (corresponds with maximum design flows and worst case total emissions)

7. Predicted impacts

7.1 Overview

Dispersion modelling was conducted for the worst-case pollutants emitted from the Puma and Terminals sites. The model was used to predicted ground level pollutant concentrations at each of the sensitive receptors and the maximum on and off-site concentration (calculated via a Cartesian receptor grid). Both incremental (concentrations predicted as a direct result of on-site activities) and cumulative (predicted incremental concentration plus background concentration) pollutant concentrations were calculated. The predicted ground level concentrations of each pollutant was assessed against its impact assessment criteria. No incremental or cumulative exceedances were predicted.

7.2 Odour

The peak on and off-site 99th percentile ground level odour concentration was 0.3 OU. Odour results are presented in Table 7-1 and Figure 7-1.

Table 7-1 Predicted odour concentrations (99th percentile, 1 second averaged)

Pollutant	Averaging period	Predicted concentration (99th percentile, OU)	Assessment criteria (OU)	Compliant	Compliance factor
Odour	1 second	0.34	2	Yes	5.9

1.1 Sulfur dioxide

The predicted 10 minute, 1 hour, 24 hour and annual averaged sulfur dioxide concentration were modelled as it was identified as a key pollutant with significant emissions during PMB batch mixing. It should be noted that sulfur addition (which causes higher sulfur dioxide emissions) only occurs during PMB batch mixing and not during CRMB batch mixing. However the higher sulfur dioxide emission was modelled to occur from all tanks to account for the worst case scenario. It is understood that Puma intends to complete a maximum of four mixing loads (additions of sulfur) per day. The predicted impacts were conservatively modelled assuming constant 24 hourly emission rates. As a result, the predicted sulfur dioxide concentration accounts for all possible worst case dispersion scenarios.

The predicted incremental and cumulative sulfur dioxide concentrations at all receptors are presented in Table 7-2. Cumulative sulfur dioxide concentrations were calculated using the adopted background concentrations discussed in Section 2.3. Background 10 minute averaged sulfur dioxide concentrations were not available from the DPIE monitoring stations, therefore background 1 hour data was used in the cumulative 10 minute assessment.

Contour plots of predicted increment sulfur dioxide concentrations are provided in Figure 7-2 and Figure 7-3 for 10 minute and 1 hourly averaging time periods respectively.

Table 7-2 Predicted sulfur dioxide concentrations

Receptor	Predicted incremental SO_2 concentration (100th percentile, $\mu g/m^3$)				Predicted cumulative SO_2 concentration (100th percentile, $\mu g/m^3$)			
Pollutant averaging period	10 minute	1 hour	24 hour	Annual	10 minute	1 hour	24 hour	Annual
Assessment criteria ($\mu g/m^3$)	712	570	228	60	712	570	228	60
Philip bay residential area	83.6	47.9	14.7	3.5	172.7	136.9	35.6	6.3
Yarra Bay Bicentennial Park	83.1	47.4	16.2	3.7	172.2	136.5	37.2	6.4
Yarra Recreation reserve	73.6	44.7	12.8	3.1	162.6	133.7	33.8	5.9
Botany cemetery	72.5	40.5	13.3	1.6	161.5	129.5	34.3	4.3
Matraville residential area	67.1	40.6	9.3	0.9	156.2	129.7	30.3	3.6
Botany residential area	87.4	48.9	6.4	0.6	176.5	138.0	27.3	3.4

7.3 Benzene

Benzene was modelled as it was identified at the critical pollutant with the least margin of compliance that originated from tank headspace (refer Section 4.4).

The maximum on and off-site 99.9th percentile 1 hour averaged benzene concentration is presented in Table 7-3. Contour plots of predicted increment benzene concentrations are provided in Figure 7-4.

Table 7-3 Predicted Benzene concentrations

Pollutant	Averaging period	Predicted concentration (99.9th percentile, mg/m^3)	Assessment criteria (mg/m^3)	Compliant	Compliance factor
Benzene	1 hour	0.000011	0.029	Yes	2,661

7.4 Other toxics

It should be noted that the other toxic pollutants identified were not separately modelled as the emission metric for these constituents were low. The maximum on and off-site concentrations of these other toxic pollutants was calculated based on benzene mass flowrate and predicted benzene concentration.

Table 7-4 gives the predicted peak levels for each toxic pollutant. All toxic pollutants are predicted to comply with the assessment criteria with significant compliance factors.

Table 7-4 Toxic pollutant concentrations (99.9th percentile, 1 hour averaged)

Pollutant	Averaging period	Predicted concentration (99.9th percentile, mg/m3)	Assessment criteria (mg/m3)	Compliant	Compliance factor
Toluene	1 hour	0.000012	0.36	Yes	30,146
Xylene	1 hour	0.000016	0.19	Yes	12,221
Trimethyl-benzene	1 hour	0.000015	2.2	Yes	146,871
Chloromethane	1 hour	0.00000018	1.9	Yes	10,804,718
Acetone	1 hour	0.000042	22	Yes	522,468
Ethyl Benzene	1 hour	0.00000019	8	Yes	42,361,376

7.5 Nitrogen dioxide

Nitrogen dioxide was modelled as it was identified at the critical pollutant with the least margin of compliance that originated from combustion in the hot oil heater and combustor (refer Section 4.4).

The predicted incremental and cumulative 1 hour and annually averaged nitrogen dioxide concentrations at each receptor are presented in Table 7-5. Cumulative nitrogen dioxide concentrations were calculated using the adopted background concentrations discussed in Section 2.3.

A contour plot presenting the incremental nitrogen dioxide concentration is provide in Figure 7-5.

Table 7-5 Predicted nitrogen dioxide concentrations (100th percentile, 1 hour averaged)

Receptor	Predicted incremental concentration (100th percentile, µg/m3)		Predicted cumulative concentration (100th percentile, µg/m3)	
Pollutant averaging period	1 hour	Annual	1 hour	Annual
Assessment criteria (µg/m3)	246	62	246	62
Philip bay residential area	3.8	0.17	129.8	20.5
Yarra Bay Bicentennial Park	4.2	0.19	130.2	20.5
Yarra Recreation reserve	3.9	0.15	129.9	20.4
Botany cemetery	3.6	0.08	129.6	20.4
Matraville residential area	2.8	0.01	128.8	20.3
Botany residential area	2.9	0.02	128.9	20.3

7.6 Other constituents

It should be noted that other constituent pollutants identified were not separately modelled as the emission metric for these constituents were low. The expected concentrations of these constituent pollutants was estimated using the mass flowrate and predicted concentration of the modelled pollutants (benzene and nitrogen dioxide). Constituent pollutant concentrations were estimated using results for the averaging period and percentile that correspond to the constituent pollutants assessment criteria.

Carbon monoxide and PM_{10} concentrations were estimated using the predicted nitrogen dioxide concentration and mass flowrate. PAH emissions are present from both tank headspace and combustion emissions sources. Consequently predicted PAH concentration calculations were based off both benzene and NO_2 flowrates and predicted concentrations.

Table 7-6 gives the predicted peak on and off-site concentrations for each pollutant. All pollutants are predicted to comply with the assessment criteria.

The predicted cumulative 24 hour and annual PM_{10} has a low compliance factor. This is primarily attributed to high PM_{10} background concentrations as background concentrations account for 88.2% of the 24 hour PM_{10} criteria and 71.8% of the annual PM_{10} criteria.

Table 7-6 Peak on and off-site constituent pollutant concentrations

Pollutant	Averaging period and percentile	Predicted concentration (µg/m^3)		Criteria (µg/m^3)	Compliant	Compliance factor
		Incremental	Cumulative			
Carbon monoxide	1 hour, 100th percentile	69.1	1564.1	30000	Yes	19.2
PM_{10}	24 hour, 100th percentile	3.0	45.9	50	Yes	1.1
	Annual, 100th percentile	0.4	18.0	25	Yes	1.4
PAHs	1 hour, 99.9th percentile	0.0005	0.0005	0.4	Yes	783.3



Paper Size A4

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

Odour Contours (OU)

- 0.1
- 0.2
- 0.3

- Sensitive receivers
- Puma Energy Site
- Terminal Site B

Puma Energy Australia
Botany PMB Project

Job Number	21-27357
Revision	A
Date	15 Sep 2020

Predicted incremental odour impact
(1 second averaged, OU)

Figure 7-1

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Metres

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Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Sensitive receivers
- Puma Energy Site
- Terminal Site B

Sulfur Dioxide Contours (µg/m3 per Hour)

- 250
- 500
- 712

Puma Energy Australia
Botany PMB Project

Job Number	21-27357
Revision	A
Date	12 Oct 2018

Predicted incremental sulfur dioxide impact (10 minute averaged, µg/m3)

Figure 7-2

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Metres

Map Projection: Transverse Mercator
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Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Sensitive receivers
- Puma Energy Site
- Terminal Site B

Sulfur Dioxide Contours (µg/m3 per Hour)

- 250
- 570

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Botany PMB Project

Job Number	21-27357
Revision	A
Date	12 Oct 2018

Predicted incremental sulfur dioxide impact (1 hour averaged, µg/m3)

Figure 7-3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Sensitive receivers
- Puma Energy Site
- Terminal Site B

Benzene Contours (µg/m3 per Hour)

- 0.005
- 0.01

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Revision	A
Date	12 Oct 2018

Predicted incremental benzene impact (1 hour averaged, µg/m3)

Figure 7-4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Sensitive receivers
- Puma Energy Site
- Terminal Site B

Nitrogen Dioxide Contours (µg/m3 per Hour)

- 10
- 20
- 40

Puma Energy Australia
Botany PMB Project

Job Number	21-27357
Revision	A
Date	12 Oct 2018

Predicted incremental nitrogen dioxide impact (1 hour averaged, µg/m3)

Figure 7-5

N:\AU\Sydney\Projects\21\27357\GIS\Maps\Deliverables\21_27357_Z005_BSO2Contours_SMA.mxd (SMA record: 5)

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8. Conclusion and recommendations

GHD conducted an air quality assessment for Puma Energy's proposed PMB and CRMB production facility at the existing Terminals site.

Emission rates used in the assessment were based on sampling of similar facilities in Australia. Air quality dispersion modelling was undertaken in accordance with the Approved Methods to predict pollutant concentrations at sensitive receptor locations and maximum on sampling grid concentrations.

The modelling was undertaken using AUSPLUME for the critical pollutants (highest ranked pollutants based on their emission rate with respect to compliance criteria). The critical pollutants were found to be odour, sulfur dioxide, benzene and nitrogen dioxide.

The assessment identified that all pollutants were predicted to comply with their assessment criteria with significant compliance factors.

Appendices

Appendix A – Proposal narrative functional description and process flow diagram

Puma Energy (Australia) Pty Ltd

Specification

Document Number: PB2036-2000-ELE-FDE-001-A

Title **NARRATIVE FUNCTIONAL DESCRIPTION**

Project Name: Sydney - Botany Bay Bitumen

Project Number: PB2036

Client: PUMA

SYNOPSIS

This specification outlines the minimum mandatory requirements for Engineering and Design of the work performed on Automation and Control Systems within the Sydney Terminal, for the Botany Bay Bitumen project.

				MB	AG
B	15.05.2020	Re-issued for review	J. Crombi	M.Bhavsar	A. Ghelichi
A	10.12.2019	Issued for Review	M.Bhavsar	A. Ghelichi	B. Tahmaseby
REV	**DATE**	**DESCRIPTION**	**PREPARED**	**REVIEWED**	**APPROVED**

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1. GENERAL

1.1 Introduction

The purpose of this document is to describe the intended operation of the new Polymer Modified Bitumen (PMB) and Crumbed Rubber Modified Bitumen (CRMB) production facility being commissioned at the existing Puma Bitumen Import Facility at Port Botany in Sydney. The key functions of the new PMB/CRMB plant are:

- Receipt, storage, handling and transfer of polymer binder or other solid bitumen modifiers;
- Blending of polymer/modifiers, C170 bitumen and Extract Oil to produce PMB;
- Blending of crumbed rubber, C170 Bitumen;
- PMB sampling and storage;
- CRMB sampling and storage
- Transfer of PMB/CRMB between tanks;
- Load out of PMB/CRMB to the existing road gantry.

A separate Process Control System (PCS) shall be installed to operate the PMB manufacturing area. The PCS controls and monitors automation activities within the PMB plant, it also interfaces with the ESD system and the PCS for the existing Bitumen Import Facility.

An Emergency Shutdown (ESD) System will be provided to stop all product flow in the event of an emergency. The ESD is a separate hardwired system designed to shut down equipment in a safe mode.

A simplified SCADA (or other system) will be designed and installed to meet the control functions for the facility. Tank inventory management software (Entis or TankMaster) will be used to monitor tank levels and set alarms. This document is a guide to understanding the required functionality.

The SCADA will automate most of the PMB plant functions, with the exception of the solids material handling. This will be a manual operation with local control pendants provided to the Operator. Where possible, existing control configuration and functionality from the existing bitumen facility shall be replicated to the rest of the PMB plant where there are similarities in operation e.g. mixing, transfer, and load out activities. Replication of the controls at the user level and configuration level is desirable to provide consistency in the operation of the new and existing plant.

Reference should be made to the Functional Description documents for the Bitumen Import Facility to understand the control requirements of the PMB plant

and how they can be best integrated into the existing control system. These documents are referenced in Section 3.0.

1.2 Project Scope

Puma currently operates a bitumen import, storage and distribution facility located within Port Botany in New South Wales. The bitumen facility primarily stores and loads out C170 and C320 grades of bitumen and has the capability to oxidise these grades to higher viscosities as required.

The purchase of the BP bitumen business included formulas for the Olexobit range of Polymer Modified Bitumen (PMB) for which Puma has now found a ready market. In order to meet the PMB market – a significant quantity of which is centred on NSW – a new PMB manufacturing facility is required in NSW. The new PMB plant comprises the following main systems and equipment:

- 1 x 50T heated/insulated blend tank including high sheer mixer/shredder for the manufacture of all PMB/CRMB grades .
- 2 x 100T heated and insulated storage tanks complete with mixers to hold finished PMB/CRMB
- 1 x 50T heated and insulated Extract oil storage tank
- 1 x 100T heated and insulated buffer tank for the storage of C170 grade bitumen – this tank is required to cover periods when bitumen from the existing facility is not available (e.g. during tank ship discharges). Base grade C170 bitumen will be transferred from the main facility using the existing transfer pumps and heat exchangers.
- Heating for the PMB facility – The existing site hot oil heaters are rated at 2 x 3000 KW – the PMB plant heating required is relatively small therefore utilizing the existing heaters should be possible. Heat metering will be required to enable additional gas usage to be monitored.
- Hot oil circulation for both tank heating and tracing in the PMB area will utilise the existing pumps.
- Bulk materials handling system for polymer, Buna, wax and sulphur loading into batch tank – conveyor type.
- Loading and transfer pumps
- Homogeniser – 1 x 60T/hr capacity
- PMB loading capability – Propose to use existing gantry and loading arms with product line tie in located as close to the loading arm as possible.
- Sour gas system linked to all tanks. A vapour incinerator already exists which generally runs well below its design capacity as the existing plant normally generates much lower gas volumes. The vapour combustor is capable of handling the additional vapour flow generated by the PMB

plant but may require production scheduling at times when the existing blowing plant is producing maximum vapour flow.

Refer to Section 2 for a complete list of relevant drawings, P&IDs and Control Functionality Table.

1.3 Definitions

Abbreviations, acronyms, and other terminology used in this document are defined in the table below:

Abbreviation	Definition
BLC	Bay Load Controller
CRMB	Crumbed Rubber Modified Bitumen
ESD	Emergency Shutdown
MCC	Motor Control Centre
MOC	Management of Change
PCS	Process Control System
PLC	Programmable Logic Controller
PMB	Polymer Modified Bitumen
SCADA	Supervisory Control & Data Acquisition
TTLR	Tanker Truck Loading Rack
VSD	Variable Speed Drive

2. Reference Documents

The following documents are referenced by this report:

Document no.	Document Title	Rev
2036-R-0001	PFD – Botany Bay PMB Production Facility	0
2036-Q-0001	P&ID – Botany Bay PMB Production Facility Storage Tanks	0B
2036-Q-0002	P&ID – Botany Bay PMB Production Facility Mix Tanks	0C

Document no.	Document Title	Rev
2036-Q-0003	P&ID – Botany Bay PMB Production Facility Tankfarm & Pump	0B
2036-Q-0005	P&ID – Botany Bay PMB Production Facility Tankfarm & Pump	0A
2036-Q-0006	P&ID – Botany Bay PMB Production Facility Gantry	0A
2036-Q-0007	P&ID – Botany Bay PMB Production Facility Hot Oil System	0A
2036-Q-0008	P&ID – Botany Bay PMB Production Facility Hot Oil System	0A
2036-Q-0010	*see P&ID 218533-PI-19 below*	
2036-Q-0011	P&ID – Botany Bay PMB Production Facility Material Handling System	0A
2036-Q-0012	P&ID – Botany Bay PMB Production Facility High Temperature Heating Oil Loop *refer 218533-PI-22 below*	0
218533-PI-09	P&ID – Port Botany Bitumen Import Facility Day Tanks Manifold	4
218533-PI-10	P&ID – Port Botany Bitumen Import Facility Tanker Loading Bays	7
218533-PI-11	P&ID – Port Botany Bitumen Import Facility Batch Process Check Tank Manifold	7
218533-PI-12	P&ID – Port Botany Bitumen Import Facility T281 Batch Process Tank	2
218533-PI-13	P&ID – Port Botany Bitumen Import Facility T282 Batch Process Tank	2
218533-PI-19	P&ID – Port Botany Bitumen Import Facility Bitumen Vapour Combustion – Sheet 2	2
218533-PI-22	P&ID – Port Botany Bitumen Import Facility High Temperature Heating Oil Loop	2
218533-P-FD001	Narrative Functional Description Port Botany Bitumen Import Facility	4
218533-P-FD005	Combustor Vapour Ducting Narrative Functional Description	1
218533-P-FD100	Bitumen Facility Emergency Shutdown Sequences	0

3. Equipment Details

This section lists the major equipment, instrumentation, motor drives and valves that will be installed as part of the PMB Production Facility. When reading the operational sequence descriptions that are described in the subsequent sections of this document, reference should be made back to these equipment details

3.1 Major Equipment

Equipment No.	Equipment Type	Function
T4000	Storage Tank	Storage of Bitumen C170
T4100	Storage Tank	Storage of Extract Oil
T4200	Batch Tank	PMB/CRMB Batch Mixing Tank
T4600	Storage Tank	PMB/CRMB Storage
T4700	Storage Tank	PMB/CRMB Storage
P4000	Pump	C170 Transfer Pump
P4100	Pump	Extract Oil Unloading/Transfer Pump
P4200	Pump	Transfer Pump
P4300	Gantry Pump	Loadout PMB/CRMB from storage tank to Gantry Bay 1 or 2
P4400	Gantry Pump	Loadout PMB/CRMB from storage tank to Gantry Bay 1 or 2
H4200	Homogeniser	
M4200	Shredder	
A4600	Mixer	Mix contents of T4600
A4700	Mixer	Mix contents of T4700
K4200/K4201	P4200 Strainer	Capture foreign matter at P4200 suction
K4600/K4601	P4400 Strainer	Capture foreign matter at P4400 suction
K4700/K4701	P4300 Strainer	Capture foreign matter at P4300 suction

SSB-4000	P4000 Strainer	Capture foreign matter at P4000 suction
SSB-4100	P4100 Strainer	Capture foreign matter at P4100 suction
SP4000	KO Pot	Separate carryover liquid in vapour stream to combustor
SP4001	Venturi System	For conveying solids
H4000	Hopper	For storing solids

3.2 Instrumentation and Status

Instrument	Description	Low-Low Alarm	Low Alarm	High Alarm	High-High Alarm	Set Point
LIT-4000	T4000 Level (mm)	2197 Note 3	2297 Note 4	11875 Note 1	12315 Note 2	-
LIT-4001	T4000 Level (mm)	2197 Note 3	2297 Note 4	11875 Note 1	12315 Note 2	-
LIT-4100	T4100 Level (mm)	2143 Note 3	2243 Note 4	11056 Note 1	11970 Note 2	-
LIT-4101	T4100 Level (mm)	2143 Note 3	2243 Note 4	11056 Note 1	11970 Note 2	-
LIT-4200	T4200 Level (mm)	2217 Note 5	2317 Note 6	5130 Note 1	5415 Note 2	-
LIT-4201	T4200 Level (mm)	2217 Note 5	2317 Note 6	5130 Note 1	5415 Note 2	-
LIT-4600	T4600 Level (mm)	2197 Note 3	2297 Note 4	11875 Note 1	12315 Note 2	-
LIT-4601	T4600 Level (mm)	2197 Note 3	2297 Note 4	11875 Note 1	12315 Note 2	-
LIT-4700	T4700 Level (mm)	2197 Note 3	2297 Note 4	11875 Note 1	12315 Note 2	-
LIT-4701	T4700 Level (mm)	2197 Note 3	2297 Note 4	11875 Note 1	12315 Note 2	-
TIT-4000	T4000 Temperature 1 (°C)	170.0	180.0	195	200	190.0
TIT-4001	T4000 Temperature 2 (°C)	170.0	180.0	195	200	190.0
TIT-4002	C170 Feed Temperature (°C)	170.0	180.0	N/A	N/A	-

Instrument	Description	Low-Low Alarm	Low Alarm	High Alarm	High-High Alarm	Set Point
TIT-4002	T4000 C170 Inlet Temperature (°C)	140	150			
TIT-4003	C170 Feed Temperature (°C)					
TIT-4100	T4100 Temperature 1 (°C)	80.0	90.0	120.0	130.0	110.0
TIT-4101	T4100 Temperature 2 (°C)	80.0	90.0	120.0	130.0	110.0
TIT-4102	Extract Oil Temperature (°C)	80.0	90.0	120.0	130.0	-
TIT-4200	T4200 Temperature 1 (°C)	170.0	180.0	195.0	200.0	190.0
TIT-4201	T4200 Temperature 2 (°C)	170.0	180.0	195	200	190.0
TIT-4600	T4600 Temperature 1 (°C)	170.0	180.0	195	200	190.0
TIT-4601	T4600 Temperature 2 (°C)	170.0	180.0	195	200	190.0
TIT-4700	T4700 Temperature 1 (°C)	170.0	180.0	195	200	190.0
TIT-4701	T4700 Temperature 2 (°C)	170.0	180.0	195	200	190.0
TIT-4800	Gantry Bay 2 Temperature (°C)	N/A	N/A	195	200	-
TIT-4801	Gantry Bay 1 Temperature (°C)	N/A	N/A	195	200	-
PIT-4000	P4000 Discharge Pressure (kPag)	N/A	N/A	750	800	450
DPIT-4000	P4000 Suction Strainer DP	0.0	0.0	20.0	25.0	-
PIT-4100	P4100 Discharge Pressure (kPag)	N/A	N/A	750	800	450
DPIT-4100	P4100 Suction Strainer DP	0.0	0.0	20.0	25.0	-
PIT-4201	P4200 Discharge Pressure (kPag)	N/A	N/A	900	1000.0	-
PIT-4202	P4200 Suction Pressure (kPag)	-75	-70	N/A	N/A	-

Instrument	Description	Low-Low Alarm	Low Alarm	High Alarm	High-High Alarm	Set Point
PIT-4203	H4200 Homogeniser Discharge Pressure (kPag)	N/A	N/A	900	1000.0	-
PIT-4204	H4200 Homogeniser Suction Pressure (kPag)	-75	-70	N/A	N/A	-
DPIT-4200	P4200 Suction Strainer DP	0.0	00	20.0	25.0	-
PIT-4600	P4400 Discharge Pressure (kPag)	0.0	0.0	900.0	1000.0	-
DPIT-4600	P4400 Suction Strainer DP	0.0	0.0	20.0	25.0	-
PIT-4300	P4300 Discharge Pressure (kPag)	0.0	0.0	900.0	1000.0	-
DPIT-4300	P4300 Suction Strainer DP	0.0	0.0	20.0	25.0	-
FIT-4000	C170 Volume Flowrate (L/min)					
FIT-4200	PMB Batch Tank Volume Flowrate (L/min)					
TT-4004	P4000 Motor Temperature (°C)			90	100	
TT-4003	P4000 Hot Oil Jacket Temperature (°C)	170	180	190	200	
TT-4103	P4100 Motor Temperature (°C)			90	100	
TT-4102	P4100 Hot Oil Jacket Temperature (°C)	80	90			
TT-4204	P4200 Motor Temperature (°C)			90	100	
TT-4205	P4200 Hot Oil Jacket Temperature (°C)	170	180			
TT-4207	H4200 Motor Temperature (°C)			90	100	
TT-4208	H4200 Hot Oil Jacket Temperature (°C)	170	180			
TT-4603	P4400 Motor Temperature (°C)			90	100	
TT-4602	P4400 Hot Oil Jacket Temperature (°C)	170	180			

Instrument	Description	Low-Low Alarm	Low Alarm	High Alarm	High-High Alarm	Set Point
TT-4301	P4300 Motor Temperature (°C)			90	100	
TT-4302	P4300 Hot Oil Jacket Temperature (°C)	170	180			
TT-4604	A4600 Motor Temperature (°C)			90	100	
TT-4702	A4700 Motor Temperature (°C)			90	100	
SC-4200	P4200 VSD Speed (RPM)					
LEL-4000	Sour Gas LEL Level (%)	0.0	0.0	20.0	>25.0	-
LEL-4001	Sour Gas LEL Level (%)	0.0	0.0	20.0	>25.0	
AA-4000	H2S DETECTOR (PPM)				>8	
AA-4001	H2S DETECTOR (PPM)				>8	
AA-4002	H2S DETECTOR (PPM)				>8	
AA-4003	H2S DETECTOR (PPM)				>8	
AA-4004	H2S DETECTOR (PPM)				>8	

Notes:

1. 90% of total volume
2. 95% of total volume
3. 150mm above coil height
4. 250mm above coil height
5. 150mm above lower coil outlet
6. 250mm above lower coil outlet

3.3 Motor Drives and interlocks

Motor Number	Equipment Name	Start Interlock	Run Interlock
P4000	C170 Transfer Pump	T4000 Low Level High Motor Temp High Oil Jacket Temp	

Motor Number	Equipment Name	Start Interlock	Run Interlock
P4100	Extract Oil Unloading/Transfer Pump	High Motor Temp High Oil Jacket Temp	High Discharge Pressure Low Suction Pressure
P4200	Transfer Pump	T4200 Low Level High Motor Temp High Oil Jacket Temp	High Discharge Pressure Low Suction Pressure
P4400	PMB Loading Pump	T4600 / T4700 Low Level T4700 High Temp T4600 High Temp High Motor Temp High Oil Jacket Temp	
P4300	CRMB Loading Pump	T4600 / T4700 Low Level T4700 High Temp T4600 High Temp High Motor Temp High Oil Jacket Temp	
M4200	Shredder	T4200 Low Level T4200 High Temp High Motor Temp	
A4600	Mixer	T4600 Low Level T4600 High Temp High Motor Temp	
A4700	Mixer	T4700 Low Level T4700 High Temp High Motor Temp	

Note:

1. All Start Interlocks shall also act as Run Interlocks unless otherwise stated.

2. The table above does not include standard MCC permissive as these interlocks are assumed to apply to all drives. Similarly, Emergency Stops are not covered as they shall be hardwired into the control circuit.

3. Motor current interlocks shown above shall include appropriate time delays to filter out start up transients.

4. Low Pressure interlocks shown above shall include filters on VSD output plus time delay to filter out nuisance alarms and allow pump to reach running speed.

5. High Pressure interlocks shown above shall include time delay to filter out nuisance alarms and allow pump to reach running speed.

6. All Run interlocks are required to latch to allow the Operator to determine the reason for the interlock trip. Common Reset for trips to be provided on each individual drive faceplate.

7. Control functions shall operate normally when the Emergency Stop circuit is healthy. Control functions shall fail safe when the Emergency Stop circuit is active.

8. Operators may select “Maintenance Mode” on any drive. When this mode is active, the drive shall turn off. This also disables any sequence from accessing this drive, such that the sequence will be interlocked.

3.4 Valves and Interlocks

Valve Number	Description	Open Interlocks	Normal State	Fail State
XV-4000	T4000 Outlet to P4000	LT-4001 Low; OR XV-4001 Open	Closed	Closed
XV-4001	C170 Feed Line Valve to T4000	LT-4001 High; OR XV-4000 Open XV-1004 Open; OR XV-1003 Open	Closed	Closed
XV-4000	T4000 Vent to Combustor		Open	Closed
XV-4100	T4100 Outlet to P4100	LT-4101 Low	Closed	Closed
XV-4101	P4100 Discharge to Mix Tank T4200	XV-4010 Open	Closed	Closed
XV-4010	P4100 Discharge to Portable PMB/CRMB Unit	XV-4101 Open	Closed	Closed
XV-4011	P4000 Discharge to Portable PMB/CRMB Unit	XV-4002 Open	Closed	Closed
XV-4200	T4200 Outlet to P4200/H4200	LT-4201 Low; OR XV-4201 Open	Closed	Closed
XV-4201	T4200 Inlet Valve	LT-4201 High; OR MOV-4202 Open; OR XV-4205 Open; OR XV-4204 Open; OR XV-4200 Open	Closed	Closed

Valve Number	Description	Open Interlocks	Normal State	Fail State
XV-4220	SP4000 Sour Gas Inlet		Open	closed
XV-4003	SP4000 Outlet to Combustor	LS-4000 High; OR	Open	Closed
XV-4200	T4200 Vent to Combustor		Closed	Closed
XV-4214	Inlet to Portable PMB/CRMB Unit	TBA		
XV-4215	Outlet from Portable PMB/CRMB Unit	TBA		
XV-4216	PMB/CRMB from P-PMB to Gantry	TBA	Closed	Closed
XV-4217	PMB/CRMB from P-PMB to T4600/T4700	TBA	Closed	Closed
XV-4203	T4200 Outlet to P4200	LT-4201 Low; OR XV-4201 Open; OR	Closed	Closed
XV-4204	P4200 Recycle to T4200	XV-4601 Open; OR XV-4701 Open; OR XV-4205 Open	Closed	Closed
XV-4205	H4200 Recycle to T4200	XV-4601 Open; OR XV-4701 Open; OR XV-4204 Open	Closed	Closed
XV-4600	T4600 Outlet to P4400/P4300	LT-4601 Low; OR XV-4601 Open; OR XV-4700 Open	Closed	Closed
XV-4601	T4600 Inlet Valve	LT-4601 High; OR XV-4600 Open; OR XV-4701 Open; OR	Closed	Closed
XV-4219	T4600 Recycle to T4200 Transfer to T4700	XV-4204 Open; OR XV-4701 NOT Open XV-4701 Open; OR XV-4204 NOT Open;	Closed	Closed

Valve Number	Description	Open Interlocks	Normal State	Fail State
XV-4600	T4600 Vent to Combustor		Open	Closed
XV-4700	T4700 Outlet to P4400/P4300	LT-4701 Low; OR XV-4701 Open; OR XV-4600 Open	Closed	Closed
XV-4701	T4700 Inlet valve	LT-4701 High; OR XV-4700 Open; OR XV-4601 Open; OR XV-4204 Open; OR	Closed	Closed
XV-4702	T4700 Recycle to T4200 Transfer to T4600	XV-4204 Open; OR XV-4601 NOT Open XV-4601 Open; OR XV-4204 NOT Open;	Closed	Closed
XV-4700	T4700 Vent to Combustor		Open	Closed
XV-4451	PMB/CRMB from T4600 to Gantry Bay 1	XV-4453 Open; OR XV-4452 Open; OR XV-4801 NOT Open; OR XV1001 Open; OR XV-1906 NOT Open	Closed	Closed
XV-4711	PMB/CRMB from T4700 to Gantry Bay 2	XV-4452 Open; OR XV-4453 Open; OR XV-4800 NOT Open; OR XV-1002 Open; OR XV-1907 NOT Open	Closed	Closed
XV-4800	ESD Valve in Gantry Bay 2	FV-1002 Open; OR |XV-1907 NOT Open	Closed	Closed
XV-4801	ESD Valve in Gantry Bay 1	FV-1001 Open; OR XV-1906 NOT Open	Closed	Closed
TCV-4000	T4000 Hot Oil Coils (Internal)	LIT-4001 Low; OR TIT-4000/4001 High; OR T4000 in pump transfer sequence	Closed	Closed
TCV-4100	T4100 Hot Oil Coils (Internal)	LIT-4101 Low; OR TIT-4100/4101 High; OR	Closed	Closed
TCV-4200-1	T4200 Hot Oil Coils (External Coil 1)	LIT-4201 Low; OR TIT-4200/4201 High; OR	Closed	Closed

Valve Number	Description	Open Interlocks	Normal State	Fail State
TCV-4200-2	T4200 Hot Oil Coils (External Coil 2)	LIT-4201 Low; OR TIT-4200/4201 High; OR	Closed	Closed
TCV-4600	T4600 Hot Oil Coils (Internal)	LIT-4601 Low; OR TIT-4600/4601 High; OR	Closed	Closed
TCV-4700	T4700 Hot Oil Coils (Internal)	LIT-4701 Low; OR TIT-4700/4701 High; OR T4700 in pump loadout/transfer sequence	Closed	Closed

Notes:

1. Emergency Stops are not covered by the table above, as they shall be hardwired into the control circuit. All valves to go to the fail-safe (de-energised) state when an ESD is active.

2. Operators may select “Maintenance Mode” on any valve. When this mode is active, the valve shall be forced to the de-energised state. This also disables any sequence from accessing this valve, such that the sequence will be interlocked.

3. Position switches on valves shall raise an alarm if a valve is out-of-position

4. Emergency Stops and Faults

Several Emergency Stop pushbuttons shall be provided in the PMB plant as per the table below. These pushbuttons shall be integrated into the existing site ESD system. Field Emergency Stop pushbuttons are to be latching type.

E-Stop Tag No.	Location
ESD-1	Inside Switchroom on ESD-101 Door
ESD-2	Control Building ESD-102 Door
ESD-3	Hopper
ESD-4	Top Tank T4200
ESD-5	Pump Bank
ESD-6	External Switchroom

Each of these pushbuttons, when depressed, will shut off all pumps; stop any running sequences; de-energise all valves into the fail-safe position; and activate audible and visual alarms at the SCADA and in the field.

Aside from the E-stops, local Off buttons will be available for the following equipment:

P4000, P4100, P4200, P4300, P4400 pump motors

M4200, H4200, A4600, A4700 and MOV-4202 motors

PMB material handling system motors (conveyors, vacuum block lifter and dust extraction filter)

The facility must also have another means to stop all PMB operations from an alternate location other than the local stop e.g. at the PLC. The PMB plant will be integrated into the existing systems for site power fault, plant air fault.

5. Storage Tanks (T4000 & T4100) System

5.1 System Description

5.1.1 Overview

T4000 is a vertical steel storage tank with nominal capacity of 100T. It has two DN50 heating coils and a DN200 free vent. The tank is insulated and clad on both the shell and roof. The design temperature is 200°C; and the design pressure is 35 kPag. T4000 acts as a buffer tank to cover periods when C170 is not available from the existing Bitumen Import Facility (during tank ship unloading).

Extract Oil is delivered by road tanker and unloaded to T4100 using pump P4100. T4100 is a vertical steel storage tank with nominal capacity of 50T. The design temperature is 200°C; and the design pressure is 35 kPag.

Bitumen is supplied from the existing facility. Bitumen Loading Pump #1 (P1001) that also supplies the two bay tanker truck loading rack (TTLR) is used to transfer bitumen to the PMB plant. The pump is not designed to supply the gantry and the PMB plant simultaneously. Route selection is manual and requires the operator to open the appropriate isolation valve.

Both Bitumen C170 and Extract Oil are stored at a temperature of approximately 190°C and 110°C respectively by passing hot oil through the heating coils. Two temperature probes are mounted in each of the tanks. The first probe is mounted below the low level mark but above the heating coils. The second probe is mounted at a higher elevation in the tank. The PMB operator can select either of the probes as the measured variable for the temperature control. The output from each controller drives a single On/Off valve that, when energised open, directs hot oil through the respective tank heating coils and when de-energised shuts off hot oil to the tank heating coils.

The levels in the tanks are monitored by a radar type level transmitters. The signal from each transmitter generates a high level alarm and a low level alarm.

An independent level transmitter is fitted to each tank with high, high-high and low, low-low alarms. For T4000 only; when the level in a tank reaches the

high-high level the inlet isolation valve is tripped closed and an audible and visual alarm is raised. On low-low level the outlet isolation valve is tripped closed and tank heating is inhibited by forcing the thermal oil On/Off valve to the fully closed position. The levels in each tank as measured by the two transmitters are compared and a deviation alarm is generated if the results exceed a pre-set value.

T4000 tank only has a connection to a vapour extraction system. This system draws vapours from within the vapour space of the tank to prevent fugitive emissions to atmosphere as the tank fills and breathes.

5.1.2 Tank Status

The operator can mark T4000 or T4100 as “In Service” or “Out of Service”. When a tank is marked as “Out of Service”, control sequences cannot transfer into or out of it. T4000 cannot be put into “Out of Service” if a transfer sequence to/from the tank is already running.

5.1.3 Operator Controls

The SCADA screens shall provide the controls to the Operator to start, pause, or stop a transfer. The graphics shall provide an overview of the associated instrumentation.

The PLC shall allow an Operator to select the required mode by selecting the source tank, desired manifolds and pump. The PLC will then automatically align the appropriate valves and start the transfer pump. The transfer sequence will then transfer product until:

1. A High level is reached in the destination tank; OR
2. A Low level is reached in the source tank.

Extract Oil is supplied in isotainers and must unloaded manually from road tanker to tank T4100.

The following table lists the selections that shall be available to an Operator in order to use the pump transfer sequence.

P1001 Operator Controls	
Description	**Selection**
Select “From Tank”	Select from the popup graphic
Select “To Tank”	**Select from the popup graphic**
Start Transfer	**Press the “Transfer” button**
Stop Transfer	Press the “Stop” button

5.1.4 Pump Speed Control

The speed of P1001 will be controlled by monitoring the flow of C170 being transferred (FQI-4000). If the flow reaches High (FAH-4000) the VSD will turn down the pump speed to maintain the desired flow or until the pump reaches a minimum speed at which point it will trip to prevent damage to the pump. An alarm is generated in SCADA (FALL-4000). If the bitumen C170 temperature reaches Low-Low (TALL-4002) the P1001 will also trip to protect the pump

P1001 can also be used to loadout to gantry (Bay 1 or Bay 2). However, this is not currently in operation (line to Bay 2 has a blind spool installed and line to Bay 1 has been isolated). P1001 has a design flowrate of 1500 LPM. It will not be used for simultaneous loadout to gantry as well as transfer to the PMB plant.

5.2 Operational Sequences

The following sections describe the intended operational sequences of T4000; and should be read in conjunction with the Equipment Details. The sequences should also be read in conjunction with the Cause & Effect Matrix in Appendix A.

1) Operator selects the required transfer from SCADA. The SCADA screen will display the available tanks (T281 or T282).

2) If satisfied with the information displayed, the Operator selects the “FROM TANK” button. Operator is prompted to enter the requested volume of C170. This will trigger the PLC to reset the FQI-4000 setpoint equal to the required volume of C170.

3) The PLC shall set TCV-4000 to automatically control to a set point of 150°C.

4) The PLC confirms that XV-4003 is in the open position using ZS-XV4003. The PMB plant shares a vapour extraction/combustion system with the existing Bitumen Import Facility and the combustor must be operational to enable PMB production.

5) Operator presses the “TRANSFER” button to initiate C170 transfer to T4000.

6) The PLC shall command XV-1140 or XV-1141 and XV-1201 or XV-1301 in the P1001 pump suction to open (depending upon the selected tank).

7) PLC shall command XV-4001 in the tank inlet to T4000 to open.

8) After confirming that XV-1140/XV-1141 and XV-1201/XV-1301 positions are open using ZSO-1140/1141 and ZSO-1201/1301; and that XV-4001 is open using ZS-XV4001, the PLC commands P1001 to start transfer of C170 at a nominal slow-fill rate of 500L/min (note this rate is subject to change at commissioning).

9) Once T4000 level is above the tank low level, the PLC shall command P1001 to increase flowrate to a nominal fast-fill rate of 1200L/min (note this rate is subject to change at commissioning).

10) The PLC shall monitor the total volume of C170 into T4000 via FQI-4000 using the setpoint assigned in step 2). The PLC must subtract the dead volume between the location of FQI-4000 and T4000 inlet as this quantity has past the meter but will still be added to the transfer total.

11) The extraction system operates at a slight vacuum to draw bitumen vapours out of T4000 during tank filling instead of venting vapours to atmosphere. (This is mainly for odour control). The tank headspace pressure is controlled by throttling the vapour flow via FIT-4001 and FCV-4000.

12) As FQI-4000 approaches the setpoint volume, the PLC commands P1001 to reduce to slow-fill rate.

13) Once FQI-4000 setpoint volume has been achieved, the PLC commands XV-4001 to close and monitors position switch ZS-XV4001 to confirm the valve has closed.

14) Once XV-4001 is confirmed closed the PLC shall remove the run request to P1001.

15) PLC commands XV-1140 or XV-1141 and XV-1201 or XV-1301 in the P1001 pump suction to close. Transfer is complete.

5.2.1 Interlocks

The following Start and Running interlocks shall apply to the Transfer sequence:

Pre-Start Interlocks	Running Interlocks
T4000/T281/T282 “Not in Service”	T281/T282 source tank level is Low (Note 1)
P1001 Loading Pump Not Available	T4000 destination tank level is High (Note 2)
T4000 Transfer sequence is Active	
T281/T282 Transfer sequence (to T277/T278) is Active	
T281/T282 source tank level is Low	
T4000 destination tank level is High	
T281/T282 source tank temperature is <180°C	

T4000 destination tank hot oil control valve NOT closed	

Notes

1) If the source tank level becomes Low mid-sequence, this shall trip the transfer sequence and stop the transfer pump.
2) If the destination tank level becomes High or High High mid-sequence, this shall trip the transfer sequence and stop the transfer pump.

5.3 Tank Heating

Refer to Section 9 for details of the hot oil heating system for T4000

5.4 Pump (P4000 & P4100) Transfer System

The operation of transfer pumps P4000 and P4100 is included as part of the Mix Tank (T4200) System.

6. Mix Tank (T4200) System

6.1 System Description

6.1.1 Overview

T4200 is a vertical steel tank with nominal capacity of 50T that will be used for blending polymer, C170 bitumen & extract oil as well as other additives to produce specialty grade PMBs/CRMB. Once mixed and homogenised, the resultant PMB product is transferred to storage tank T4600 for quality testing and storage. T4600 serves as a dual-purpose check tank/storage tank while T4700 is the final product tank.

T4200 has two separate hot oil jackets to heat the contents to a temperature of approximately 190°C to assist in the melting/blending of modifiers into the base grade bitumen. Two temperature probes are mounted in the tank. The first probe is mounted below the low level mark. The second probe is mounted at a higher elevation in the tank. The operator can select either of the probes as the measured variable depending upon the batch recipe size. There are two control valves to modulate the supply of hot oil to the two jackets. The output from each controller drives a dedicated On/Off valve that, when open, directs hot oil through the respective external heating coil and when de-energised shuts off hot oil to that heating coil.

The level in the tank is monitored by a radar type level transmitter. The signal from the transmitter generates a high level alarm and a low level alarm.

An independent level transmitter is fitted with high, high-high and low, low-low alarms. When the level in T4200 reaches the high-high level the inlet isolation valve is tripped closed to prevent overfill. On low-low level the outlet isolation valve is tripped closed and tank heating is inhibited by forcing the hot oil On/Off valve to the fully closed position. The level in the tank as measured by the two transmitters is compared and a deviation alarm is generated if the results exceed a pre-set value.

The tank has a bottom mounted shredder for chopping up Buna rubber blocks when added as the binder. The shredder has a variable speed drive controlled by the bitumen temperature in the tank and the motor temperature.

T4200 tank has a connection to a vapour extraction system. This system draws vapours from within the vapour space of the tank to prevent fugitive emissions to atmosphere as the tank fills and breathes

There will be a selection of pre-programmed “recipes” available to the Operator, which will automatically set the required batch volume, the required volumes of C170 and extract oil and polymer binder, and duration of mixing. These recipes cannot be modified without undergoing a formal Puma Management of Change (MOC) procedure.

C170 bitumen base grade is transferred from buffer tank T4000 to T4200 using pump P4000. Extract oil is stored in tank T4100 and transferred to mix tank T4200 (only used for SBS polymer type grades where required) by pump P4100. Pumps P4000/P4100 shall initially slow-fill C170/Extract Oil into T4200 until a minimum level in the tank has been reached. The pump flowrate will then increase to high-flow and continue to fill until the required volumes have been transferred based on the recipe selected.

The polymer binders such as Styrene Butadiene Styrene (SBS), Ethylene Vinyl Acetate (EVA) or Latex (Buna) are added to the mix tank by the materials handling system. Chemical modifiers such as sulphur and viscosity modifiers such as wax can also be added depending upon the recipe. Polymer should never be added into T4200 until the bitumen level in T4200 has exceeded the low level, to avoid excessive heating of binder by the external hot oil coils.

The mix tank contents can also be circulated through a homogeniser H4200 and back to the mix tank to ensure complete blending and achieve a uniform batch of PMB. Once mixing is complete the batch is pumped out to T4600 by P4200 for sampling and/or storage. The plant will also haver the option to transfer homogenised product to T4600, which ensures that 100% of the production batch is run through the homogeniser. This will shorten homogenisation times. Load out of a PMB batch from T4200 direct to gantry is not considered part of normal operation.

6.1.2 Tank Status

The operator can mark T4200 as “In Service” or “Out of Service”. When the tank is marked as “Out of Service”, control sequences cannot load into or out of it. T4200 cannot be put into “Out of Service” if a load out sequence from the tank is already running.

6.1.3 Operator Controls

The SCADA screens shall provide the controls to the Operator to select a recipe, start, pause, stop, or change the step of the manufacturing sequence. The graphics shall provide an overview of the associated instrumentation.

When a recipe is selected by an Operator, the relevant set points and batch quantities are loaded and displayed for the Operator to confirm. Once

confirmed, the sequence will add ingredients, blend, and pump out as required.

Description	Selection
Recipe	Select from the drop down menu
Confirm Batch	Press the “CONFIRM BATCH” button
Start Batch	Press the “START” button
Pause Batch	Press the “PAUSE” button
E-stop (reset batch)	Press the “E-STOP” button
Run M4200 despite Low Temp	Press the “USE M4200” button
Run H4200 to blend T4200	Press the “USE H4200” button
Use P4200 to pump out T4200	Press the “P4200 LOADOUT” button
Use H4200 to pump out T4200	Press the “H4200 LOADOUT” button
Choose manifold and destination tank for pump out	Press the “H4200/P4200 SELECTION” button
Stop a pump out operation	Press the “LOADOUT STOP” button

6.2 Operational Sequences

The following sections describe the operational sequences of T4200 and should be read in conjunction with the Equipment Details. The sequences should also be read in conjunction with the Cause & Effect Matrix in Appendix A

6.2.1 PMB / CRMB Production

1) Operator selects the required recipe from SCADA. The SCADA screen will display that recipe’s batch volume, required volume of C170, Extract Oil, required quantities of polymer, chemical & viscosity modifiers, and duration of mixing.

   Note: For CRMB production extract oil and polymer binder are not required.

2) If satisfied with the information displayed, the Operator presses the “CONFIRM BATCH” button. This will trigger the PLC to set the FQI-4200 setpoint equal to the required volume of C170 displayed in step 1).

3) The PLC shall set TCV-4200-1 and/or TCV-4200-2 to automatically control to a set point of 195°C.

4) The PLC confirms that XV-4003 is in the open position using ZS-XV4003. The PMB plant shares a vapour extraction/combustion system with the existing Bitumen Import Facility and the combustor must be operational to enable PMB production.

5) Operator presses the “START” button to initiate C170 transfer to T4200.

6) The PLC shall command XV-4002 and XV-4201 to open

7) After confirming that XV-4002 and XV-4201 positions are open using ZS-XV4002 and ZS-XV4201, the PLC commands P4000 to start transfer of C170 at a nominal slow-fill rate of 500L/min (note this rate is subject to change at commissioning).

8) Once T4200 level is above the tank low level, the PLC shall command P4000 to increase flowrate to a nominal fast-fill rate of 1200L/min (note this rate is subject to change at commissioning).

9) The PLC shall monitor the total volume of C170 into T4200 via FQI-4200 using the setpoint assigned in step 2). The PLC must subtract the dead volume between the location of FQI-4200 and T4200 inlet as this quantity has past the meter but will still be added to the batch total.

10) The extraction system operates at a slight vacuum to draw bitumen vapours out of T4200 during tank filling instead of venting vapours to atmosphere. (This is mainly for odour control). Operator shall monitor the tank headspace pressure via PIT-4201 and the vapour flow via FIT-4001 and FCV-4200.

11) As FQI-4200 approaches the setpoint volume, the PLC commands P4000 to reduce to slow-fill rate.

12) Once FQI-4200 setpoint volume has been achieved, the PLC commands XV-4201 to close and monitors position switch ZS-XV4201 to confirm the valve has closed.

13) Once XV-4201 is confirmed closed the PLC shall remove the run request to P4000.

14) Steps 5) through 13) are repeated for Extract Oil where this is required by the particular recipe. If Extract Oil is not required for the particular recipe the PLC shall skip steps 15) through 21) and set the sequence into the polymer binder addition stage.

    Note: For CRMB production, extract oil is not required

15) The PLC resets the setpoint of FQI-4200 to equal the required volume of Extract Oil displayed in step 1). The PLC shall not reset the totalised flow (mass) of the batching flow meter. This can only be reset once the total quantity has been transferred.

16) Operator presses the “START” button to initiate Extract Oil transfer to T4200

17) The PLC shall command XV-4101 to open.

18) After confirming that XV-4101 position is open using ZS-XV4101, the PLC commands P4100 to start transfer of Extract Oil

19) The PLC shall monitor the total volume of Extract Oil into T4200 via FQI-4200 using the setpoint assigned in step 1)

20) Once FQI-4200 setpoint volume has been achieved, the PLC commands XV-4101 to close and monitors position switch ZS-XV4101 to confirm the valve has closed

21) Once XV-4101 is confirmed closed the PLC shall remove the run request to P4100.

22) The PLC sets the sequence into the polymer binder addition stage and commands MOV-4202 to open.

23) The PLC shall display message “Polymer Modifier Add Stage” to notify the Operator that they must commence the solids transfer process. Polymer & modifier additions are semi-automated tasks that require the Operator to interact with the SCADA.

24) The PLC commands the shredder M4200 to start (only used for PDB polymer type grades where required by the recipe). An inhibit only allows this step to occur when the tank level has reached minimum level.

25) Operator commences sequence to add polymer and modifiers into T4200 (refer to Section XX).
Note that some recipes call for addition of sulphur as a chemical modifier and that this results in evolution of hydrogen sulphide (H_2S). The H_2S should be drawn out by the vapour extraction system and levels are monitored by LEL-4001-S1 and LEL-4001-S2

26) Once transfer of solids is complete, the Operator resumes this sequence by confirming on the SCADA that the polymer binder addition stage is complete.

27) The PLC shall command MOV-4202 to close. The SCADA shall monitor position switch ZS-XV4202 to confirm the valve has closed.

28) Once the solids addition has been confirmed as complete, the PLC shall commence a blending timer to monitor the total mixing time of C170, Extract Oil and polymer. The required time is set by the recipe selected in 1).

29) Where a recipe requires to run the homogeniser, Operator to make selection by pressing “USE H4200”.

30) The PLC commands XV-4200 and XV-4205 to open.

31) After confirming that XV-4200 and XV-4205 positions are open using ZS-XV4200 and ZS-XV4205, the PLC commands H4200 to start at low speed. This step homogenises the batch contents to ensure complete blending.

32) Once the total mixing/homogenising duration has elapsed, the PLC shall alert the Operator that the tank can be pumped out.

33) The PLC commands XV-4205 to close and monitors position switch ZS-XV4205 to confirm that valve has closed.

34) Once XV-4205 is confirmed closed the PLC shall remove the run request to H4200 and to M4200

35) PLC then runs the transfer/load out sequence to check/storage tank T4600/T4700.

36) Operator to make their selection by pressing the “H4200/P4200 SELECTION” for pump out by H4200 or P4200. A popup menu will prompt Operator to select the destination tank T4600 or T4700.

37) PLC shall command XV-4601 or XV-4701 to open depending upon the tank selected.

38) If “P4200 LOADOUT” is selected PLC commands XV-4203 to open and XV-4204 to close. If “H4200 LOADOUT” is selected PLC commands XV-4205 and XV-4203 to close.

39) After confirming that XV-4203/XV-4204 positions are open/close using ZS-XV4203/ZS-XV4204 OR XV-4205/XV-4203 positions are close using ZS-XV4205/ZS-XV4203, the PLC shall prompt Operator to start the pump out.

40) Operator to make their selection by pressing the “P4200 LOADOUT” or “H4200 LOADOUT” buttons.

41) PLC shall command P4200 or H4200 to start at nominal slow pump out rate of 500L/min (note this rate is subject to change at commissioning.

42) Once the destination tank level is above the tank low level, the PLC shall command H4200/P4200 to increase flowrate to a nominal fast-fill rate of 1200L/min (note this rate is subject to change at commissioning).

43) PLC shall monitor the pump out rate via LIT-4200/LIT-4201. When the tank Low level is reached pump out is complete. PLC shall command XV-4601 or XV-4701 to close and monitors position switch ZS-XV4601/ZS-XV4701 to confirm that valve has closed.

44) . Once XV-4601/XV-4701 is confirmed closed the PLC shall remove the run request to P4200 or H4200.

6.2.2 Interlocks

The PMB / CRMB production sequence shall be prevented from starting if the following conditions are true:

Pre-Start Interlocks	Running Interlocks
T4200 Loadout sequence is Active	T4200 level is High
T4200 level is High	T4200 temperature is High
T4200 temperature is Low	T4200 pressure is Low or High
	Homogeniser discharge pressure High High
	Homogeniser suction pressure Low-Low

If during the sequence an interlock is activated, the sequence shall be put into a PAUSE state. From the PAUSE state, the Operator is required to fix the problem, reset the fault, and then “Restart” the sequence.

6.3 Shredder Operation

When in automatic control, M4200 will run continuously as long as the level in T4200 exceeds the Low level, and there are no interlocks active. If M4200 is out of service and unable to operate an alarm is to be raised in the PLC for Operator to check the shredder.

If M4200 motor temperature is High, this may indicate a higher-than-normal PMB viscosity. If Low, this may be indicative of a broken shaft.

6.3.1 Shredder Interlocks

The following run interlocks are built into the shredder operation

Shredder Pre-Start Interlocks	Shredder Running Interlocks
T4200 Low level	T4200 Low level
	T4200 Low temperature
	M4200 motor temperature is High

The PLC shall trip and turn off M4200 when any of the following occur:

1. An emergency stop alarm becomes active;
2. A power fault alarm becomes active.

When the trip reset is activated, the trip status on M4200 shall be cleared.

6.4 Venturi & Materials Handling System

The venturi and materials handling system combine to allow addition of solid materials into a liquid bitumen stream.

6.4.1 Equipment

The equipment listed in the table below form part of the venturi manufacturing system.

Equipment Tag	Description	Size / Capacity
H4000	Main crumbed rubber hopper	Single CR bag, 1m^3 (HOLD)
M4101	H4001 internal agitator motor	
SP4001	Venturi	6000kg / hr material
LSHH-H4000	Hopper high-high level switch	
LSLL-H4000	Hopper low-low level switch	
LIT-H4000	Hopper level transmitter	0 – 1000mm
TE-H4000	Hopper surface temperature element	Magnetic RTD
P4200	Bitumen pump for circulating through venturi	0 – 1500 l/min
MOV-4221	Solids gate control valve between H4000 and SP4001 venturi	6”
XV-4222	Venturi bitumen inlet valve	6”, 150lb
XV-4223	Venturi bitumen outlet valve	6”, 150lb
PCV-4200	Pressure control valve parallel with venturi	4”, 150lb
PIT-4205	Bitumen venturi inlet pressure transmitter	0 – 2000 kPa
PIT-4206	Venturi materials inlet pressure transmitter	-100 – 100 kPa
PIT-4207	Bitumen venturi outlet pressure transmitter	0 – 2000 kPa
FIT-4201	Bitumen venturi inlet flow transmitter	0 – 2000 l/min
XV-4224	Solenoid valve controlling air into venturi	

Venturi system and associated equipment details

6.4.2 Operation

6.4.2.1 Materials Handling System

Crumbed rubber is delivered to site in 1000kg bags which must be emptied into the materials handling system to allow controlled addition into the venturi.

The materials handling equipment consists of pneumatic bag lift attached to an overhead sliding beam crane. A single 1000kg bag sitting on a pallet is positioned under the bag lift using a forklift where it is attached to the rigging. Once the forklift has reversed, a protective gate is then closed triggering a safety interlock and allowing the bag lifting mechanism to function. The bag lift and crane controls allow the bag to be raised and positioned directly above the main hopper H4000.

With the bag positioned above hopper H4000 the operator lowers it down into a large opening where a bag spike pierces open the flexible woven bag material allowing the contents to fully empty. The empty bag is then raised and returned to the starting position where it is discarded.

With the contents of the bag inside hopper H4000 an internal agitator driven by motor M4101 is activated to break up any clumped or compressed material that may have formed. Air sparges in the hopper also prevent clumps or compressed material. A sliding gate valve MOV-4221 with variable position allows control of the materials feed rate. Hopper H4000 has level switches for high-high and low-low indication, LSHH-H4000 and LSLL-H4000, as well as a level transmitter LIT-H4000. These instruments protect the hopper from running dry or overfilling and provide feedback of the material level in the hopper

6.4.2.2 Venturi System

The venturi mechanism is used to draw in or entrain material into a flowing stream of bitumen. The venturi is essentially an eductor the uses the change in pressure energy in the flowing liquid as it passes through a restriction to create an area of low pressure sufficient to pull material into the flowing stream.

The rate of material entrainment into the venturi is proportional to the bitumen flow rate with an approximate maximum of 1500 l/min corresponding to ~6000kg/h or 100kg/min of solid material.

On the bitumen inlet and outlet to the venturi, pressure transmitters PIT-4205 and PIT-4207 respectively provide protection from back pressure which could potentially cause bitumen to flow through the materials inlet. If high-high pressure trips are activated by either inlet or outlet pressures transmitters, the venturi will be shut-down and isolated. That is, the bitumen inlet actuated ball valve XV-4222 and outlet valve XV-4223 and slide gate MOV-4221 will close and pump P4200 will stop. Both actuated valves are pneumatic with fail close operation.

A pressure transmitter PIT-4206 mounted on the venturi (Throat pressure) between the materials inlet and sliding gate valve provides indication that the venturi has developed a slight vacuum and that solid material can be added.

A pneumatic pressure control valve PCV-4200 in parallel with the venturi and actuated ball valves allows fine adjustment of the pressure conditions through the venturi. Varying the pressure through the venturi will allow the rate of materials addition to also be varied such that the two streams are balanced.

Bitumen flow transmitter FIT-4201 meters product flowing from the discharge of P4200 before entering the venturi. A control loop between the P4200 variable speed drive and flow transmitter allows precise flow rates to be achieved enabling variable and repeatable venturi operation. The flow meter also provides batch transfer quantity tracking and slow filling rates at the start and end of batches.

6.4.2.3 Venturi Manufacturing During Transfer

The most efficient venturi operating method is to combine the bitumen transfer operation and venturi solids addition into one process. That is, to transfer bitumen from the C170 storage tank T4000 through the venturi and into tank T4200 whilst adding solid materials. The below steps provide a description of the process which assumes there is enough time to add the required solid materials during a single transfer pass.

1) The operator selects “Transfer” venturi method.

2) PLC confirms tank T4200 is empty and is available for batch production.

3) The operator selects the required recipe, i.e. percentage of crumbed rubber.

4) The operator enters the batch quantity.

5) The required quantity of crumbed rubber is displayed.

6) The operator selects the source tank as T4000.

7) The operator selects the bitumen flow rate, range between 500l/min and 1500l/min.

8) The approximate crumbed rubber feed rate is shown allowing the operator to predict when to add additional bags into the hopper H4000.

9) The operator loads the hopper H4000 with the first 1000kg bag of crumbed rubber and then

10) The operator presses the “Batch Start” button.

11) The PLC confirms T4000 tank temperature is between 180°C and 200°C.

12) The PLC closes XV-4203, XV-4200, XV-4204, XV-4209, XV-4702, XV4101 and XV-4004 to ensure there are no other paths open to areas of the plant not involved in the venturi process.

13) The PLC opens T4000 outlet valve XV-4000.

14) The PLC opens T4200 inlet valve XV-4201.

15) The PLC opens PCV-4200 to 100%.

16) Pump P4200 starts and runs at slow speed. Control loop FIC-4200 adjusts the P4200 speed to 500l/min with feedback from FIT-4201.

17) The PLC monitors P4200 outlet pressure transmitter PIT-4201 to ensure it is within normal operating range. If the pressure is high, the batch will be stopped, and a warning raised on the SCADA. This may indicate a blockage or cold section of line.

18) After P4200 has run for 1 minute AND the discharge pressure is within normal limits the PLC opens venturi inlet and outlet valves XV-4222 and XV-4223.

19) Pump P4200 continues to run at slow speed. Control loop FIC-4200 adjusts the P4200 speed to 500l/min with feedback from FIT-4201.

20) The PLC starts the hopper agitator M4101.

21) As crumbed rubber material begins to fill the hopper H4000 it will eventually activate the low-low level switch LSLL-H4000 indicating that the minimum operating quantity is approaching.

22) Pressure control valve PCV-4200 begins closing pushing more bitumen through the venturi.

23) Pressure transmitter PIT-4206 indicates correct vacuum level has developed at the venturi materials inlet nozzle.

24) The PLC opens slide gate MOV-4221 to 50%.

25) Pressure control valve PCV-4200 regulates its position such that the venturi inlet pressure PIT-4206 controls the feed rate of materials in the venturi.

26) When the tank T4200 level transmitter LIT-4200 indicates the product is >500mm, pump P4200 is ramped up to the full speed setpoint.

27) The PLC opens slide gate MOV-4221 to 100%.

28) The operator is required to monitor the level of crumbed rubber in the main hopper H4000 and add bags as required.

29) Flow meter FIT-4201 provides continuous monitoring of the flow rate and accumulated batch quantity transferred into tank T4200.

30) When T4200 tank level reaches the minimum required for shredder M4200 to operate the PLC will ramp it up to full speed.

31) When the accumulated batch quantity is 500 litres from completion, pump P4200 will ramp down to 500l/min.

32) The PLC will close slide gate MOV-4221 to 50%

33) When there are 50 litres remaining in the batch, the PLC will close slide gate MOV-4221 to 0%.

34) Pressure control valve PCV-4200 will be opened to 100%.

35) The PLC will close the venturi bitumen inlet and outlet valves XV-4222 and XV-4223.

36) The PLC will continue to run P4200 pushing straight bitumen into tank T4200 until the batch pre-set quantity.

37) The PLC then stops P4200.

38) The PLC opens the instrument air inlet to the venturi materials nozzle to provide positive pressure and prevent bitumen entering.

39) The PLC then closes the venturi and transfer line by shutting XV-4000 and PCV-4200.

40) The PLC opens the T4200 recirculation / homogeniser H4200 line by opening XV-4200, XV-4204 and XV-4201.

41) The PLC starts homogeniser H4200 and ramps it up to 100% whilst shredder M4200 continues running at 100%.

42) Homogeniser and shredder continue to run for the pre-set time period as set from the SCADA production page.

43) When the homogeniser and shredder have finished operation, the batch is ready for sampling and release. The batch can be transferred to one of the finish tanks T4600 or T4700.

6.4.2.4 Venturi Manufacturing During Recirculation

An alternate venturi operating process requires a two staged approach. Firstly, the required bitumen batch quantity minus the solid material quantity is transferred into tank T4200 from tank T4000. Secondly, bitumen is recirculated using pump P4200 whilst solid materials are added. Whilst this process is less efficient and requires double handling of the bitumen, it does allow for slower addition of solid materials and allows the product in tank T4200 to be preheated. Additionally, this process may be combined with venturi transfer manufacturing in the case that the required quantity of solids could not be added during the transfer.

1) The operator selects “Recirculate” venturi method

2) PLC confirms tank T4200 is empty and is available for batch production.

3) The operator selects the required recipe, i.e. percentage of crumbed rubber.

4) The operator enters the batch quantity.

5) The PLC converts the batch quantity to a T4200 tank level in mm.

6) The required quantity of crumbed rubber is displayed.

7) The operator selects the source tank as T4000.

8) The operator selects the bitumen flow rate, range between 500l/min and 1500l/min.

9) The approximate crumbed rubber feed rate is shown allowing the operator to predict when to add additional bags into the hopper H4000.

10) The operator loads the hopper H4000 with the first 1000kg bag of crumbed rubber and then

11) The operator presses the “Batch Start” button.

12) The PLC opens the line from tank T4000 to T4200.

13) The PLC closes XV-4203, XV-4200, XV-4209, XV-4702, XV4101 and XV-4004 to ensure there are no other paths open to areas of the plant not involved in the venturi process.

14) The PLC opens T4000 outlet valve XV-4000.

15) The PLC opens XV-4204.

16) The PLC opens T4200 inlet valve XV-4201.

17) Pump P4200 starts and runs at slow speed ~ 50% for 1 minute and then ramps up to 100%.

18) Pump P4200 continues to operate until the pre-calculated T4200 tank level has been reached.

19) The line from T4000 to T4200 is then closed by shutting XV-4000, XV-4204 and XV-4201.

20) If the T4200 tank temperature is not between 180°C and 200°C, the T4200 tank hot oil heating is turned to maximum and the shredder is run on high until this is achieved.

21) The PLC opens XV-4203 and XV-4201.

22) The PLC opens PCV-4200 to 100%.

23) Pump P4200 starts and runs at slow speed. Control loop FIC-4200 adjusts the P4200 speed to 500l/min with feedback from FIT-4201.

24) The PLC monitors P4200 outlet pressure transmitter PIT-4201 to ensure it is within normal operating range. If the pressure is high, the batch will be stopped, and a warning raised on the SCADA. This may indicate a blockage or cold section of line.

25) After P4200 has run for 1 minute AND the discharge pressure is within normal limits the PLC opens venturi inlet and outlet valves XV-4222 and XV-4223.

26) Pump P4200 continues to run at slow speed. Control loop FIC-4200 adjusts the P4200 speed to 500l/min with feedback from FIT-4201.

27) The PLC starts the hopper agitator M4101.

28) As crumbed rubber material begins to fill the hopper H4000 it will eventually activate the low-low level switch LSLL-H4000 indicating that the minimum operating quantity is approaching.

29) Pressure control valve PCV-4200 begins closing pushing more bitumen through the venturi.

30) Pressure transmitter PIT-4206 indicates correct vacuum level has developed at venturi materials inlet nozzle.

31) The PLC opens slide gate MOV-4221 to 100%.

32) Pressure control valve PCV-4200 regulates its position such that the venturi inlet pressure PIT-4206 controls the feed rate of materials in the venturi.

33) The operator is required to monitor the level of crumbed rubber in the hopper H4000 and add bags as required.

34) Flow meter FIT-4201 provides continuous monitoring of the flow rate.

35) The PLC ramps up the shredder M4200 to full speed.

36) When the required quantity of crumbed rubber has been added, P4200 will ramp down to 500l/min.

37) The PLC will close slide gate MOV-4221 to 0%

38) Pressure control valve PCV-4200 will be opened to 100%.

39) The PLC will close the venturi inlet and outlet valves XV-4222 and XV-4223.

40) The PLC will continue to run P4200 pushing straight bitumen into tank T4200 for 1 minute.

41) The PLC then stops P4200.

42) The PLC opens the instrument air inlet to the venturi materials nozzle to provide positive pressure and prevent bitumen entering.

43) The PLC then closes the venturi and transfer line by shutting XV-4000 and PCV-4200.

44) The PLC opens the T4200 recirculation / homogeniser H4200 line by opening XV-4200, XV-4204 and XV-4201.

45) The PLC starts homogeniser H4200 and ramps it up to 100% whilst shredder M4200 continues running at 100%.

46) Homogeniser and shredder continue to run for the pre-set time period as set from the SCADA production page.

47) When the homogeniser and shredder have finished operation, the batch is ready for sampling and release. The batch can be transferred to one of the finish tanks T4600 or T4700.

6.4.3 Operator Controls

From the production mimic screen operators can initiate and setup the required batching parameters and monitor the entire process. The table below lists the venturi manufacturing parameters available to the operators allowing for varying production recipes, flow rates, quantities and temperatures.

Description	Min Value	Max Value	Initial Value	Security Level
Recipe Name	Crumbed Rubber		CR	2
Batch Recipe	10%	20%	15%	2
Batch Volume	5 tonnes	50 tonnes	25 tonnes	2
Venturi method	Transfer	Recirculate	Transfer	2
Bitumen Source Tank	T4000 / T4200		None	2

Destination Tank	T4200		T4200	2
Venturi flow rate	500 l/min	1500 l/min	500 l/min	2
Min T4200 temperature	170°C	200°C	180°C	2
Shredder run time	0 mins	120 mins	60 mins	2
Shredder Speed	0%	100%	0%	2
Homogeniser run time	0 mins	120 mins	0 mins	2
Homogeniser speed	40%	100%	75%	2
Finish tank	T4600	T4700		2

Operator settings for CR manufacture using venturi

6.4.4 Interlocks

The following interlocks shall be in place before starting and whilst running the venturi system.

Tag	Interlock	Condition	Action	Override
P4200	PIT-4206	High-High	Stop	NO
MOV-4221	PIT-4206	High-High	Stop	NO
XV-4222	PIT-4206	High-High	Close	NO
XV-4223	PIT-4206	High-High	Close	NO
MOV-4221	LSHH-H4000	Tripped	Close	NO
XV-4222	LSHH-H4000	Tripped	Close	NO
XV-4223	LSHH-H4000	Tripped	Close	NO
P4200	LSHH-H4000	Tripped	Stop	NO
MOV-4221	LSLL-H4000	Low-Low	Close	YES

6.4.5 Alarms

The following alarm trip set-points shall be applied.

Equipment Tag	Type	Limit Condition	Limit Access	Consequence
PIT-4205	High-High	>900kPa	Engineer	
PIT-4205	High	>750kPa	Supervisor	
PIT-4207	High-High	>900kPa	Engineer	
PIT-4207	High	>750kPa	Supervisor	
PIT-4206	High High	Vacuum (HOLD)		

6.5 Tank Heating

Refer to Section 9 for details of the hot oil heating system for T4200

7. Storage Tanks (T4600 & T4700) System

7.1 System Description

7.1.1 Overview

T4600 and T4700 are vertical steel tanks with nominal capacity of 100T to be used for storage of PMB after it has been blended and pumped out of T4200. Either tank can serve as the dual-purpose check/storage tank while the other operates as the final product storage tank. Product can be transferred between T4600 and T4700, recycled back to T4200 or loaded out to gantry.

Each tank will operate within a safe fill level and a safe low level – filling and pumping out shall automatically stop once the safe fill and safe low level, respectively, is reached.

Sampling of each batch is performed from T4600/T4700. To do this the Operator will open the sample point valve, flush the first 5-10L, collect 2-off 1L samples, and take the samples to the existing on-site laboratory for testing. If the sample is confirmed to be on-spec, the tank is marked as on-spec and permitted for loadout to gantry. If the sample is found to be off-spec, the product must be returned to T4200 and reprocessed. One of the 1L samples is retained in the laboratory for record purposes.

The product in T4600 and T4700 shall be maintained at 185°C using internal hot oil heating coils. Each tank is equipped with two heating coils. Hot oil flow through the coils will be automatically controlled based on tank temperature.

Two temperature probes are mounted in each of the tanks. The first probe is mounted below the low level mark but above the heating coils. The second probe is mounted at a higher elevation in the tank. The PMB operator can select either of the probes as the measured variable for the temperature control. The output from each controller drives a single On/Off valve that, when energised open, directs hot oil through the respective tank heating coils and when de-energised shuts off hot oil to the tank heating coils.

The levels in the tanks are monitored by a radar type level transmitters. The signal from each transmitter generates a high level alarm and a low level alarm.

An independent level transmitter is fitted to each tank with high, high-high and low, low-low alarms. When the level in a tank reaches the high-high level the inlet isolation valve is tripped closed and an audible and visual alarm is raised. On low-low level the outlet isolation valve is tripped closed and tank heating is inhibited by forcing the hot oil On/Off valve to the fully closed position. The levels in each tank as measured by the two transmitters are

compared and a deviation alarm is generated if the results exceed a pre-set value.

T4600 and T4700 will each have a variable speed tank top mixer, A4600 and A4700, to mix the PMB so that it meets the requirements for product quality/uniformity. The mixer's motor is designed to start and stop automatically at a certain minimum tank level.

The tanks have a connection to a vapour extraction system. This system draws vapours from within the vapour space of the tank to prevent fugitive emissions to atmosphere as the tank fills and breathes.

Under normal operation, filling and pumping out of the same tank simultaneously shall not be permitted.

7.1.2 Tank Safe Fill and Safe Low Levels

T4600 uses a safe fill level of 90% tank total volume and load out uses a safe low level of 150mm above the coil height on LIT-4600/4601.

T4700 uses a safe fill level of 90% of tank total volume and load out uses a safe low level of 150mm above coil height on LIT-4700/4701.

7.1.3 Tank Status

The Operator shall be able to mark each tank as "In Service" or "Out of Service". When a tank is marked as "Out of Service", sequences cannot load into or out of this tank. A tank cannot be put into "Out of Service" if a load out sequence from the tank is already running.

Operator must also be able to assign each tank as "Not Available for Sale" or "Available Ready for Sale" through a selection field on the SCADA screen. A second field displayed next to each tank on the SCADA shall allow the Operator to edit the PMB product name.

Operators will select "Not Available for Sale" if the tank does not contain PMB for sale, or is awaiting test results to confirm the product is on-spec. This is also the default status if the tank is empty, being emptied or being filled.

Operators will select "Available Ready for Sale" when the product has been confirmed on-spec. A batch number must be allocated for a particular tank before its status can be changed to "Available Ready for Sale".

Sequences shall not be able to load out of a tank to the gantry unless a tank is marked as "Available Ready for Sale". If both tanks contain the same PMB product and both are marked "Available Ready for Sale", the PLC shall track which product was manufactured first and automatically assign this as the duty tank for load out to the gantry. Operators however shall have the ability to override this and set any tank as the duty tank. When the duty tank has been emptied during load out there shall be an automatic changeover by the PLC to the next available tank.

7.2 Operational Sequences

The following sections describe the intended operational sequences of T4600 and T4700; and should be read in conjunction with the Equipment Details. The sequences should also be read in conjunction with the Cause & Effect Matrix in Appendix A.

7.2.1 Tank Mixing

When in automatic control, A4600 and A4700 will run continuously as long as the level in the respective tank exceeds the Low level, and there are no interlocks active.

If A4600/A4700 is out of service and unable to operate, or the mixer motor temperature is High, an alarm is to be raised in the PLC for Operator to check the mixer.

7.2.2 Interlocks

The PLC shall command A4600/A4700 to stop when any of the following conditions are true:

Pre-Start Interlocks	Running Interlocks
	T4600/T4700 level is Low
	T4600/T4700 temperature is Low
	A4600/A4700 motor temperature is High

The PLC shall trip and turn off A4600/A4700 when any of the following occur:

1. An emergency stop alarm becomes active;
2. A power fault alarm becomes active.

When the trip reset is activated, the trip status on A4600/A4700 shall be cleared

7.2.3 Tank Heating

Refer to Section 9 for details of the hot oil heating system for T4600/T4700.

8. Pump (P4300 & P4400) Transfer/Loadout System

8.1 System Description

8.1.1 Overview

Pumps P4300 and P4400 are identical, internal gear pumps with variable speed drive motors. These pumps will be used to transfer PMB between tanks or to load out to Bay 1 or Bay 2 at the road gantry. Each pump has its

own dedicated suction manifold to T4600/T4700, and its own discharge manifold to the gantry. A crossover between the two suction manifolds provides flexibility to the Operator to use either pump for any combination of tank/gantry transfer. Either pump shall have the ability to be set to one of two modes via the SCADA:

a) Transfer Mode; or

b) Loadout Mode.

However, the intent is to primarily use P4300 for loadout to the gantry i.e. in Loadout Mode, and P4400 for transfer between tanks i.e. in Transfer Mode.

8.1.2 Transfer Mode

PMB product may be transferred between tanks in several ways, for example: Transferring a finished batch from T4600 to T4700 or vice versa;

Returning product from T4600 or T4700 to T4200 for reprocessing (for example, if off-spec). Only P4400 has a recycle line back to the mix tank T4200; which means that if T4700 tank is off-spec and must be returned to T4200 this transfer must be done with P4400. It means that simultaneous loadout from T4600 to gantry is not possible.

In rare cases, off-spec product may be returned from a truck to any of the two tanks for further testing or mixing.

Note that there may be occasions where an Operator wants to transfer only a fraction of a tank's contents to another tank. The PLC shall provide the Operator the ability to transfer a part-batch.

8.1.3 Loadout Mode

PMB / CRMB shall be loaded out at a minimum temperature of 180°C from T4600 or T4700 to either gantry Bay 1 or 2. New pipework to the gantry will be installed dedicated to PMB / CRMB i.e. not shared with existing loadout lines. However; the gantry spear and connection to the vapour combustion system will be shared with the existing Bitumen Import Facility. The PMB pipework will tie-in close to the spear to minimise contamination from other products being loaded. From the spear, product will "gravity drop" into the road tanker.

Simultaneous loadout to gantry bay 1 and bay 2 using P4300 and P4400 pumps shall be permitted as there are dedicated pump discharge lines to the gantry. However; loadout to both bays simultaneously from the same tank and using the same pump shall not be configured.

The existing gantry is configured for driver-only loading using Accuload Bay Load Controllers (BLC) that enable the driver to initiate and control the loadout process without intervention required by an Operator. A driver's room serves as the loading control point. The loadout of PMB / CRMB shall be incorporated into the existing control system so that it can also be loaded out by drivers independently of an Operator.

8.1.4 Operator Controls

The PLC shall allow an Operator to select the required mode by selecting the source tank, destination (tank or gantry), desired manifolds and pump. The PLC will then automatically align the appropriate valves and start the correct transfer pump. The transfer sequence will then transfer product until:

3. The correct level is reached in the destination tank; OR
4. The correct volume has been transferred to the gantry; OR
5. A High level is reached in the destination tank/gantry; OR
6. A Low level is reached in the source tank.

SCADA graphics shall provide the controls to the Operator to start and stop transfers, as well as provide an overview of the associated instrumentation.

To initiate a transfer/loadout sequence the Operator will select the source tank, the source manifold, destination manifold, and the destination tank/gantry from the SCADA graphic.

Tank to tank transfers can only be initiated by an Operator in the control room. Load out to the gantry however can be initiated either by the Operator in the control room, or by an approved driver via the Accuload system at the gantry.

The following table lists the selections that shall be available to an Operator in order to use the pump transfer/loadout sequences.

P4600/P4700 Operator Controls	
Description	**Selection**
Select "From Tank"	Select from the popup graphic
Select "Stop on Volume"	**Select from the popup graphic**
Select "Transfer Volume"	**Select from the popup graphic**
Select "To Tank / Gantry"	**Select from the popup graphic**
Start Transfer	**Press the "Transfer" button**
Stop Transfer	Press the "Stop" button

8.1.5 Pump Speed Control

The speed of P4400 and P4300 is controlled by monitoring the pump motor temperature (TE-4600 /TE-4300). If the motor temperature reaches High (TT-4603 /TT-4301) or the pump jacket temperature reaches Low (TT-4602 /TT-4302) the VSD shall turn down the pump speed until the maximum temperature is maintained or the pump reaches minimum speed at which point the pump will trip to prevent damage to it. An alarm is generated in

SCADA if motor temperature is High or jacket temperature is Low. A pump trip alarm on High-High or Low-Low temperature is also generated.

The pump's discharge pressure (PIT-4600 /PIT-4300) is also constantly monitored but not used to control the pump's VSD.

When loading out to the gantry, the flowrate is controlled by the Accuload based on the flowrate required (low-flow or high-flow). The Accuload will send the flow request to the PLC which will control the % opening of the control valve FCV-4800/4801. The backpressure created by the control valve % opening will affect TE-4606 /TE-4300 which will control the pump VSD.

The intent is to limit flow to the gantry to a maximum of 1000LPM if loading out to a single gantry bay, and a maximum of 1500LPM if loading out to two gantry bays (750LPM each). As the flowrates are viscosity-dependent, the appropriate % opening setting of FCV-4800/4801 for slow and fast fill will need to be determined during commissioning.

Currently, there are existing proximity sensors for the gantry spears which are connected to the PLC and indicate when the spear is lowered into the loading position. These sensors serve as an interlock for truck loading i.e. loading cannot start (or will be stopped if already loading) if this input is not active. The Bay 1 interlock shall prevent FCV-4801 from opening and the Bay 2 interlock shall prevent FCV-4800 from opening.

8.2 Operational Sequences

The following sections describe the intended operational sequences of pumps P4400 and P4300 and should be read in conjunction with the Equipment Details. The sequences should also be read in conjunction with the Cause and Effect Matrix in Appendix A.

8.2.1 Transfer Mode Sequence

1) Operator selects T4600 or T4700 in the "From Tank" popup depending on the required source tank.

2) The PLC must confirm that this tank passes all Status checks (i.e. tank is "In Service") before allowing tank selection, otherwise returns an error message.

3) The PLC commands XV-4600 to open if Operator selects T4600 in the "From Tank" popup.

4) The PLC commands XV-4700 to open if Operator selects T4700 in the "From Tank" popup.

5) Operator selects T4600, T4700 or T4200 in the "To Tank/Gantry" popup depending on the required destination tank.

6) The PLC shall prompt the Operator to confirm the transfer volume. The PLC shall compare this with the available ullage in the destination tank and verify that there is sufficient volume in the destination tank.

7) The PLC shall open/close actuated valves as required to line up the "From Tank" and "To Tank" pathway.

8) When all valves have been lined up, the PLC shall command the transfer pump P4400 to start the transfer

9) The PLC shall check that all tank unloading and loading permissives/interlocks are satisfied before permitting transfer pump to start. This includes confirming that the hot oil control valve (TCV-4600 or TCV-4700) is Closed on the source tank.

10) The PLC shall monitor and compare the change in volume/levels in the source tank and the destination tank to verify that product is not being inadvertently directed elsewhere.

11) If there is a discrepancy, the PLC shall raise a deviation alarm on the SCADA to alert the Operator as well as shutdown the transfer pump.

8.2.2 Interlocks

The following Start and Running interlocks shall apply to the Transfer sequence:

Pre-Start Interlocks	Running Interlocks
T4600/T4700 "Not in Service"	T4600/T4700 source tank level is Low (Note 1)
T4600/T4700 Transfer/Loadout sequence is Active	T4600/T4700 destination tank level is High (Note 2)
T4600/T4700 source tank level is Low	Loading to Bay 1 and the bay has a high alarm (LSH-1001)
T4600/T4700 destination tank level is High	Loading to Bay 2 and the bay has a high alarm (LSH-1002)
T4600/T4700 source tank temperature is <180°C	
T4600/T4700 source tank hot oil control valve NOT closed	

Notes

3) If the source tank level becomes Low mid-sequence, this shall trip the transfer sequence and stop the transfer pump.

4) If the destination tank level becomes High or High High mid-sequence, this shall trip the transfer sequence and stop the transfer pump.

8.2.3 Loadout Mode Sequence

Gantry load out of PMB shall replicate existing procedures for the Bitumen Import Facility. Generally, the procedure will be as follows:

1) Driver performs set up procedures and swipes card in driver's room to authorise load.

2) Once the PLC and Accuload BLC permissives have been verified, Accuload BLC sends product request signals to PLC.

3) PLC commands gantry shutoff valves XV-4451/XV-4452 or XV-4453/XV-4711 to open, depending upon whether loadout is to bay 1 or bay 2 and whether pump P4400 or P4300 has been selected. This is followed by opening gantry control valve FCV-4801 (bay 1) or FCV-4800 (bay 2).

   i) Note the PLC shall command the gantry control valve to open at the low-flow setting for the beginning and end of the transfer. Otherwise the PLC shall set the control valve to the high-flow setting

4) PLC commands the loadout pump (P4400 or P4300) to start.

5) Note that if the duty tank is emptied during load out there shall be an automatic changeover by the PLC to the next tank (if "In Service" and "Available Ready for Sale").

6) Totalisers FQC-4801 and FQC-4800 will totalise the volume transferred to each bay. Once the required volume has been transferred, the PLC shall stop the pump then close the control and shutoff valves.

7) As per the existing gantry configuration, FQC-4801 (bay 1) PMB totaliser shall reset when XV-4451/XV-4452 receives a command to open, and FQC-4800 (bay 2) PMB totaliser shall reset when XV-4453/XV-4711 receives a command to open.

8.2.4 Interlocks

All Transfer Mode interlocks shall apply to the Loadout Mode. In addition, the following Start and Running interlocks shall also apply to the Loadout sequence:

Pre-Start Interlocks	Running Interlocks
Source Tank is not "In service" and "Available Ready for Sale"	
ZS-1001 (Bay 1) or ZS-1002 (Bay 2) Arm-in-position sensor is not Active	
More than one product is requested from the Accuload	
One of P4400 or P4300 is already loading to the gantry	

LSH-1001 is active (if intending to load out to Bay 1)	
LSH-1002 is active (if intending to load out to Bay 2)	

9. Hot Oil System

9.1 System Description

The PMB plant will tie into the existing hot oil system that consists of heaters H205 and H206, and two hot oil circulation pumps (P2102 and P2103). The PMB plant will require hot oil as follows:

- T4000 internal hot oil coils
- T4100 internal hot oil coils
- T4200 hot oil jackets (external to tank);
- T4600 internal hot oil coils;
- T4700 internal hot oil coils
- P4000/P4100/P4200/P4300/P4400 pump hot oil jackets
- H4200 homogeniser hot oil jacket
- Heat tracing on pipework and equipment.

T4200 is fitted with two sets of heating coils in an external tank jacket. The hot oil runs through the coils to heat the product in the tank. TCV-4200-1 and TCV-4200-2 are installed in the hot oil supply line to control the flow of hot oil through the heating coils.

T4000, T4100, T4600 and T4700 are fitted with internal heating coils inside the tank. The hot oil runs through the coils to heat the product in the tank. Control valves TCV-4000, TCV-4100, TCV-4600 and TCV-4700, respectively, are installed in the hot oil supply lines to control the flow of hot oil through the heating coils.

The temperature gauging on the tanks will be used to drive the control valves based on temperature set points. The intent is to maintain T4000, T4100 and T4200 at 195°C and T4600 and T4700 at 185°C. Tie-ins will be made to the existing hot oil supply and return headers from H205/H206 and P2102/P2103.

9.2 Operational Sequences

The following sections describe the intended operational sequences of the hot oil system and should be read in conjunction with the Equipment Details.

9.2.1 Tank Temperature Control

The PLC shall control the opening/closing of the hot oil control valves to maintain the tanks at a desired temperature. The temperature setpoint is set by the tank operational sequence, or manually entered by the Operator on the SCADA.

The PLC shall close these valves if the respective tank is being pumped out (i.e. the tank is active in a transfer or loadout sequence) to prevent the potential for overheating while the tank is being emptied. If these valves are not closed, the pumps will not be permitted to load out of the tank.

The control of these valves shall be set to automatic when any of the following occur:

1. Tank level is healthy (i.e. not High or Low);
2. Tank temperature is healthy (i.e. not High or Low);
3. The site trip Reset is activated.

The control of these valves shall be set to manual and 0% open when any of the following occur:

1. Tank has a High temperature;
2. Tank has a Low level;
3. An emergency stop alarm is active;
4. A power fault alarm is active.

10. Sour Gas System

10.1 System Description

PMB production generates noxious vapours referred to as off gas. The intent is to remove off gas and send it to the existing incineration system that services the Bitumen Import Facility.

The Puma Energy vapour system must operate in coordination with that of the existing bitumen plant. Certain production or operational sequences may require preferential use of the vapour destruction system; therefore, permissive and status signals will be exchanged between the plant control systems.

The vapour space of tanks T4000, T4200, T4600 and T4700 will be integrated into the existing off gas header. The sour gas from these tanks will be piped to a local knockout vessel, SP4000, where any condensate will be drained into a 205L drum, and the remaining light fractions will be piped to the sour gas line for combustion.

Each tank will have a gooseneck free vent to permit fresh air makeup into the tank. The sour gas header is operated at a slight vacuum to draw vapours out of the respective tank rather than venting the vapours to atmosphere.

Actuated valves XV-4010, XV-4610 or XV-4710 on storage tanks T4000, T4600 and T4700 are located on the off-gas line connected to the main vapour system header from each tank. During pump out of T4000, T4600 or T4700 these valves remain closed to ensure fresh air is drawn into the tank through the goose neck inlet, instead of vapour from the sour gas system. During filling of any of the tanks, the respective actuated valves shall remain open such that vapour inside the tank is drawn through to the sour gas system.

The actuated valve XV-4210 on mixing tank T4200 is located in series with the goose neck inlet such that it can isolate the tank vapour space from the outside atmosphere. When this tank is being pumped out the actuated valve will open allowing fresh air into the tank vapour space. Conversely, when the tank is being filled, the actuated valve will close forcing vapour in the tank ullage space into the sour gas header.

The off-gas vent header will also have a large DN200 flow control valve FCV-4001 that draws air into the header to dilute the sour gas. FCV-4001 is designed to Fail Open which provides a backup for vacuum relief should the actuated valves fail to open.

A maximum flow rate from the Puma vapour system is set at 1250m^3/hr which is measured via flow meter FIT-4000. If this flow rate exceeds the maximum allowable level, the vapour system will be progressively shutdown. That is, in order of lower priority, tank vent valves will be closed until the flowrate is less than 1250 m^3/hr.

Measurement of the lower explosive limit (LEL) in the sour gas header system is made using two sets of sampling and detection units. LEL-4000 sensor sampling location is directly after the final main header isolation valve XV-4003. Its intent is to ensure even after the sour gas system has been isolated that no potentially explosive atmosphere in present in the line connecting to the combustor. LEL-4001 sensor sampling location is in between the two header isolation valves which provides a warning and allowance for the valve reaction time encase of LEL detection.

In line with the existing sour gas system, the following trip and alarm points are defined:

1) If LEL-4000 OR LEL-4001 > 40% LEL

    a) Send trip signal to combustor

    b) Shutdown all vapour system valves

    c) Stop all pumps and manufacturing processes

    d) Raise alarm on SCADA

2) If LEL-4000 OR LEL-4001 > 25% LEL

   a) Shutdown all vapour system valves

   b) Stop all tank filling and manufacturing

   c) Raise alarm on SCADA

3) If LEL-4000 OR LEL-4001 > 20% LEL

   a) Open fresh air inlet valve FCV-4201 to 100%

   b) Raise alarm on SCADA

4) If PIT-4201 >0kPa

   a) Close all tank vapour vent valves

10.1.1 Equipment

The equipment listed in the table below form part of the sour gas system.

Equipment Tag	Description	Size / Capacity
XV-4003	Sour gas header final isolation valve	10”
XV-4220	Sour gas header isolation valve	8”
FCV-4202	Control valve in parallel with XV-4220	1”
FCV-4201	Fresh air inlet valve	8”
XV-4010	T4000 vapour vent valve	4”
XV-4210	T4200 vapour vent valve	10”
XV-4610	T4600 vapour vent valve	4”
XV-4710	T4700 vapour vent valve	4”
PIT-4201	Sour gas tank header pressure transmitter	-100kPa – 100kPa
PIT-4202	Sour gas header pressure transmitter adjacent SP4000	-100kPa – 100kPa
LS-4000	SP4000 Knock out pot liquid level switch	ON/OFF
FIT-4000	Sour gas header flow meter	0 – 1800m^3
LEL-4000	LEL detector and trip circuit downstream of SP4000	0% - 100% LEL
LEL-4001	LEL detector and trip circuit upstream of SP4000	0% - 100% LEL
SP4000	Sour gas system knock-out pot	0.42m^3

10.2 Operational Sequences

The following sections describe the intended operational sequences of the off-gas system and should be read in conjunction with the Equipment Details.

10.2.1 SQ4000 - Initialisation

This sequence covers initialising the sour gas system and assumes the combustor is running normally and there have been no LEL trips prior.

1) PLC detects combustor healthy and running signals are OK.
2) Sensors LEL-4000 and LEL-4001 readings are less than 20%.
3) The PLC opens the final main vapour header valve XV-4003.
4) The PLC confirms vacuum pressure on PIT-4202 < -3kPa
5) The PLC opens the main vapour header valve XV-4220.
6) The PLC confirms vacuum pressure on PIT-4201 < -3kPa
7) Fresh air inlet valve FCV-4201 opens for 5 minutes to purge the vapour header and then closes.

10.2.2 SQ-4001 - Normal Tank Venting

In this scenario it is assumed that no tanks are being filled or emptied and the sour gas system has completed the initialisation sequence SQ4000.

1) Fresh air inlet valve FCV-4201 opens for 5 minutes to purge the vapour header and then closes.
2) The PLC open T4200 air inlet valve XV-4210 for 10 minutes and then closes.
3) The PLC open T4000 air inlet valve XV-4010 for 10 minutes and then closes.
4) The PLC open T4600 air inlet valve XV-4610 for 10 minutes and then closes.
5) The PLC open T4700 air inlet valve XV-4710 for 10 minutes and then closes.
6) If no tanks are being filled or Return to step 1.

10.2.3 SQ4002 – T4000 Tank Filling

This process assumes the sour gas system has completed the initialisation sequence SQ4000 and is currently in normal tank venting sequence SQ4001.

When any tanks bitumen inlet valve is opened it is assumed that a transfer of product into this tank is imminent. In this case the normal tank venting sequence SQ4001 is interrupted and the tank being filled is vented. When more than one tank is being filled simultaneously, multiple tank filling sequences are run.

1) The PLC detects XV-4001 tank T4000 inlet valve is open.

2) The transfer pump is interlocked.

3) The PLC opens T4000 vent valve XV-4010.

4) The transfer pump interlock is removed.

5) The PLC closes all other tank vent valves XV-4210, XV-4610 and XV-4710. This assumes no other tanks are being filled.

6) When the transfer is completed and XV-4001 closes, the PLC returns to SQ4001.

10.2.4 SQ4003 – T4200 Tank Filling

1) The PLC detects XV-4201 tank T4200 inlet valve is open.

2) The transfer pump is interlocked.

3) The PLC closes T4200 vent valve XV-4210 preventing vapours escaping to atmosphere.

4) The transfer pump interlock is removed.

5) The PLC closes all other tank vent valves XV-4010, XV-4610 and XV-4710. This assumes no other tanks are being filled.

6) When the transfer is completed and XV-4201 closes, the PLC returns to SQ4001.

10.2.5 SQ4004 – T4600 Tank Filling

1) The PLC detects XV-4601 tank T4600 inlet valve is open.

2) The transfer pump is interlocked.

3) The PLC opens T4600 vent valve XV-4610.

4) The transfer pump interlock is removed.

5) The PLC closes all other tank vent valves XV-4010, XV-4210 and XV-4710. This assumes no other tanks are being filled.

6) When the transfer is completed and XV-4601 closes, the PLC returns to SQ4001.

10.2.6 SQ4005 – T4700 Tank Filling

7) The PLC detects XV-4701 tank T4700 inlet valve is open.

8) The transfer pump is interlocked.

9) The PLC opens T4700 vent valve XV-4710.

10) The transfer pump interlock is removed.

11) The PLC closes all other tank vent valves XV-4010, XV-4210 and XV-4610. This assumes no other tanks are being filled.

12) When the transfer is completed and XV-4701 closes, the PLC returns to SQ4001.

10.2.7 SQ4006 – T4000 Tank Emptying

This process assumes the sour gas system has completed the initialisation sequence SQ4000 and is currently in normal tank venting sequence SQ4001.

When any tanks bitumen outlet valve is opened it is assumed that a transfer of product out of this tank is imminent. In this case the normal tank venting sequence SQ4001 is interrupted and the tank being emptied is isolated from the vapour system to allow fresh air into the tank vapour space. When more than one tank is being emptied simultaneously, multiple tank emptying sequences are run.

1) The PLC detects XV-4000 tank T4000 outlet valve is open.

2) The transfer pump is interlocked.

3) The PLC closes T4000 vent valve XV-4010.

4) The transfer pump interlock is removed.

5) When the transfer is completed and XV-4000 closes, the PLC returns to SQ4001.

10.2.8 SQ4007 – T4200 Tank Emptying

1) The PLC detects XV-4200 or XV-4203 tank T4200 outlet valves are open.

2) The transfer pump is interlocked.

3) The PLC opens T4200 vent valve XV-4210.

4) The transfer pump interlock is removed.

5) When the transfer is completed and XV-4200 and XV-4203 are closed, the PLC returns to SQ4001.

10.2.9 SQ4008 – T4600 Tank Emptying

1) The PLC detects XV-4600 tank T4600 outlet valve is open.

2) The transfer pump is interlocked.

3) The PLC closes T4600 vent valve XV-4610.

4) The transfer pump interlock is removed.

5) When the transfer is completed and XV-4600 closes, the PLC returns to SQ4001.

10.2.10 SQ4009 – T4700 Tank Emptying

1) The PLC detects XV-4700 tank T4700 outlet valve is open.

2) The transfer pump is interlocked.

3) The PLC closes T4700 vent valve XV-4710.

4) The transfer pump interlock is removed.

5) When the transfer is completed and XV-4700 closes, the PLC returns to SQ4001.

10.2.11 SQ4010 – Initialisation After LEL Trip

Following a trip event where either LEL-4000 or LEL-4001 have detected an LEL greater than 25%, the whole vapour system will be shutdown and need to be initialised in a manner that prevents a flammable atmosphere being sent to the combustor.

1) PLC detects combustor healthy and running signals are OK.

2) The PLC opens the final main vapour header valve XV-4003.

3) The PLC confirms vacuum pressure on PIT-4202 < -3kPa.

4) The PLC opens fresh air inlet valve FCV-4201 to 100%.

5) A control loop adjusts FCV-4201 position to maintain the vapour header flow rate to be less than 1250m^3/hr.

6) The PLC monitors LEL-4000 and LEL-4001 and waits for both readings to be less than 5% LEL.

7) The PLC begins opening control valve FCV-4202 until the vacuum pressure on PIT-4201 < -3kPa.

8) The PLC monitors LEL-4000 and LEL-4001 ensuring the LEL readings remain below 20%. Also monitor pressure in PIT-4201.

9) The positions of flow control valves FCV-4201 and FCV-4202 are controlled ensuring both LEL-4000 and LEL-4001 readings remain below 20%.

10) Once LELs are below 20% and PIT-4201 about 0 kPa or slight vacuum, the PLC opens tank T4200 tank vent valve XV-4210 for 10 minutes and then closes.

11) The PLC opens the main vapour header valve XV-4220

12) The PLC opens tank T4000 tank vent valve XV-4010 for 10 minutes and then closes.

13) The PLC opens tank T4600 tank vent valve XV-4610 for 10 minutes and then closes.

14) The PLC opens tank T4700 tank vent valve XV-4710 for 10 minutes and then closes.

15) The PLC closes control valve FCV-4202 to 0%.

16) Return to SQ4001.

10.2.12 SQ4011 – Vapour Header Flowrate

The vapour header flowrate measured via FIT-4000 is maintained below the maximum permissible level of 1250m^3/hr with the following process.

1) The PLC detects FIT-4000 flowrate > 1250m^3/hr.

2) If SQ4001 tank sweeping sequence is active, close tank vent valves, or

3) If inter-tank transfer in progress, stop transfer, close tank vent valves.

4) If the PLC still detects FIT-4000 flowrate > 1250m^3/hr and T4200 manufacturing is in progress, then

5) Stop T4200 manufacturing.

6) Shutdown vapour system valve XV-4220.

7) Wait for FIT-4000 flowrate to be < 1000m^3/hr.

8) Perform initialisation sequence SQ4000.

10.2.13 Operator Controls

From the vapour system mimic screen operators can monitor the current sequence in progress, all process variables, valve positions and flow rate. The table below lists the vapour system parameters available to the operators.

Description	Min Value	Max Value	Initial Value	Security Level
Vapour system Status	Automatic	Shutdown	Automatic	2

Operator settings for vapour system

11. Utilities

11.1 Air

New air piping shall be reticulated from the adjacent supply header to provide air to the PMB plant actuated valves. Air supply to valves shall be sacrificial

plastic tubing (UV-resistant) such that in the event of a fire the valves fail safe.

11.2 Water

New water piping shall be reticulated from the adjacent supply header to all safety showers. All water lines shall be lagged to mitigate solar radiation overheating the water lines.

Safety showers will be provided in close proximity to the storage tank sample points, hot oil manifold, pump strainers, and the truck unloading point.

11.3 Lighting

Existing lighting infrastructure will be used in the PMB supersac bag unloading area and the loading gantry.

New lighting infrastructure shall be provided as required in the storage shed and around the PMB production plant.

12. APPENDICES

A. Cause and Effect Chart, 2036-EQCE-0001

NOTES ( ):
1. Pump speed control philosophy is to slow the pump incrementally before tripping

HOLDS:
1 Subject to Confirmation

LEGEND:

C	Close
O	Open
OI	Open inhibit
ESD	Emergency Shutdown
SD	Shutdown
ST	Start
A	Activate
SI	Start Inhibit

CAUSE

Tag No	Description	Setting	P&ID NO.	EFFECT	P&ID No	2036-Q-0001	2036-Q-0001	21853-PI-10	2036-Q-0001	2036-Q-0001	2036-Q-0001	2036-Q-0008	2036-Q-0008	2036-Q-0002	2036-Q-0008	2036-Q-0008	2036-Q-0003	2036-Q-0003	2036-Q-0002	2036-Q-0002	2036-Q-0002	2036-Q-0002	2036-Q-0002	2306-Q-0008	2036-Q-0003	2036-Q-0003	2036-Q-0003	2036-Q-0003	2036-Q-0003	2036-Q-0005	2036-Q-0005	2036-Q-0005	2036-Q-0005	2036-Q-0005	2036-Q-0008	2036-Q-0006	2036-Q-0006	2036-Q-0006	2036-Q-0011	2036-Q-0011	2036-Q-0011			COMMENTS
					Description	Bitumen C170 Pump	Extract Oil Pump	Loading Pump #1	C170 Bitumen Inlet to T4000	C170 Bitumen Outlet from T4000	T4 100 Extract Oil Inlet/Outlet	Hot Oil supply to T4000	Hot Oil supply to T4100	T4200 Shredder Motor	Hot Oil supply to T4200 coil 1	Hot Oil supply to T4200 coil 2	Homogeniser	PMB Transfer Pump	T4200 Mix Tank Inlet	T4200 Mix Tank Outlet	Tank T-4000 Vapour Air Purge	T4200 Sour Gas	Vapour Discharge from Knock out Pot SP4000	Vapour inlet to Knock out Pot SP4000	Hot Oil supply to T4600	Mixer for T4600	PMB Outlet fromT4600	PMB Inlet to T4600	Tank T-4600 Vapour Air Purge	Loading Pump	Mixer for T4700	PMB Inlet to T4700	PMB Outlet from T4700	Tank T-4600 Vapour Air Purge	Gantry Pump	Hot Oil Supply to T4700	P4400 Supply to Gantry	P4300 Supply to Gantry	Loading Arm at Gantry Bay 2	Solid outlet from Hopper H4000	Bitumen supply for Venturi SP4001	Bitumen From Venturi SP4001			
					Tag No	P4000	P4100	P1001	XV-4001	XV-4000	XV-4100	TCV-4000	TCV-4100	M4200	TCV-4200-1	TCV-4200-2	H4200	P4200	XV-4201	XV-4200	XV-4010	XV-4210	XV-4003	XV-4220	TCV-4600	A4600	XV-4600	XV-4601	XV-4610	P4400	A4700	XV-4701	XV-4700	XV-4710	P4300	TCV-4700	XV-4453	XV-4711	XV-4800	XV-4221	XV-4222	XV-4223			
TAHH-4004	P4000 Motor Temperature High High	HOLD1	2036-Q-0001			SD																																					
TALL-4003	P4000 Pump Jacket Temperature Low Low	170°C	2036-Q-0001			SD																																					
ZIC-XV4000	XV-4000 Not Open	-	2036-Q-0001			SI																																					
TALL-4002	Bitumen C170 Temperature Low Low	170°C	2036-Q-0001					SD																																				
TAHH-4103	P4100 Motor Temperature High High	HOLD1	2036-Q-0001				SD																																				
TALL-4102	P4100 Pump Jacket Temperature Low Low	80°C	2036-Q-0001				SD																																				
ZIC-XV4100	XV-4100 Not Open	-	2036-Q-0001				SI																																				
FAL-4000	Bitumen C170 Flow Low	HOLD1	2036-Q-0001						C																																			
FALL-4000	Bitumen C170 Flow Low Low	HOLD1	2036-Q-0001					SD																																				
FAHH-4000	Bitumen C170 Flow High High	HOLD1	2036-Q-0001					SD																																				
LAHH-4001	T4000 Tank Level High High	12315 mm	2036-Q-0001					SD																																				
LAH-4001	T4000 Tank Level High	11875 mm	2036-Q-0001						C																																			
LAL-4001	T4000 Tank Level Low	2297 mm	2036-Q-0001									C																																
LALL-4001	T4000 Tank Level Low Low	2197 mm	2036-Q-0001			SD																																						
LAHH-4101	T4100 Tank Level High High	11970 mm	2036-Q-0001				SD																																					
LAH-4101	T4100 Tank Level High	11056 mm	2036-Q-0001																																									
LAL-4101	T4100 Tank Level Low	2243 mm	2036-Q-0001								C		C																															
LALL-4101	T4100 Tank Level Low Low	2143 mm	2036-Q-0001				SD																																					
PAHH-4000	P4000 Pump Discharge Pressure High High	1000 kPag	2036-Q-0001			SD																																					
PAHH-4100	P4100 Pump Discharge Pressure High High	1000 kPag	2036-Q-0001				SD																																					
DPAHH-4000	DPIT-4000 Differential Pressure High High	25 kPa	2036-Q-0001			SD																																					
DPAHH-4100	DPIT-4100 Differential Pressure High High	25 kPa	2036-Q-0001				SD																																					
TAHH-4202	M4200 Temperature High High	HOLD1	2036-Q-0002											SD																															
TAHH-4200	T4200 Tank Temperature High High	200°C	2036-Q-0002											SD	C	C	SD																											
TALL-4200	T4200 Tank Temperature Low Low	170°C	2036-Q-0002											SD			SD	SD																											
FALL-4200	Bitumen C170/Extract Oil Flow Low Low	HOLD1	2036-Q-0002			SD	SD																																					
LAHH-4201	T4200 Tank Level High High	5415 mm	2036-Q-0002			SD	SD																																					
LAH-4201	T4200 Tank Level High	5130 mm	2036-Q-0002																C																									
LAL-4201	T4200 Tank Level Low	2317 mm	2036-Q-0002											SI	C	C																											
LALL-4201	T4200 Tank Level Low Low	2217 mm	2036-Q-0002														SD	SD																											
ZIC-XV4200	XV-4200 Not Open	-	2036-Q-0002														SI	SI																											
ZIC-XV4203	XV-4203 Not Open	-	2036-Q-0002															SI																											
LAHH-1002	Truck Level High High		2036-Q-0006																																				C						
ZIO-1002	Arm Connection Open		2036-Q-0006																																				C						
PAHH-4206	Pressure at Venturi Throat High High	-1 kPag (HOLD1)	2036-Q-0011																																					C	C	C			

UGL

REV	DESCRIPTION	DATE	BY	CHECKED	APPROVED	CLIENT
B	RE-ISSUED FOR REVIEW	15-May-20	MB	JC	AG	BT
A	ISSUED FOR REVIEW	10-Dec-19	MB	AG	AG	BT

UGL DOC No. PB2036-2000-PRO-REP-001

PUMA ENERGY

BY: MB	DATE:	SCALE: NA
CHECKED: AG	DATE:	REF:
APPROVED: AG	DATE:	STATUS:

PROJECT TITLE: Project No.

DRAWING TITLE:
PUMA ENERGY (AUSTRALIA) HOLDINGS
PMB BITUMEN
BOTANY BAY PMB PRODUCTION FACILITY
CAUSE AND EFFECT CHART SHEET 1 OF 1

SHEET SIZE	PUMA DOCUMENT NO.	REVISION
A3	2036-EQCE-0001	B

NOTES ( ):

1. Pump speed control philosophy is to slow the pump incrementally before tripping

HOLDS:

1 Subject to Confirmation

LEGEND:

C	Close
O	Open
OI	Open inhibit
ESD	Emergency Shutdown
SD	Shutdown
ST	Start
A	Activate
SI	Start Inhibit

CAUSE

EFFECT

Tag No	Description	Setting	P&ID NO.	P&ID No	Description	Tag No	COMMENTS
				2036-Q-0001	Bitumen C170 Pump	P4000	
				2036-Q-0001	Extract Oil Pump	P4100	
				21853-PI-10	Loading Pump #1	P1001	
				2036-Q-0001	C170 Bitumen Inlet to T4000	XV-4001	
				2036-Q-0001	C170 Bitumen Outlet from T4000	XV-4000	
				2036-Q-0001	T4100 Extract Oil Inlet/Outlet	XV-4100	
				2036-Q-0008	Hot Oil supply to T4000	TCV-4000	
				2036-Q-0008	Hot Oil supply to T4100	TCV-4100	
				2036-Q-0002	T4200 Shredder Motor	M4200	
				2036-Q-0008	Hot Oil supply to T4200 coil 1	TCV-4200-1	
				2036-Q-0008	Hot Oil supply to T4200 coil 2	TCV-4200-2	
				2036-Q-0003	Homogeniser	H4200	
				2036-Q-0003	PMB Transfer Pump	P4200	
				2036-Q-0002	T4200 Mix Tank Inlet	XV-4201	
				2036-Q-0002	T4200 Mix Tank Outlet	XV-4200	
				2036-Q-0002	Tank Vapour Air Purge	FCV-4001	
				2036-Q-0002	T4200 Sour Gas	FCV-4200	
				2036-Q-0002	SP-4000 Vapour Discharge	XV-4003	
				2036-Q-0002	Vapour inlet to SP-4000	XV-4220	
				2306-Q-0008	Hot Oil supply to T4600	TCV-4600	
				2036-Q-0003	Mixer for T4600	A4600	
				2036-Q-0003	PMB Outlet from T4600	XV-4600	
				2036-Q-0003	PMB Inlet to T4600	XV-4601	
				2036-Q-0003	Tank T-4600 Vapour Air Purge	XV-4610	
				2036-Q-0003	Loading Pump	P4400	
				2036-Q-0005	Mixer for T4700	A4700	
				2036-Q-0005	PMB Inlet to T4700	XV-4701	
				2036-Q-0005	PMB Outlet from T4700	XV-4700	
				2036-Q-0005	Tank T-4600 Vapour Air Purge	XV-4710	
				2036-Q-0005	Gantry Pump	P4300	
				2036-Q-0008	Hot Oil Supply to T4700	TCV-4700	
				2036-Q-0006	P4400 Supply to Gantry	XV-4453	
				2036-Q-0006	P4300 Supply to Gantry	XV-4711	
				2036-Q-0006	Loading Arm at Gantry Bay 2	XV-4800	
				2036-Q-0011	Solid outlet from Hopper H4000	XV-4221	
				2036-Q-0011	Bitumen supply for Venturi SP4001	XV-4222	
				2036-Q-0011	Bitumen From Venturi SP4001	XV-4223	
LSHH-4000	SP4000 Liquid level High High	HOLD 1	2036-Q-0002				
TAHH-4204	P4200 Motor Temperature High High	100°C	2036-Q-0003				
TALL-4205	P4200 Pump Jacket Temperature Low Low	170°C	2036-Q-0003				
TAHH-4207	H4200 Motor Temperature High High	100°C	2036-Q-0003				
TAHH-4208	H4200 Homogeniser Temperature High High	200°C	2036-Q-0003				
TALL-4208	H4200 Homogeniser Temperature Low Low	170°C	2036-Q-0003				
TAHH-4600	T4600 Tank Temperature High High	200°C	2036-Q-0003				
TALL-4600	T4600 Tank Temperature Low Low	170°C	2036-Q-0003				
TAHH-4601	T4600 Tank Temperature High High	200°C	2036-Q-0003				
TALL-4601	T4600 Tank Temperature Low Low	170°C	2036-Q-0003				
TALL-4602	P4400 Pump Jacket Temperature Low Low	170°C	2036-Q-0003				
TAHH-4603	P4400 Motor Temperature High High	100°C	2036-Q-0003				
ZIC-XV4600	XV-4600 Not Open	-	2036-Q-0003				
TAHH-4604	A4600 Motor Temperature High High	100°C	2036-Q-0003				
LAH-4601	T4600 Tank Level High	11875 mm	2036-Q-0003				
LAHH-4601	T4600 Tank Level High High	12315 mm	2036-Q-0003				
LAL-4601	T4600 Tank Level Low	2291 mm	2036-Q-0003				
LALL-4601	T4600 Tank Level Low Low	2197 mm	2036-Q-0003				
PAHH-4201	P4200 Pump Discharge Pressure High High	1000 kPag	2036-Q-0003				
PALL-4202	P4200 Pump Suction Pressure Low Low	(-) 75 kPag	2036-Q-0003				
PAHH-4203	H4200 Homogeniser Discharge Pressure High High	1000 kPag	2036-Q-0003				
PALL-4204	H4200 Homogeniser Suction Pressure Low Low	(-) 75 kPag	2036-Q-0003				
PAHH-4600	P4400 Pump Discharge Pressure High High	1000 kPag	2036-Q-0003				
DPAH-4200	DPIT-4200 Differential Pressure High	20 kPa	2036-Q-0003				
DPAHH-4200	DPIT-4200 Differential Pressure High High	25 kPa	2036-Q-0003				
DPAH-4600	DPIT-4600 Differential Pressure High	20 kPa	2036-Q-0003				
DPAHH-4600	DPIT-4600 Differential Pressure High High	25 kPa	2036-Q-0003				
TAHH-4700	T4700 Tank Temperature High High	200°C	2036-Q-0005				
TALL-4700	T4700 Tank Temperature Low Low	170°C	2036-Q-0005				
TAHH-4701	T4700 Tank Temperature High High	200°C	2036-Q-0005				
TALL-4701	T4700 Tank Temperature Low Low	170°C	2036-Q-0005				
TAHH-4702	A4700 Motor Temperature High High	HOLD 1	2036-Q-0005				
TALL-4302	P4300 Pump Jacket Temperature Low Low	140 °C	2036-Q-0005				
TAHH-4301	P4300 Motor Temperature High High	100°C	2036-Q-0005				
LAH-4700	T4700 Tank Level High	11875 mm	2036-Q-0005				
LAHH-4700	T4700 Tank Level High High	12315 mm	2036-Q-0005				
LAL-4700	T4700 Tank Level Low	2297 mm	2036-Q-0005				
LALL-4700	T4700 Tank Level Low Low	2197 mm	2036-Q-0005				
PAHH-4700	P4700 Pump Discharge Pressure High High	1000 kPag	2036-Q-0005				
DPAH-4700	DPIT-4700 Differential Pressure High	20 kPa	2036-Q-0005				
DPAHH-4700	DPIT-4700 Differential Pressure High High	25 kPa	2036-Q-0005				
ZIC-XV4700	XV-4700 Not Open	-	2036-Q-0005				
TAHH-4800	Gantry Bay 2 Temperature High High	200°C	2036-Q-0006				
TAHH-4801	Gantry Bay 1 Temperature High High	200°C	2036-Q-0006				
LEL-4000-HH	High High LEL Level in PMB Sour Gass System	>25%	2036-Q-0002	SD	SD	SD	C C C C SD C C SD SD C C C C C C SD C C SD SD C C C SD C C C C C C SD
LEL-4001-HH	High High LEL Level in PMB Sour Gass System	>25%	2036-Q-0002	SD	SD	SD	C C C C SD C C SD SD C C C C C C SD C C SD SD C C C SD C C C C C C
AA-4000	High High H2S level in PMB Facility (T4200)	>8 ppm (HOLD)	2036-Q-0002	SD	SD	SD	C C C C SD C C SD SD C C C C C C SD C C SD SD C C C SD C C C C C C
AA-4001	High High H2S level in PMB Facility (T4200)	>8 ppm (HOLD)	2036-Q-0002	SD	SD	SD	C C C C SD C C SD SD C C C C C C SD C C SD SD C C C SD C C C C C C
AA-4004	High High H2S level in PMB Facility (T4600)	>8 ppm (HOLD)	2036-Q-0002	SD	SD	SD	C C C C SD C C SD SD C C C C C C SD C C SD SD C C C SD C C C C C C
AA-4002	High High H2S level in PMB Facility (T4700)	>8 ppm (HOLD)	2036-Q-0002	SD	SD	SD	C C C C SD C C SD SD C C C C C C SD C C SD SD C C C SD C C C C C C
AA-4003	High High H2S level in PMB Facility (Gantry Area)	>8 ppm (HOLD)	2036-Q-0002	SD	SD	SD	C C C C SD C C SD SD C C C C C C SD C C SD SD C C C SD C C C C C C
	Terminal Combustor not available (Signal from Terminal)			SD	SD	SD	C C C C SD C C SD SD C C C C C C SD C C SD SD C C C SD C C C C C C
	E Stop						
ESD-1	Inside Switchroom on ESD-101 Door			SD	SD	SD	C C C C C C SD SD C C C C C C SD C C C C SD C C C C C C
ESD-2	Control Building ESD-102 Door			SD	SD	SD	C C C C C C SD SD C C C C C C SD C C C C SD C C C C C C
ESD-3	Hopper			SD	SD	SD	C C C C C C SD SD C C C C C C SD C C C C SD C C C C C C
ESD-4	Top Tank T4200			SD	SD	SD	C C C C C C SD SD C C C C C C SD C C C C SD C C C C C C
ESD-5	Pump Bank			SD	SD	SD	C C C C C C SD SD C C C C C C SD C C C C SD C C C C C C
ESD-6	External Switchroom			SD	SD	SD	C C C C C C SD SD C C C C C C SD C C C C SD C C C C C C

UGL

REV	DESCRIPTION	DATE	BY	CHECKED	APPROVED	CLIENT
B	RE-ISSUED FOR REVIEW	15-May-20	MB	JC	AG	BT
A	ISSUED FOR REVIEW	10-Dec-19	MB	AG	AG	BT

UGL DOC No. PB2036-2000-PRO-REP-001

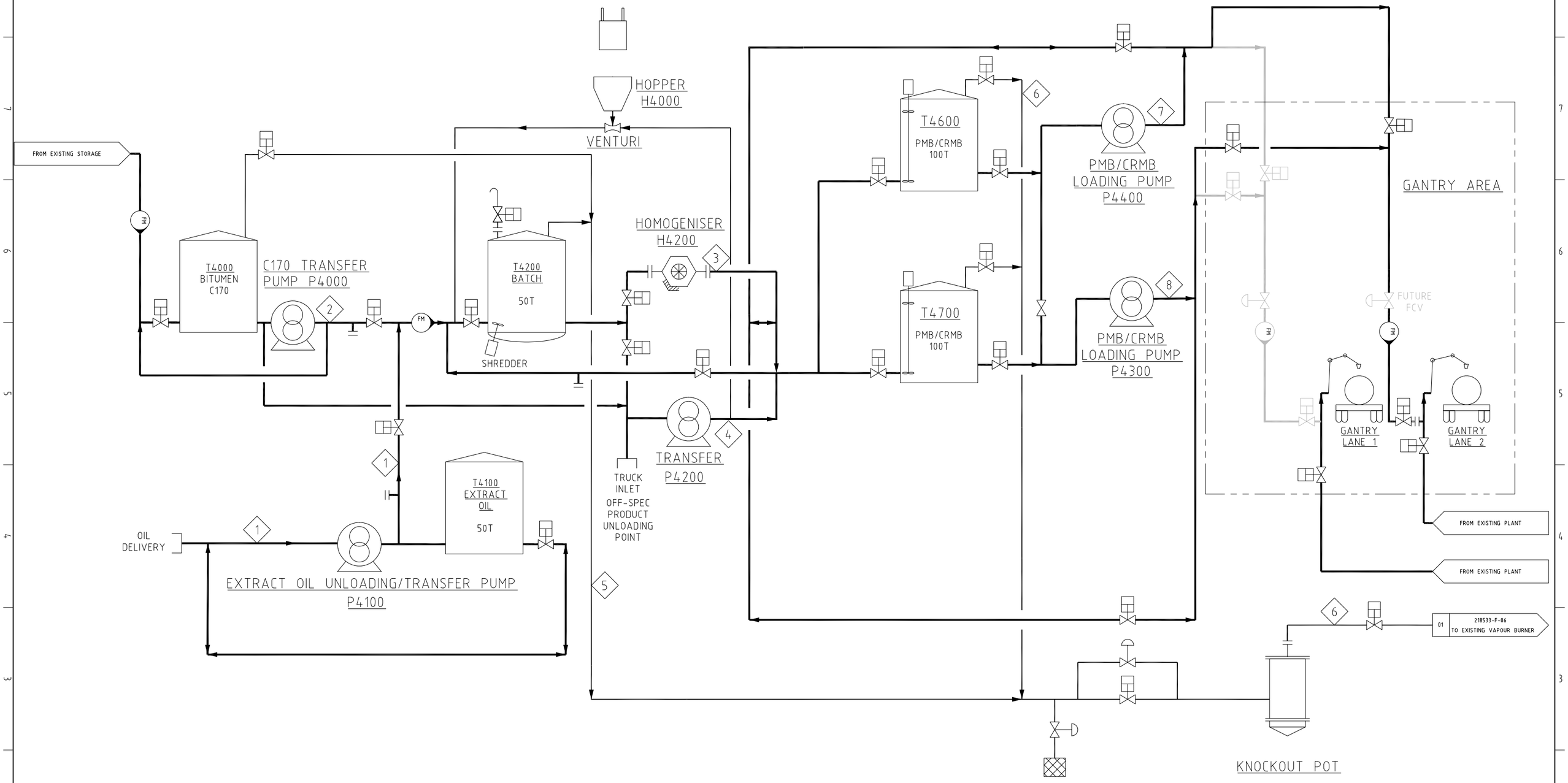
PUMA ENERGY

BY: MB	DATE:	SCALE: NA
CHECKED: AG	DATE:	REF:
APPROVED: AG	DATE:	STATUS:

PROJECT TITLE: Project No.

DRAWING TITLE: PUMA ENERGY (AUSTRALIA) HOLDINGS PMB BITUMEN BOTANY BAY PMB PRODUCTION FACILITY CAUSE AND EFFECT CHART SHEET 2 OF 2

SHEET SIZE	PUMA DOCUMENT NO.	REVISION
A3	2036-EQCE-0001	B



No	1	2	3	4	5	6	7	8
SERVICE	EXTRACT OIL	BITUMEN	PMB/CR	PMB/CR	VAPOUR	VAPOUR	PMB/CR	PMB/CR
TEMP	60°	190°	190°	190°	190°	190°	195°	195°
FLOW RATE (lpm)	1000	1000	1000	1500	10,000	24,000	1500	1500

REV	DATE	DESIGNATION	DRN	CHK	APP
			JAG	MB	AG
0B	23.07.2020	RE-ISSUED FOR CONSTRUCTION	JAG	MB	AG
0A	24.03.2020	RE-ISSUED FOR CONSTRUCTION - LOCATION OF VENTURI	JAG	MB	AG
0	17.03.2020	ISSUED FOR CONSTRUCTION	JAG	MB	AG

UGL

DIMENSIONS IN MM U.N.O.
DRAWINGS TO AS1100
DO NOT SCALE
THIRD ANGLE PROJECTION

ISSUED FOR CONSTRUCTION

NOTES

PUMA ENERGY

PUMA ENERGY (AUSTRALIA) HOLDINGS

PUMA ENERGY (AUSTRALIA) KWINANA P/L
PROJECT DELIVERY OFFICE
A.C.N. 167 227 858 TEL (07) 3518 1300
LEVEL 3, 51 ALFRED ST FORTITUDE VALLEY QLD 4006

Scale	Drawn Date	Format Size
NTS	07.06.16	A1

DRN	CHK	ENG	APP
DR	JH	PM / JS	ST

Project name: BOTANY BAY PMB PRODUCTION FACILITY
Location: SIMBLIST ROAD, PORT BOTANY, NSW
Drawing title: BOTANY BAY PMB PRODUCTION FACILITY
PROCESS FLOW DIAGRAM
Project No. 2036
Drawing N° **2036-R-0001**
Revision 0B

Appendix B – ETC sampling report

20 January 2006

Report No: 060008r

GHD Services Pty Ltd
Level 8, 180 Lonsdale Street
Melbourne VIC 3000

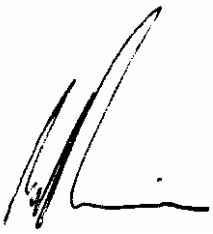
Emission Testing – January 2006
Boral Gepps Cross and Salisbury Quarry

Dear Mr. Scott Anderson,

Tests were performed on 12 January 2006 to determine levels of odour, volatile organic compounds (VOC's) and polycyclic aromatic hydrocarbons (PAH's) in the headspaces of a bitumen kettle at Boral Gepps Cross and another at Boral Salisbury Quarry.

DEFINITIONS 2
PLANT OPERATING CONDITIONS 2
TEST METHODS 3
DEVIATIONS FROM TEST METHODS 3
ODOUR SAMPLING AND ANALYSIS PARAMETERS 4
RESULTS 5
Bitumen kettle headspace – Gepps Cross 5
Bitumen kettle headspace – Salisbury Quarry 8

Yours faithfully
Emission Testing Consultants Pty Ltd



Matthew Heskin
Director

matthewheskin@emission.com.au

NATA Accredited Laboratory Number: 14601

NATA endorsed test report. This document shall not be reproduced, except in full.

DEFINITIONS

The following symbols and abbreviations are used in this test report:

NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow that may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
BSP	British standard pipe.
VOC	Any chemical compound based on carbon in the boiling range 36 to 126°C, with a vapour pressure of at least 0.010kPa at 25°C (or having a corresponding volatility under the particular conditions of use) that adsorb onto activated charcoal and desorb into CS_2, or that can be collected in a tedlar bag and be quantitatively recovered, and that are detected by GCMS. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are CO, CO_2, carbonic acid, metallic carbides and carbonate salts.
D	Duct diameter or equivalent duct diameter for rectangular ducts.
>	Greater than
<	Less than the minimum limit of detection using the specified method.
~	Approximately
NA	Not applicable

PLANT OPERATING CONDITIONS

Plant operating conditions were supplied by Boral personnel.

Site	Gepps Cross	Salisbury Quarry
Bitumen grade		
Volume of bitumen in kettle (L)	13000	31750
Temperature of bitumen (°C)	160	150
Temperature of headspace (°C)	143	122
Ambient temperature (°C)	20.8	17.1
Relative humidity (%)	63	71

NATA endorsed test report.
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TEST METHODS

The following methods are accredited with the National Association of Testing Authorities (NATA) and are approved for the sampling and analysis of gases. Specific details of the methods are available on request.

All sampling and analysis conducted in accordance with EPA Vic approved methods and EPA publication 440.1.

All parameters are reported adjusted to dry NTP conditions unless otherwise stated.

On site sampling guidelines: according to ETC method 1.

Odour: according to AS4323.3, by dynamic olfactometry (forced-choice technique). Panel n-butanol threshold determination by analysis against a NATA certified n-butanol gas standard. Sampling conducted in duplicate. Concentrations reported on a wet NTP basis.

Volatile organic compounds (VOC): according to Vic EPA method 4230, by on site sampling onto a sorbent tube, with subsequent laboratory analysis by solvent desorption and GCMS. Where possible the ten major organic compounds were identified, quantified and reported. Any other VOC's were quantified as the top compound present. Analysis performed under subcontract by MGT Environmental Consulting (NATA accreditation number 1261); report number 190326 dated 19 January 2006. Sampling conducted in duplicate.

Note: Laboratory analysis is not NATA endorsed.

Polycyclic aromatic hydrocarbons (PAHs): sampled according to Vic EPA method 4230, by on site sampling into a filter and sorbent tube, with subsequent laboratory analysis according to USEPA 8270C by solvent desorption and GCMS. Analysis performed under subcontract by MGT Environmental Consulting (NATA accreditation number 1261); report number 190326 dated 19 January 2006. Sampling conducted in duplicate.

DEVIATIONS FROM TEST METHODS

Polycyclic aromatic hydrocarbons (PAHs): greater than 10% of the total amount of naphthalene was present in the back section of the sorbent tube of all four samples. This may have lead to an underestimation of the concentration present in the headspaces of either or both kettles.

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ODOUR SAMPLING AND ANALYSIS PARAMETERS

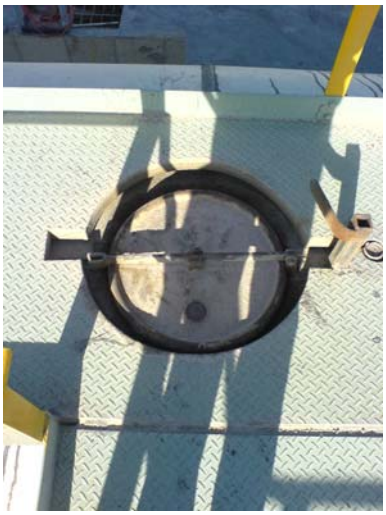
Technique:	**AS4323.3 - Forced Choice**
Reference odorant and threshold limits:	n-Butanol, 20 to 80 ppb
Panel n-Butanol threshold value:	64 ppb
Date and time of analysis:	13/01/2006 @ 1000 - 1100hrs
Pre-dilution:	0.4L sample air + 10L dilution air (1 in 26)
Pre-dilution equipment:	Dry Gas Meter 1025

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RESULTS

Bitumen kettle headspace – Gepps Cross

12 January 2006



Odour Results	Sample ID	Sampling Times	Concentration
Odour	169	0828-0829	69,000 ou
	182	0829-0830	77,000 ou
Average Results			**73,000 ou**

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Bitumen kettle headspace – Gepps Cross

12 January 2006

Volatile Organic Compound (VOC) Results (GC Mario)	Sampling Times	Concentration at NTP	
2-ethyl-1-decanol* - Test 1	0825-0835	150	mg/m³
2-ethyl-1-decanol* - Test 2	0825-0835	170	mg/m³
Average Results		**160**	**mg/m³**
2-propyl-1-heptanol* - Test 1	0825-0835	130	mg/m³
2-propyl-1-heptanol* - Test 2	0825-0835	170	mg/m³
Average Results		**150**	**mg/m³**
2-butyl-1-octanol* - Test 1	0825-0835	120	mg/m³
2-butyl-1-octanol* - Test 2	0825-0835	130	mg/m³
Average Results		**130**	**mg/m³**
2-ethyl-1-dodecanol* - Test 1	0825-0835	110	mg/m³
2-ethyl-1-dodecanol* - Test 2	0825-0835	160	mg/m³
Average Results		**130**	**mg/m³**
Hexyl octyl ether* - Test 1	0825-0835	50	mg/m³
Hexyl octyl ether* - Test 2	0825-0835	49	mg/m³
Average Results		**49**	**mg/m³**
1,3,5-trimethylbenzene* - Test 1	0825-0835	33	mg/m³
1,3,5-trimethylbenzene* - Test 2	0825-0835	31	mg/m³
Average Results		**32**	**mg/m³**
1,2,3-trimethylbenzene* - Test 1	0825-0835	30	mg/m³
1,2,3-trimethylbenzene* - Test 2	0825-0835	28	mg/m³
Average Results		**29**	**mg/m³**
m,p-xylenes - Test 1	0825-0835	23	mg/m³
m,p-xylenes - Test 2	0825-0835	22	mg/m³
Average Results		**22**	**mg/m³**
1,2,4-trimethylbenzene* - Test 1	0825-0835	22	mg/m³
1,2,4-trimethylbenzene* - Test 2	0825-0835	20	mg/m³
Average Results		**21**	**mg/m³**
Toluene - Test 1	0825-0835	13	mg/m³
Toluene - Test 2	0825-0835	13	mg/m³
Average Results		**13**	**mg/m³**
Minor VOC's* - Test 1	0825-0835	880	mg/m³
Minor VOC's* - Test 2	0825-0835	870	mg/m³
Average Results		**870**	**mg/m³**

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Bitumen kettle headspace – Gepps Cross

12 January 2006

Polycyclic Aromatic Hydrocarbon (PAH) Results GC Mario	Sampling Times	Concentration at NTP	
Acenaphthene - Test 1	0825-0835	< 0.005	mg/m³
Acenaphthene - Test 2	0825-0835	< 0.010	mg/m³
Acenaphthylene - Test 1	0825-0835	< 0.005	mg/m³
Acenaphthylene - Test 2	0825-0835	< 0.005	mg/m³
Anthracene - Test 1	0825-0835	< 0.005	mg/m³
Anthracene - Test 2	0825-0835	< 0.005	mg/m³
Benz(a)anthracene - Test 1	0825-0835	< 0.005	mg/m³
Benz(a)anthracene - Test 2	0825-0835	< 0.005	mg/m³
Benzo(a)pyrene - Test 1	0825-0835	< 0.005	mg/m³
Benzo(a)pyrene - Test 2	0825-0835	< 0.005	mg/m³
Benzo(b)fluoranthene - Test 1	0825-0835	< 0.005	mg/m³
Benzo(b)fluoranthene - Test 2	0825-0835	< 0.005	mg/m³
Benzo(g,h,i)perylene - Test 1	0825-0835	< 0.005	mg/m³
Benzo(g,h,i)perylene - Test 2	0825-0835	< 0.005	mg/m³
Benzo(k)fluoranthene - Test 1	0825-0835	< 0.005	mg/m³
Benzo(k)fluoranthene - Test 2	0825-0835	< 0.005	mg/m³
Chrysene - Test 1	0825-0835	< 0.005	mg/m³
Chrysene - Test 2	0825-0835	< 0.005	mg/m³
Dibenz(a,h)anthracene - Test 1	0825-0835	< 0.005	mg/m³
Dibenz(a,h)anthracene - Test 2	0825-0835	< 0.005	mg/m³
Fluoranthene - Test 1	0825-0835	< 0.005	mg/m³
Fluoranthene - Test 2	0825-0835	< 0.005	mg/m³
Fluorene - Test 1	**0825-0835**	**0.045**	**mg/m³**
Fluorene - Test 2	**0825-0835**	**0.045**	**mg/m³**
Average Results		**0.045**	**mg/m³**
Indeno(1,2,3-cd)pyrene - Test 1	0825-0835	< 0.005	mg/m³
Indeno(1,2,3-cd)pyrene - Test 2	0825-0835	< 0.005	mg/m³
Naphthalene - Test 1	**0825-0835**	**2.0**	**mg/m³**
Naphthalene - Test 2	**0825-0835**	**1.7**	**mg/m³**
Average Results		**1.9**	**mg/m³**
Phenanthrene - Test 1	0825-0835	< 0.02	mg/m³
Phenanthrene - Test 2	0825-0835	< 0.02	mg/m³
Pyrene - Test 1	0825-0835	< 0.005	mg/m³
Pyrene - Test 2	0825-0835	< 0.005	mg/m³
Total PAH - Test 1	**0825-0835**	**2.3**	**mg/m³**
Total PAH - Test 2	**0825-0835**	**1.9**	**mg/m³**
Average Results		**2.1**	**mg/m³**

Refer to "**DEVIATIONS FROM TEST METHODS**" on page 4.

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Bitumen kettle headspace – Salisbury Quarry

12 January 2006



Odour Results	Sample ID	Sampling Times	Concentration
Odour	6	0720-0721	77,000 ou
	183	0721-0722	82,000 ou
Average Results			**79,000 ou**

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Bitumen kettle headspace – Salisbury Quarry

12 January 2006

Volatile Organic Compound (VOC) Results SQ Mike	Sampling Times	Concentration at NTP	
2-butyl-1-octanol* - Test 1	0715-0725	450	mg/m³
2-butyl-1-octanol* - Test 2	0715-0725	310	mg/m³
Average Results		**380**	**mg/m³**
2-ethyl-1-decanol* - Test 1	0715-0725	380	mg/m³
2-ethyl-1-decanol* - Test 2	0715-0725	240	mg/m³
Average Results		**310**	**mg/m³**
Hexyl octyl ether* - Test 1	0715-0725	270	mg/m³
Hexyl octyl ether* - Test 2	0715-0725	190	mg/m³
Average Results		**230**	**mg/m³**
2-propyl-1-heptanol* - Test 1	0715-0725	220	mg/m³
2-propyl-1-heptanol* - Test 2	0715-0725	150	mg/m³
Average Results		**180**	**mg/m³**
1,3,5-trimethylbenzene* - Test 1	0715-0725	100	mg/m³
1,3,5-trimethylbenzene* - Test 2	0715-0725	70	mg/m³
Average Results		**87**	**mg/m³**
m,p-xylene - Test 1	0715-0725	92	mg/m³
m,p-xylene - Test 2	0715-0725	64	mg/m³
Average Results		**78**	**mg/m³**
2-ethyl-1-dodecanol* - Test 1	0715-0725	86	mg/m³
2-ethyl-1-dodecanol* - Test 2	0715-0725	58	mg/m³
Average Results		**72**	**mg/m³**
Toluene - Test 1	0715-0725	81	mg/m³
Toluene - Test 2	0715-0725	57	mg/m³
Average Results		**69**	**mg/m³**
1,2,3-trimethylbenzene* - Test 1	0715-0725	81	mg/m³
1,2,3-trimethylbenzene* - Test 2	0715-0725	53	mg/m³
Average Results		**67**	**mg/m³**
1,2,4-trimethylbenzene* - Test 1	0715-0725	58	mg/m³
1,2,4-trimethylbenzene* - Test 2	0715-0725	40	mg/m³
Average Results		**49**	**mg/m³**
Minor VOC's* - Test 1	0715-0725	1,400	mg/m³
Minor VOC's* - Test 2	0715-0725	980	mg/m³
Average Results		**1,200**	**mg/m³**

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Bitumen kettle headspace – Salisbury Quarry

12 January 2006

Polycyclic Aromatic Hydrocarbon (PAH) Results SQ Mike	Sampling Times	Concentration at NTP		
Acenaphthene - Test 1	0715-0725	<	0.005	mg/m³
Acenaphthene - Test 2	0715-0725	<	0.005	mg/m³
Acenaphthylene - Test 1	0715-0725	<	0.005	mg/m³
Acenaphthylene - Test 2	0715-0725	<	0.005	mg/m³
Anthracene - Test 1	0715-0725	<	0.005	mg/m³
Anthracene - Test 2	0715-0725	<	0.005	mg/m³
Benz(a)anthracene - Test 1	0715-0725	<	0.005	mg/m³
Benz(a)anthracene - Test 2	0715-0725	<	0.005	mg/m³
Benzo(a)pyrene - Test 1	0715-0725	<	0.005	mg/m³
Benzo(a)pyrene - Test 2	0715-0725	<	0.005	mg/m³
Benzo(b)fluoranthene - Test 1	0715-0725	<	0.005	mg/m³
Benzo(b)fluoranthene - Test 2	0715-0725	<	0.005	mg/m³
Benzo(g,h,i)perylene - Test 1	0715-0725	<	0.005	mg/m³
Benzo(g,h,i)perylene - Test 2	0715-0725	<	0.005	mg/m³
Benzo(k)fluoranthene - Test 1	0715-0725	<	0.005	mg/m³
Benzo(k)fluoranthene - Test 2	0715-0725	<	0.005	mg/m³
Chrysene - Test 1	0715-0725	<	0.005	mg/m³
Chrysene - Test 2	0715-0725	<	0.005	mg/m³
Dibenz(a,h)anthracene - Test 1	0715-0725	<	0.005	mg/m³
Dibenz(a,h)anthracene - Test 2	0715-0725	<	0.005	mg/m³
Fluoranthene - Test 1	0715-0725	<	0.005	mg/m³
Fluoranthene - Test 2	0715-0725	<	0.005	mg/m³
Fluorene - Test 1	**0715-0725**		**0.048**	**mg/m³**
Fluorene - Test 2	**0715-0725**		**0.037**	**mg/m³**
Average Results			**0.043**	**mg/m³**
Indeno(1,2,3-cd)pyrene - Test 1	0715-0725	<	0.005	mg/m³
Indeno(1,2,3-cd)pyrene - Test 2	0715-0725	<	0.005	mg/m³
Naphthalene - Test 1	**0715-0725**		**1.2**	**mg/m³**
Naphthalene - Test 2	**0715-0725**		**1.6**	**mg/m³**
Average Results			**1.4**	**mg/m³**
Phenanthrene - Test 1	0715-0725	<	0.03	mg/m³
Phenanthrene - Test 2	0715-0725	<	0.03	mg/m³
Pyrene - Test 1	0715-0725	<	0.005	mg/m³
Pyrene - Test 2	0715-0725	<	0.005	mg/m³
Total PAH - Test 1	0715-0725		1.5	mg/m³
Total PAH - Test 2	0715-0725		1.8	mg/m³
Average Results			**1.6**	**mg/m³**

Refer to "**DEVIATIONS FROM TEST METHODS**" on page 4

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Appendix C – Air Noise Environment sampling report

Air Noise Environment
Environmental Monitoring and Assessment

Emissions Monitoring: Pinkenba Facility: H655 and TK406

Puma Energy

398 Tingara Street

Pinkenba,

QLD 4008

Sampling Date: 28 September 2020

Issued: 12 October 2020

Prepared by:
Air Noise Environment
ABN: 13 081 834 513





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DOCUMENT CONTROL SHEET

Document Details

Project Reference:	0183.Draft results01.odt
Document Title:	Emissions Monitoring: Pinkenba Facility: H655 and TK406
Client:	Puma Energy
Document Reference:	C:\Users\gh\Desktop\207402.0183\Reporting\0183.Draft results01.odt

Version Number

Version:	Issue Date:	Prepared by:	Description:	Approved by:	Signature:
00	7/10/20	Gary Hall	Draft provisional results	-	-
01	12/10/20	Gary Hall	Updated Draft Results	-	-
02					

Revision History

Revision:	Issue Date:	Approved by:	Signature:	Details of Revision:
01.1				
01.2				

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Where site inspections, testing or fieldwork have taken place, the report is based on the information made available by the client or their nominees during the visit, visual observations and any subsequent discussions with regulatory authorities. It is further assumed that normal activities were being undertaken at the site on the day of the site visit(s).

The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Air Noise Environment Pty Ltd for the purposes of this project is both complete and accurate.

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Table 1: Summary of Results for VOC and PAH for TK406 6

Summary

Gas emission sampling was conducted from the heater stack H655 and from the TK406 tank vent at the Puma Pinkenba Bitumen plant on 28 September 2020.

A total of 5 odour samples were collected. 2 odour samples were collected at the H655 stack. 3 odour samples were collected at the TK406 vent. Sampling for SO_2 was conducted with a real time electro-chemical gas analyser. An average of the SO_2 results is included in the summary table below. The raw data spreadsheets are available for review.

A summary of the provisional results are included in Table 1 and Table 2 below.

Table 1: Summary of Results

Compound	Stack (H655)	TK406 Vent	Units
Odour (Sample 1)	279 OU (11:45)	92,700 OU (11:13)	OU
Odour (Sample 2)	470 OU (11:50)	92,700 (OU) (11:20)	OU
Odour (Sample 3)	-	46,300 (OU) (12:14)	OU
Sulphur Dioxide (average)	4 ppm (11:20 – 12:26)	9 ppm (11:30 – 12:37)	ppm
PAH (Sample 1)	BDL[d] (11:50)	See Table 2 below (11:20)	mg/m^3
PAH (Sample 2)	BDL[d] (11:54)	See Table 2 below (11:28)	mg/m^3
PAH (Sample 3)	-	See Table 2 below (12:25)	mg/m^3
Speciated VOC (Sample 1)	BDL[d] (11:50)	See Table 2 below (11:20)	mg/m^3
Speciated VOC Sample 2)	BDL[d] (11:54)	See Table 2 below (11:28)	mg/m^3
Speciated VOC (Sample 3)	-	See Table 2 below (12:25)	mg/m^3
Velocity	2.6[a]	-[b]	m/s
Stack/Duct Temperature	215	28[c]	°C
Duct diameter	1.2	0.21	m

[a] Velocity measured during 17 June sampling campaign, Report 6200.H655.report01.1 (included as Appendix 2)
[b] Velocity was not possible to measure at the sampling nipple on the tank duct.
[c] Surface temperature of the Tank vent duct.
[d] Below Detection Limits (approximately <0.1 mg/Nm^3)

Production data during sampling:

Crumbed rubber was added to the Tank TK406 from 10:20 am to 11:00 am. Sampling was conducted after the crumbed rubber was added to the tank.

The odour Laboratory results are included as Appendix 1

Sampling results for 17 June 2020 for the H655 stack are included in Appendix 2.

Table 2: Summary of Results for VOC and PAH for TK406

Compound	TK406 Vent (11:20)	TK406 Vent (11:28)	TK406 Vent (12:25)	Units [a]
Naphthalene	1.38	1.31	1.63	mg/Nm^3
Benzene	6.74	5.39	5.54	mg/Nm^3
Toluene	33.06	29.58	29.01	mg/Nm^3
Ethylbenzene	6.61	5.60	5.27	mg/Nm^3
m & p-Xylenes	171.93	147.90	145.05	mg/Nm^3
o-Xylene	1.72	1.37	1.23	mg/Nm^3
Styrene	0.56	0.40	0.29	mg/Nm^3
Isopropylbenzene	0.94	0.80	0.71	mg/Nm^3
n-Propylbenzene	1.08	0.90	0.79	mg/Nm^3
1,3,5-Trimethylbenzene	1.08	0.88	0.75	mg/Nm^3
1,2,4-Trimethylbenzene	4.10	3.28	2.77	mg/Nm^3
sec-Butylbenzene	0.19	0.15	-	mg/Nm^3
4-Isopropyltoluene	5.29	4.33	3.82	mg/Nm^3
n-Butylbenzene	1.85	1.58	1.32	mg/Nm^3

[a] mg/Nm^3 (wet)

The following compounds were analysed- Only those compounds where results were detected are reported above.:
Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, Benzo(b)&(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(ah)anthracene, Benzo(ghi)perylene, Benzene, Toluene, Ethylbenzene, m & p-Xylenes, o-Xylene, Styrene, Isopropylbenzene, n-Propylbenzene, 1,3,5-Trimethylbenzene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, sec-Butylbenzene, 4-Isopropyltoluene, n-Butylbenzene, Dichlorodifluoromethane, Chloromethane, Vinyl chloride, Bromomethane, Chloroethane, Trichlorofluoromethane, 1,1-Dichloroethane, Dichloromethane, trans-1,2-Dichloroethene, 1,1-Dichloroethene, 2,2-Dichloropropane, cis-1,2-Dichloroethene, Bromochloromethane, 1,1,1-Trichloroethane, Carbon tetrachloride, 1,1-Dichloropropene, 1,2-Dichloroethane, Trichloroethene, 1,2-Dichloropropane, Dibromomethane, cis-1,3-Dichloropropene, trans-1,3-Dichloropropene, 1,1,2-Trichloroethane, Tetrachloroethene, 1,3-Dichloropropane, 1,2-Dibromoethane, 1,1,1,2-Tetrachloroethane, 1,1,2,2-Tetrachloroethane, 1,2,3-Trichloropropane, 1,2-Dibromo-3-chloropropane, Hexachlorobutadiene, Chlorobenzene, Bromobenzene, 2-Chlorotoluene, 4-Chlorotoluene, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, 1,2-Dichlorobenzene, 1,2,4-Trichlorobenzene, 1,2,3-Trichlorobenzene, Chloroform, Bromodichloromethane, Dibromochloromethane, Bromoform,

Appendix 1 – Odour Results

Appendix 2 – Sampling Results from H655 Sampled on 17 June 2020

THE ODOUR UNIT (QLD) PTY LTD

Accreditation Number: 14974

Odour Sample Measurement Results
Panel Roster Number: BNE20200928_034

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Sample Odour Concentration (ou)
6279.1 Stack	BC20169	28/09/2020 11:45	28/09/2020 14:35	4	8	279
6279.2 Stack	BC20168	28/09/2020 11:50	28/09/2020 14:07	4	8	470
6279.3 T406	BC20171	28/09/2020 11:13	28/09/2020 15:24	4	8	92,700
6279.4 T406	BC20172	28/09/2020 11:20	28/09/2020 15:48	4	8	92,700
6279.5 T406	BC20170	28/09/2020 12:14	28/09/2020 14:57	4	8	46,300

Samples Received in Laboratory – From: ANE – Gary Hall Date: 28/09/2020 Time: 13:30

Note: The following are not covered by the NATA Accreditation issued to The Odour Unit Pty Ltd:

1. The collection of Isolation Flux Hood (IFH) samples and the calculation of the Specific Odour Emission Rate (SOER).
2. Final results that have been modified by the dilution factors where parties other than The Odour Unit Pty Ltd have performed the dilution of samples.

THE ODOUR UNIT (QLD) PTY LTD

Accreditation Number: 14974

Odour Panel Calibration Results

Reference Odorant	Reference Odorant Panel Roster Number	Concentration of Reference gas (ppb)	Panel Target Range for n-butanol (ppb)	Measured Concentration (ou)	Measured Panel Threshold (ppb)	Does this panel calibration measurement comply with AS/NZS4323.3:2001 (Yes / No)
n-butanol	BNE20200928_034	51,100	$20 \leq \chi \leq 80$	1,449	35	Yes

Comments

Odour Characterisation Results	
Sample ID	Character
BC20168	Chlorine, oily, fuel, mechanic workshop
BC20169	Chlorine, smoky
BC20170	Burnt, gassy, new shoes
BC20171	Smoky, gassy, rubber, plastic
BC20172	Smoky, gassy, rubber

Disclaimers

1. Parties, other than The Odour Unit Pty Ltd, responsible for collecting odour samples have advised that they have voluntarily furnished these odour samples, appropriately collected and labelled, to The Odour Unit Pty Ltd for the purpose of odour testing.
2. The collection of odour samples by parties other than The Odour Unit Pty Ltd relinquishes The Odour Unit Pty Ltd from all responsibility for the sample collection and any effects or actions that the results from the test(s) may have.
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Report Status

Status	Version	Date	Prepared by	Checked by	Change	Reason
Final	1.0	28/09/2020	Stephen Munro	Stephen Munro	-	-
Revised	-	-	-	-	-	-

END OF DOCUMENT

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NATA
Accreditation Number: 14974

Odour Concentration Measurement Report

The measurement was commissioned by:

Organisation	Air Noise Environment	Telephone	07 3245 7808
Contact	Gary Hall	Facsimile	--
Sampling Site	Undisclosed	Email	gary.hall@ane.com.au
Sampling Method	Undisclosed	Sampling Team	ANE

Order details:

Order requested by	Gary Hall	Order accepted by	Stephen Munro
Date of order	25 September 2020	TOU Project #	Q2190_05
Order number	Email	Project Manager	Stephen Munro
Signed by	--	Testing operator	Stephen Munro

Investigated Item	Odour concentration in odour units 'ou', determined by sensory odour concentration measurements, of an odour sample supplied in a sampling bag.
Identification	The odour sample bags were labelled individually. Each label recorded the testing laboratory, sample number, sampling location (or Identification), sampling date and time, dilution ratio (if dilution was used) and whether further chemical analysis was required.
Method	The odour concentration measurements were performed using dynamic olfactometry according to the Australian/New Zealand Standard: Stationary source emissions – Part 3: '*Determination of odour concentration by dynamic olfactometry* (AS/NZS4323.3:2001). The odour perception characteristics of the panel within the presentation series for the samples were analogous to that for butanol calibration. Any deviation from the Australian standard is recorded in the 'Comments' section of this report.
Measuring Range	The measuring range of the olfactometer is $2^2 \leq \chi \leq 2^{18}$ ou. If the measuring range was insufficient the odour samples will have been pre-diluted. The machine is not calibrated beyond dilution setting 2^{17}. This is specifically mentioned with the results.
Environment	The measurements were performed in an air- and odour-conditioned room. The room temperature is maintained at 22 °C ±3 °C.
Measuring Dates	The date of each measurement is specified with the results.
Instrument Used	The olfactometer used during this testing session was: TOU-OLF-004
Instrumental Precision	The precision of this instrument (expressed as repeatability) for a sensory calibration must be $r \leq 0.477$ in accordance with the AS/NZS4323.3:2001. $r = 0.352$ (August 2020) Compliance – Yes
Instrumental Accuracy	The accuracy of this instrument for a sensory calibration must be $A \leq 0.217$ in accordance with the AS/NZS4323.3:2001. $A = 0.169$ (August 2020) Compliance – Yes
Lower Detection Limit (LDL)	The LDL for the olfactometer has been determined to be 16 ou (4 times the lowest dilution setting)
Traceability	The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. The assessors are individually selected to comply with fixed criteria and are monitored in time to keep within the limits of the standard. The results from the assessors are traceable to primary standards of n-butanol in nitrogen. Note Disclaimers on last page of this document.

NATA

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Date: Monday, 28 September 2020

Panel Roster Number: BNE20200928_034

S. Munro
Authorised Signatory

Appendix 2 – Sampling Results from H655 Sampled on 17 June 2020

Air Noise Environment
Environmental Monitoring and Assessment

Emissions Monitoring: Pinkenba Facility: H655

Puma Energy

398 Tingara Street

Pinkenba,

QLD 4008

Sampling Date: 17 June 2020

Issued: 28 August 2020

Prepared by:
Air Noise Environment
ABN: 13 081 834 513

NATA
WORLD RECOGNISED
ACCREDITATION

Accredited for Compliance with ISO/IEC 17025 – Testing







NATA Accreditation Number: 15841

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Should you have any queries regarding the contents of this document, please contact Air Noise Environment.

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DOCUMENT CONTROL SHEET

Document Details

Project Reference:	6200.H655.report.01.1.odt
Document Title:	Emissions Monitoring: Pinkenba Facility: H655
Client:	Puma Energy
Document Reference:	N:\6200 - 207402.0125\Reporting\6200.H655.report.01.1.odt

Version Number

Version:	Issue Date:	Prepared by:	Description:	Approved by:	Signature:
00	27/8/2020	Puneet Verma	Internal Draft	-	-
01	28/8/2020	Puneet Verma	Final	Gary Hall	

Revision History

Revision:	Issue Date:	Approved by:	Signature:	Details of Revision:
01.1	28/8/2020	Gary Hall		Corrected file name and Stack number in title
01.2				

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Where site inspections, testing or fieldwork have taken place, the report is based on the information made available by the client or their nominees during the visit, visual observations and any subsequent discussions with regulatory authorities. It is further assumed that normal activities were being undertaken at the site on the day of the site visit(s).

The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Air Noise Environment Pty Ltd for the purposes of this project is both complete and accurate.

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Executive Summary

Stack emission sampling was conducted from the heater stack H655 at the Puma Pinkenba Bitumen plant on 17 June 2020. A summary of the results are included in Table 1 below.

Table 1: Summary of Results

Compound	Release Point	Units
	H655	
Carbon Monoxide (CO)	25	mg/m^3
Particulates (TSP)	2.5	mg/m^3
NO_x (expressed as NO_2)	97	mg/m^3
Sulphur Trioxide (SO_3) (expressed as SO_2)	4.6	mg/m^3
Sulphur Dioxide (SO_2)	147	mg/m^3
Total SO_x (expressed as SO_2)	152	mg/m^3

1 Introduction

Puma Energy commissioned Air Noise Environment Pty Ltd to conduct monitoring of air emissions from their Pinkenba Facility as part of their requirements for the Environmental authority EPPR00854713.

Table 1.1 details the monitoring locations and the monitoring performed at each location. The monitoring was completed on 17 June 2020.

Table 1.1: Monitoring Locations and Parameters

Compound	Release Point
	H655
Velocity, Flowrate and Temperature	✔
Combustion Gases (CO, O_2, CO_2)	✔
Moisture Content	✔
Particulates	✔
Sulphur Dioxide (SO_2)	✔
Oxides of Nitrogen (NO, NO_2, NO_x)	✔
Sulphur Dioxide (SO_2) and Sulphur Trioxide/Sulphuric Acid (SO_3, H_2SO_4)	✔

The monitoring of air emissions at the Pinkenba Facility was completed during normal operating conditions. Any factors that may have affected the monitoring results were not observed by, or brought to the notice of Air Noise Environment (ANE) staff except where noted in this report.

2 Methodology

2.1 Emission Testing

Table 2.1 below lists the Methods used when undertaking emission monitoring at the Pinkenba Facility.

All air quality monitoring undertaken by the Company has been undertaken in accordance with the methods identified in Table 2.1 below unless as specified in Section 2.3.

Table 2.1: Summary Of Emission Monitoring Methods

Measurement Parameter	Method Equivalency
Sampling Positions	**AS4323.1-1995** Method 1: selection of sampling positions
Velocity, Flowrate and Temperature	**AS 4323.2-1995** Stationary Source Emissions - Method 2: Determination of Total Particulate Matter - Isokinetic Manual Sampling - Gravimetric Method
Oxygen and Carbon Dioxide	**USEPA Method 3a** Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources
Moisture Content	**USEPA Method 4** Determination of Moisture Content in Stack Gases
Particulates	**AS 4323.2-1995** Stationary Source Emissions - Method 2: Determination of Total Particulate Matter - Isokinetic Manual Sampling - Gravimetric Method
Oxides of Nitrogen (NO, NO_2, NO_x)	**USEPA Method 7E** Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Sulphur Dioxide (SO_2) and Sulphur Trioxide/Sulphuric Acid (SO_3, H_2SO_4)	**USEPA Method 8** Determination of Sulfuric Acid and Sulfur Dioxide Emissions from Stationary Sources
Carbon Monoxide	**USEPA Method 10B** Determination of Carbon Monoxide Emissions from Stationary Sources

2.2 Laboratory Analysis

Table 2.2 Provides a list of the NATA accredited laboratories that performed the applicable analysis, NATA accreditation number, and report number.

Table 2.2: Table of NATA Accredited Laboratories with NATA Accreditation Number

Measurement Parameter	NATA Accreditation Number	Report Number
Particulates (gravimetric)	National Measurement Institute - 198	RN1259377
Sulphur Dioxide (SO_2) and Sulphur Trioxide/Sulphuric Acid (SO_3, H_2SO_4)		

2.3 Deviation from Methods

The gas meter and critical orifice within the isokinetic sampling console was aligned as specified by US EPA Method 5 - Determination of Particulate Matter Emissions from Stationary Sources. AS4323.2 requires the critical orifice to be positioned before the gas meter within the sampling system.

3 Results

3.1 Introduction

The following sections present a summary of results for each sampling location.

3.5 H655

Table 3.4 provides a summary of process conditions during the air emissions monitoring for Release Point – H655 at Pinkenba Facility.

Table 3.1: Process Conditions During Monitoring of Emissions from H655

Parameter	Result	Units
Gas Flow Rate	125	m^3/hr
Oil circulation	ON	-
Burner setting	Auto	-

Results of emissions monitoring for H655 are provided in Table 3.2 and Table 3.3 below for emissions monitoring completed on 17 June 2020.

Table 3.2: Flow and Sample Characteristics for H655

Parameter	Monitoring Result	Units
Run Start Time	10:37	hh:mm
Run Stop Time	11:57	hh:mm
Meter Calibration Factor	1.046	-
Pitot Tube Coefficient	0.84	-
Nozzle Diameter	11.00	mm
Total Meter Volume	0.615	m^3
Average Meter Temperature	21	°C
Average Stack Temperature	211	°C
Barometric Pressure	767.31	mm Hg
Stack Static Pressure	-0.2	mm H_2O
Calculated Stack Moisture	8.3	%
Carbon Dioxide Percentage	8.58	%
Oxygen Percentage	4.93	%
Dry Gas Molecular Weight	29.57	g/g-mole
Wet Stack Gas Molecular Weight	28.61	g/g-mole
Average Stack Gas Velocity	2.6	m/s

Parameter	Monitoring Result	Units
Stack Diameter	1.200	m
Actual Stack Flow Rate	170	m^3/min
Dry Standard Stack Flow Rate	91	Nm^3/min
Percent of Isokinetic Rate	97.1	%

Table 3.3: Emissions Monitoring Results for H655

Compound	Emission Concentration (mg/Nm^3)	Emission Rate (g/min)	Emission Rate (g/s)	Emission Rate (kg/hour)
CO	25	2.3	0.038	0.14
Particulates (TSP)	2.5	0.23	0.0038	0.0014
NO_x (expressed as NO_2)	97	8.8	0.15	0.53
SO_3 (expressed as SO_2)	4.6	0.42	0.007	0.030
SO_2 (expressed as SO_2)	147	13.3	0.22	0.80
Total SO_x (expressed as SO_2)	152	13.8	0.23	0.83

3.2 Accuracy of Monitoring Results

Table 3.4 presents a summary of the estimated method uncertainties for each of the monitoring parameters.

Table 3.4: Estimated Method Uncertainties for H655

Measurement Parameter	Method	% Uncertainty	Uncertainty	Units
Oxygen	USEPA Method 3A	2	0.10	%
Carbon Dioxide		2	0.17	%
Oxides of Nitrogen (NO, NO_2, NO_x)	USEPA Method 7E	2	0.94	ppm
Sulphur Dioxide (SO_2)	USEPA Method 6C	2.53	0.62	ppm
Carbon Monoxide	USEPA Method 10B	3.2	0.65	ppm
Particulates	AS 4323.2	15	0.39	mg/Nm^3
Sulphates	US EPA Method 8	10	1.66	mg/Nm^3

Uncertainty values cited are calculated at the 95% confidence level, with a coverage factor of 2.

Appendix A – Glossary of Terms

APPENDIX A: GLOSSARY OF TERMS	
<	The analytes tested for was not detected, the value stated is the reportable limit of detection
µg	Micrograms (10^{-6}grams)
AS	Australian Standard
dscm	dry standard cubic meters (at 0°C and 1 atmosphere)
g	grams
kg	kilograms
m	metres
m^3	Cubic Metres, actual gas volume in cubic metres as measured.
mg	Milligrams
min	Minute
mg/m^3	Milligrams (10^{-3}) per cubic metre.
mmH_2O	Millimetres of water
Mole	SI Unit defined as an amount of a substance that contains as many elementary entities (e.g. atoms, molecules, ions, electrons) as there are atoms in 12 grams of pure Carbon-12 (^{12}C)
N/A	Not Applicable
ng	Nanograms (10^{-9} grams)
Nm^3	Normalised Cubic Metres - Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa).
ou	Odour Units
°C	Degrees Celsius
$µg/m^3$	Micrograms (10^{-6}) per cubic metre. Conversions from $µg/m^3$ to parts per volume concentrations (ie, ppb) are calculated at 25 °C.
ppb / ppm	Parts per billion / million.
PM	Particulate Matter.
PM_{10}, $PM_{2.5}$, PM_1	Fine particulate matter with an equivalent aerodynamic diameter of less than 10, 2.5 or 1 micrometres respectively. Fine particulates are predominantly sourced from combustion processes. Vehicle emissions are a key source in urban environments.
sec	Second
Sm^3	Standardised Cubic Metres - Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa) and corrected to a standardised value (e.g. 7% O_2).

APPENDIX A: GLOSSARY OF TERMS	
STP	Standard Temperature and Pressure (0°C and 101.3 kPa).
TVOC	Total Volatile Organic Compounds. These compounds can be both toxic and odorous.
USEPA	United States Environmental Protection Agency

Appendix D – newEQ report

project ID	**05291**
issue number	**1**
client	**Sami Bitumen**
issue date	**30th September 2010**
testing date	**8th September 2010**
contact	**Mr. Scott van Woerkom**

newEQ is part of the Pacific Environment Limited group of companies
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Source emissions monitoring conducted at Sami Bitumen's Port of Brisbane facility

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This report is an initial release

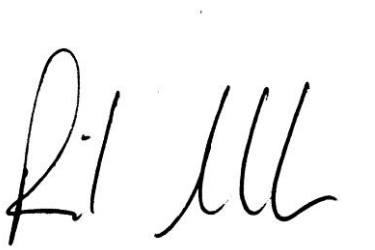
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NATA Signatory (QSTI)
Director

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EXECUTIVE SUMMARY

Table 1 provides summary results of emission monitoring conducted from the Port of Brisbane plant. The figures have been rounded up to three decimal places; for further details refer to supporting documentation.

Table 1 Summary of results

Emission Test	Result		Units of Measure
Date of test		Wednesday 8th September 2010	
Temperature		70.0	°C
Velocity		25.3	m/s
Volumetric flowrate		16.162	Nm^3/s
Moisture content		32.2	%
Carbon dioxide (average)	<	0.5	%
Oxygen (average)		10.6	%
Carbon Monoxide		981	mg/Nm^3 (dry)
Oxides of Nitrogen (as NO_2)		28.7	mg/Nm^3 (dry)
Total Organic Carbon (as propane)		58,700	mg/Nm^3 (dry)
Sulphur Gases (average)			
Hydrogen Sulphide		65.3	ppm
Carbonyl Sulphide		17.6	ppm
Sulphur Dioxide		0.480	ppm
Methyl mercaptan		5.03	ppm
ethyl mercaptan	<	0.0150	ppm
Dimethyl Sulphide		1.77	ppm
Dimethyl disulphide		0.0120	ppm
carbon disulphide		1.10	ppm
i-propyl mercaptan		0.354	ppm
n-propyl mercaptan		1.07	ppm
Hydrogen Chloride		419	mg/Nm^3 (dry)
Hydrogen Fluoride		11.6	mg/Nm^3 (dry)
Chlorine		4.66	mg/Nm^3 (dry)

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INTRODUCTION

New Environmental Quality (newEQ) was commissioned by Sami Bitumen to sample process gases from their Port of Brisbane facility, Queensland. Sampling and analysis was conducted by newEQ on Wednesday the 8th September 2010.
newEQ was responsible for the collection and analysis of all samples. The collected samples remained sealed and preserved in the appropriate manner. Upon return to the laboratory the samples were prepared and analysed by the correct methodologies.

TEST METHODS

All sampling and analysis was conducted by newEQ unless otherwise stated. The results presented in this report are related to one or more reference calibrations held by newEQ.

Table 2: Test Methods

Parameter	Test Method	NATA	Sample Note	Analysis Note
Sample plane criteria	AS 4323.1	Yes	A	1
Gas Velocity and Temperature	USEPA Method 2	Yes	B	1
Stack gas density (O2 & CO2)	USEPA Method 3A	Yes	C	1
Moisture content	USEPA Method 4	Yes	D	1
Nitrogen oxides	USEPA Method 7E	Yes	C	1
Carbon monoxide	USEPA Method 10	Yes	C	1
Speciated Volatile Organic Carbons	USEPA Method 18	Yes	nil	2
Total Volatile Organic Carbons	USEPA Method 25A	Yes	E	1
Hydrogen Chloride	USEPA Method 26	Yes	nil	2
Sulphur Compounds	USEPA Method 18	No	F	3

Table 3: Sampling Notes

ID	Note
A	Sample point was located after the condenser and cyclone system. Two 20mm holes were available through which to extract the samples. The points were located in a straight section of the 6 inch pipe work connecting the system. The points were approximately 5 diameters downstream from a bend in the pipe. The flue gas contained a relatively high moisture content and an oil residue, which could not be removed sufficiently with the condition unit available at the time. The oil residue interfered with this conditioning unit, making it unusable for this application. Gas bag samples were taken in its place.
B	Velocities and temperature measurements were conducted using a standard type pitot and K-type thermocouple connected to a digital manometer and thermocouple indicator. In total, 4 traverse points were measured along a single traverse axis.
C	Analyser calibration and drift determination was conducted before and after the onsite sampling event in newEQ laboratory. Due to the nature of the flue gas, the analyser was unable to be run continuously on the source, instead tedlar bag samples with dilution factors were collected and analysed periodically.
D	Moisture determinations were conducted using wet bulb / dry bulb temperature measurements and calculations based on ASME steam table data.
E	Tedlar bag samples were collected and analysed on site using a Flame Ionisation Detector. The calibration gas used was propane; therefore results are referenced to ppm as propane.
F	Tedlar bag samples with a dilution factor of 3 were collected and sent to Advanced Analytical for sulphur gas analysis. Prior to shipping a brief sample was extracted on a Drager Tube for indicative H2S concentration. Analysis at the lab revealed further VOCs during the screen which were also reported by this lab.

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Table 4: Analysis Notes

Note	Company	NATA Accreditation ID	Report Number
1	newEQ	15438	05291
2	SGS Australia	2562 (4354)	SE 81259
3	Advanced Analytical	na	A10/3181

QUALITY ASSURANCE & QUALITY CONTROL (QA/QC)

newEQ operates within a quality system that meets the requirements of ISO17025 (NATA). Our quality system defines specific procedures and methodologies to ensure any project undertaken by newEQ is conducted with the highest level of quality given the specific confines of each project. These procedures address such facets as:

- project management
- equipment calibration and maintenance
- adherence to specific sampling methodologies
- selection of sub-contracting laboratories
- storage and freight of collected samples
- final report preparation

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DEFINITIONS

The following terms and abbreviations may be used in this report:

Table 5: Definitions

Symbol	Definition
<	The analytes tested for was not detected; the value stated is the reportable limit of detection
Am^3	Gas volume in cubic metres at measured conditions
AS	Australian Standard
BH	Back half of sample train (filter holder and impingers) (referred to during sample recovery)
^oC	Degrees Celsius
dscm	dry standard cubic meters
FH	Front half of sample train (probe and filter holder) (referred to during sample recovery)
g	Grams
kg	Kilograms
m	Metres
m^3	actual gas volume in cubic metres as measured
mb	Millibars
mg	Milligrams (10^{-3} grams)
min	Minute
ml	Millilitres
mmH_2O	Millimetres of water
Mole	SI unit that measures the amount of substance
N/A	Not applicable
ng	Nanograms (10^{-9} grams)
Nm^3	Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa)
PM	Particulate matter
ppm-c	Parts per million referenced to carbon
ppm-p	Parts per million referenced to propane
sec	Second
Sm^3	Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa) and corrected to a standardised value (e.g. 7% O_2)
STP	Standard temperature and pressure (0°C and 101.3 kPa)
TVOC	Total volatile organic compounds
USEPA	United States Environmental Protection Authority

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CALCULATION OF RESULTS

Table 6: Source data

Source Data			
Client			Sami Bitumen
Site			Port of Brisbane
Sample Point			After Condenser & Cyclone
Historical Data & Hardware Information - Manual Sample			
Run Start Date		dd-mm-yy	Wednesday, 8 September 2010
Project ID			05291
Positioning compliance check with AS4323.1			Non-ideal
Stack Test Data			
Average Stack Temperature	$(t_s)_{avg}$	°C	69.75
Barometric Pressure	(P_b)	mb	1023
Stack Static Pressure	(P_{static})	mm H_2O	88.00
Absolute Stack Pressure	(P_s)	mb	1032
Moisture Content Data (using wet/dry calculations)			
Calculated Stack Moisture	$(B_{ws(calc)})$	%	32.20
Stack Gas Density Analysis Data			
Dry Gas Molecular Weight	(M_d)	kg/Nm3	1.27
Dry Gas Molecular Weight	(M_d)	g/g-mole	28.43
Wet Stack Gas Molecular Weight	(M_s)	g/g-mole	25.07
Volumetric Flow Rate Data (at Sample Plane)			
Average Stack Gas Velocity	(v_s)	m/sec	25.30
Stack Diameter	Ds	m	0.16
Stack Cross-Sectional Area	(A_s)	m^2	0.02
Upstream distance (from disturbance)	B	m	0.80
Downstream distance (from disturbance)	A	m	0.50
Actual Stack Flow Rate	(Q_{sa})	m^3/min	29.388
Wet Standard Stack Flow Rate	(Q_{sw})	Nm^3/min-wet	23.837
Dry Standard Stack Flow Rate	(Q_{sd})	Nm^3/min-dry	16.162

Table 7: Gas composition data

Onsite gas analysis						
Run ID				2-3		2-4
Time Start				9:48		9:54
Time Finish				9:54		9:58
Oxygen		%		10.60		10.50
Carbon Dioxide		%	<	0.50	<	0.50
Carbon Monoxide		ppm		777.00		792.00
	1.25	mg/Nm3		971.25		990.00
		g/min		15.70		16.00
Oxides of Nitrogen (as NO2)		ppm		13.00		15.00
	2.05	mg/Nm3		26.65		30.75
		g/min		0.43		0.50
Total Volatile Orgainc Carbon (as propane)		ppm		31,000.00		28,600.00
	1.969	mg/Nm3		61,039.00		56,313.40
		g/min		986.52		910.15
H2S (Drager Tube)		ppm	>	60.00	>	60.00
	1.52	mg/Nm3	>	91.20	>	91.20
		g/min	>	1.47	>	1.47

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Table 8: USEPA Method 18 tube results

USEPA Method 18 (carbon tube sampling)								
Run ID		**1-1**				**1-2**		
Time Start		8:28				8:45		
Time Finish		8:34				8:50		
Note		Tube samples						
		Concentration		Emission rate		Concentration		Emission rate
		mg/Nm^3		g/min		mg/Nm^3		g/min
Acetone	<	25.6	<	0.41	<	29.0	<	0.47
Propylene Oxide	<	25.6	<	0.41	<	29.0	<	0.47
Acrylonitrile	<	25.6	<	0.41	<	29.0	<	0.47
Methylethylketone (MEK)	<	25.6	<	0.41	<	29.0	<	0.47
Hexane		76.7		1.24		50.7		0.82
Ethylacetate	<	25.6	<	0.41	<	29.0	<	0.47
1,2-Dichloroethane	<	25.6	<	0.41	<	29.0	<	0.47
Benzene	<	25.6	<	0.41	<	29.0	<	0.47
Carbon tetrachloride	<	25.6	<	0.41	<	29.0	<	0.47
Cyclohexane	<	25.6	<	0.41	<	29.0	<	0.47
Ethyl acrylate	<	25.6	<	0.41	<	29.0	<	0.47
Trichloroethene	<	25.6	<	0.41	<	29.0	<	0.47
1,4-Dioxane	<	25.6	<	0.41	<	29.0	<	0.47
Epichlorohydrin	<	25.6	<	0.41	<	29.0	<	0.47
Methylisobutylketone (MIBK)	<	25.6	<	0.41	<	29.0	<	0.47
Toluene	<	25.6	<	0.41	<	29.0	<	0.47
Butylacetate	<	25.6	<	0.41	<	29.0	<	0.47
Tetrachloroethene	<	25.6	<	0.41	<	29.0	<	0.47
Chlorobenzene	<	25.6	<	0.41	<	29.0	<	0.47
Ethylbenzene	<	25.6	<	0.41	<	29.0	<	0.47
m&p-Xylene	<	51.1	<	0.83	<	57.9	<	0.94
Cylcohexanone	<	25.6	<	0.41	<	29.0	<	0.47
Styrene	<	25.6	<	0.41	<	29.0	<	0.47
o-Xylene	<	25.6	<	0.41	<	29.0	<	0.47
Nonane		61.4		0.99		43.4		0.70
Isopropylbenzene	<	25.6	<	0.41	<	29.0	<	0.47
Diisobutylketone (DIBK)	<	25.6	<	0.41	<	29.0	<	0.47
a-Methylstyrene	<	25.6	<	0.41	<	29.0	<	0.47
Benzyl chloride	<	25.6	<	0.41	<	29.0	<	0.47
Decane		43.5		0.70		29.7		0.48
Benzoylchloride	<	25.6	<	0.41	<	29.0	<	0.47
Naphthalene	<	25.6	<	0.41	<	29.0	<	0.47
Dodecane	<	25.6	<	0.41	<	29.0	<	0.47

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Table 9: USEPA Method 18 rinse results

USEPA Method 18 (carbon tube sampling for VOCs)			
Run ID	**1-3**		
Time Start	8:28		
Time Finish	8:50		
Note	Rinse sample		
	Concentration		Emission rate
	mg/Nm^3		g/min
Dichlorodifluoromethane (CFC-12)	< 0.68	<	0.011
Chloromethane	0.71		0.011
Vinyl Chloride (chloroethene)	< 0.04	<	0.001
Bromomethane	< 1.36	<	0.022
Chloroethane	1.11		0.018
Trichlorofluoromethane	< 0.14	<	0.002
Acetone (2-propanone)	162.98		2.634
1,1-Dichloroethene	< 0.07	<	0.001
Methyl Iodine (iodomethane)	< 0.68	<	0.011
Acrylonitrile	< 0.07	<	0.001
Methylene Chloride (DCM)	< 0.68	<	0.011
Allyl Chloride	< 0.07	<	0.001
Carbon Disulphide	< 0.07	<	0.001
trans-1,2-Dichloroethene	< 0.07	<	0.001
Methyl-tert-butyl ether (MtBE)	< 0.27	<	0.004
1,1-Dichloroethane	< 0.07	<	0.001
2-Butanone (MEK)	5.30		0.086
cis-1,2-Dichloroethene	< 0.07	<	0.001
Bromochloromethane	< 0.07	<	0.001
Chloroform	< 0.07	<	0.001
2,2-Dichloropropane	< 0.07	<	0.001
1,2-Dichloroethane	< 0.07	<	0.001
1,1,1-Trichloroethane	< 0.07	<	0.001
1,1-Dichloropropene	< 0.07	<	0.001
Carbon tetrachloride	< 0.07	<	0.001
Benzene	0.67		0.011
Dibromomethane	< 0.07	<	0.001
1,2-Dichloropropane	< 0.07	<	0.001
Trichloroethene (TCE)	< 0.07	<	0.001
2-Nitropropane	< 13.58	<	0.220
Bromodichloromethane	< 0.07	<	0.001
cis-1,3-Dichloropropene	< 0.07	<	0.001
4-Methyl-2-Pentanone (MIBK)	< 0.68	<	0.011
trans-1,3-Dichloropropene	< 0.07	<	0.001
1,1,2-Trichloroethane	< 0.07	<	0.001

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Table 10: USEPA Method 18 rinse results cont.

	Concentration mg/Nm^3		Emission rate g/min
Toluene	0.72		0.012
1,3-Dichloropropane	< 0.07	<	0.001
2-Hexanone (MBK)	< 0.68	<	0.011
Dibromochloromethane	< 0.07	<	0.001
1,2-Dibromoethane (EDB)	< 0.07	<	0.001
Tetrachloroethene (PCE- perchloroethylen	< 0.07	<	0.001
1,1,1,2-Tetrachloroethane	< 0.07	<	0.001
Chlorobenzene	< 0.07	<	0.001
Ethyl benzene	0.16		0.003
Bromoform	< 0.07	<	0.001
m/p-Xylenes	0.39		0.006
Cis-1,4-dichloro-2-butene	< 0.14	<	0.002
Styrene (vinyl benzene)	< 0.07	<	0.001
1,1,2,2-Tetrachloroethane	< 0.07	<	0.001
o-Xylene	0.43		0.007
1,2,3-Trichloropropane	< 0.07	<	0.001
Trans-1,4-dichloro-2-butene	< 0.14	<	0.002
Isopropylbenzene (Cumene)	< 0.07	<	0.001
Bromobenzene	< 0.07	<	0.001
n-Propylbenzene	< 0.07	<	0.001
2-Chlorotoluene	< 0.07	<	0.001
4-Chlorotoluene	< 0.07	<	0.001
1,3,5-Trimethylbenzene	< 0.07	<	0.001
tert-Butylbenzene	< 0.07	<	0.001
1,2,4-Trimethylbenzene	0.56		0.009
sec-Butylbenzene	< 0.07	<	0.001
1,3-Dichlorobenzene	< 0.07	<	0.001
1,4-Dichlorobenzene	< 0.04	<	0.001
p-Isopropyl toluene	< 0.07	<	0.001
1,2-Dichlorobenzene	< 0.07	<	0.001
n-Butylbenzene	0.27		0.004
1,2-Dibromo-3-chloropropane	< 0.07	<	0.001
1,2,4-Trichlorobenzene	< 0.07	<	0.001
Naphthalene	0.18		0.003
Hexachlorobutadiene	< 0.14	<	0.002
1,2,3-Trichlorobenzene	< 0.07	<	0.001
Vinyl acetate	< 1.36	<	0.022

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Table 11: Sulphur gas and VOC results

USEPA Method 18 (Bag sample for Sulphur Compounds & subsequent VOCs)				
Run ID		**2-1**		**2-2**
Time Start		9:41		9:45
Time Finish		9:43		9:47
		Concentration ppm		Concentration ppm
Sulphur Gases				
Hydrogen Sulphide		90.6		39.9
Carbonyl Sulphide		5.04		30.0
Sulphur Dioxide		0.510		0.450
Methyl mercaptan		6.48		3.57
ethyl mercaptan	<	0.0150	<	0.0150
Dimethyl Sulphide		2.388		1.152
Dimethyl disulphide		0.0120	<	0.003
carbondisulphide		1.536		0.663
i-propyl mercaptan		0.486		0.222
n-propyl mercaptan		1.479		0.651
Additional VOCs				
acetone		70.8		34.8
2-butanone		22.11		11.52
3-methyl-2-butanone		1.779		0.933
methylisobutylketone		3.72		2.04
ethyl acetate		17.37		8.97
methanol	<	0.003	<	0.003
ethanol		36.9		17.1
i-propanol		26.31		13.32
t-butanol	<	0.006	<	0.006
propanol		33		15.51
2-butanol	<	0.012	<	0.012
i-butanol	<	0.012	<	0.012
butanol	<	0.018	<	0.018
tetrachloroethylene		0.078		0.039
propene		18.66		12.03
propane		13.56		8.55
i-butane		5.19		2.79
butane		24		12.39
pentane		21.189		11.301
3-methylpentane		52.2		27.96
hexane		16.59		7.98

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Table 12: VOC results cont.

		Concentration ppm		Concentration ppm
methylcyclopentane	<	0.009	<	0.009
cyclohexane		1.74		0.72
3-methylhexane	<	0.009	<	0.009
heptane		17.34		9.21
octane		12.66		6.42
nonane		9.36		4.86
decane		6.18		2.76
undecane		4.08		1.29
dodecane		1.95		0.51
tridecane		0.63		0.06
Benzene		41.4		19.44
Toluene		13.14		6.48
Ethyl Benzene		1.32		0.6
m-,p-Xylenes		1.65		0.78
o-Xylene		0.81		0.39
styrene		0.21		0.09
1,3,5-trimethylbenzene		0.9		0.39
1,2,3-trimethylbenzene		1.59		0.66
4-ethyltoluene		0.414		0.198
naphthalene	<	0.003	<	0.003
freon12	<	0.015	<	0.015
freon114	<	0.033	<	0.033
freon11	<	0.027	<	0.027
freon113	<	0.018	<	0.018
methylchloride		16.89		11.31
vinylchloride	<	0.015	<	0.015
ethylchloride		19.44		9.99
dichloromethane		0.021		0.021
1,1-dichloroethane	<	0.009	<	0.009
chloroform		0.021	<	0.009
1,1,1-trichloroethane	<	0.015	<	0.015
carbontetrachloride	<	0.018	<	0.018
1,2-dichloroethane	<	0.021	<	0.021
trichloroethylene		0.042		0.021
tetrachloroethylene		0.078		0.039

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Table 13: VOC results cont.

		Concentration ppm		Concentration ppm
trans 1,2-dichloroethylen	<	0.021	<	0.021
cis 1,2-dichloroethylene	<	0.015	<	0.015
1,1-dichloroethylene	<	0.027	<	0.027
acetaldehyde		30.9		17.58
2-propenal		0.18		0.09
propanal		11.61		5.58
2-methylpropanal		2.46		1.23
2-methyl-propenal		0.54		0.42
butanal		30.75		15.36
2-butenal	<	0.006	<	0.006
pentanal		19.44		9.66
hexanal		28.62		14.1
heptanal		34.86		15.51
octanal		12.03		6.66
nonanal		5.73		1.05
decanal		6.54		0.51

Table 14: Document Control

Report ID	Issue	Date	Comment	Author	Quality
05291	1	30th September 2010	Initial release	TB	DA

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Appendix E – Chemical odour level calculations

Table C1 Chemical Odour Level - Calculation

Odorous Constituent	Concentration (ppm)	Threshold (ppm)	Concentration (OU)
Hydrogen Sulphide	65	0.0005[a]	130 000
Carbonyl Sulphide	17.6	NA	-
Methyl Mercapton	5.03	0.00042[b]	12 000
Ethyl Mercapton	<0.015	0.4[b]	-
Dimethyl sulphide	1.77	2.5[b]	12 500
Dimethyl disulphide	0.012	7.5[b]	-
Carbon disulphide	1.1	0.042[c]	8
i-propyl mercapton	0.354	0.45[b]	-
n-propyl mercapton	1.07	0.75[b]	-
Total	-	-	154 508

a Literature review Australian and overseas odour threshold data and ambient air quality criteria for hydrogen sulphide – a report for NSW EPA, Australian Water Technologies, January 2001.

b. State Environment Protection Policy Air Quality Management (SEPP – AQM) EPA Victoria, 2001.

c. Compilation of odour threshold values in air and water, L.J van Gemert, National Institute for Water Supply and A.H Nettenbreijer, Central Institute for Nutrition and Food Research TNO, June 1977.

Appendix F – Bulwer experimental run data

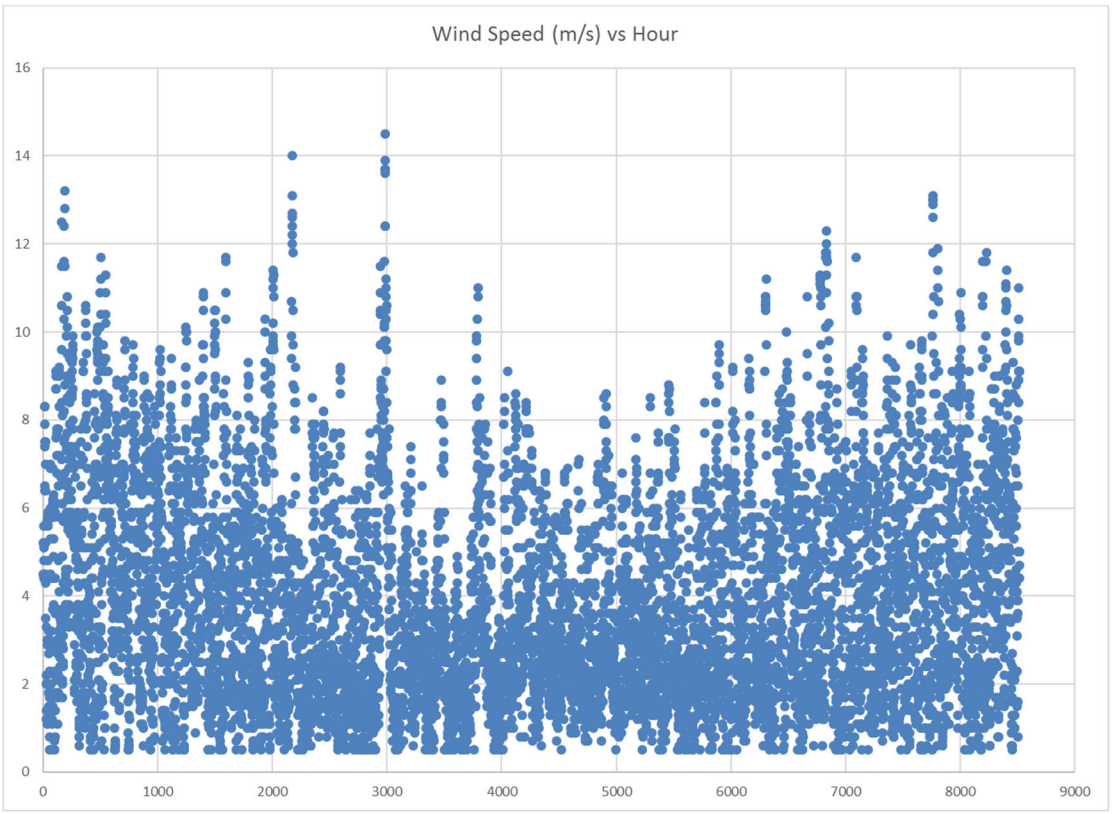
Sampling Time Lag: 7 mins
Sulphur Additions: 1
Sulphur Addition Size: 45 kg

Time	Adjusted Time	H_2S Conc. (%w/v)	H_2S Dev. (%w/v)	Comments	Time After Sulphur Addition (mins)	H_2S Flow rate (Nm^3/hr)	H_2S Production Rate (kg/hr)	Cumulative H_2S Production (kg)	Cumulative % of S added released as H_2S
14:27	14:20	0	0						
14:28	14:21	0	0						
14:29	14:22	0	0	Sulphur Added	-7	0	0.00	0.00	0.0%
14:30	14:23	0	0		-6	0	0.00	0.00	0.0%
14:31	14:24	0	0		-5	0	0.00	0.00	0.0%
14:32	14:25	0	0		-4	0	0.00	0.00	0.0%
14:33	14:26	0	0		-3	0.00	0.00	0.00	0.0%
14:34	14:27	0	0		-2	0.00	0.00	0.00	0.0%
14:35	14:28	0.00	0.06		-1	0.52	0.79	0.01	0.0%
14:36	14:29	0.13	0.05		0	0.75	1.15	0.03	0.1%
14:37	14:30	0.28	0.06		1	1.62	2.47	0.07	0.2%
14:38	14:31	0.44	0.07		2	2.55	3.88	0.14	0.3%
14:39	14:32	0.60	0.07		3	2.90	4.41	0.21	0.4%
14:40	14:33	0.70	0.07		4	4.06	6.17	0.31	0.7%
14:41	14:34	0.67	0.07		5	5.04	7.67	0.44	0.9%
14:42	14:35	0.81	0.08		6	4.69	7.14	0.58	1.2%
14:43	14:36	0.82	0.07		7	4.75	7.23	0.68	1.4%
14:44	14:37	0.87	0.08		8	5.04	7.67	0.81	1.7%
14:45	14:38	0.85	0.09		9	4.93	7.49	0.93	2.0%
14:46	14:39	0.88	0.07		10	5.10	7.76	1.06	2.2%
14:47	14:40	0.89	0.07		11	5.16	7.85	1.19	2.5%
14:48	14:41	0.85	0.09		12	4.93	7.49	1.32	2.8%
14:49	14:42	0.86	0.09		13	4.98	7.58	1.45	3.0%
14:50	14:43	0.83	0.07		14	4.81	7.32	1.57	3.3%
14:51	14:44	0.84	0.07		15	4.87	7.40	1.69	3.5%
14:52	14:45	0.87	0.08		16	5.04	7.67	1.82	3.8%
14:53	14:46	0.83	0.08		17	4.81	7.32	1.94	4.1%
14:54	14:47	0.83	0.06		18	4.81	7.32	2.06	4.3%
14:55	14:48	0.82	0.07		19	4.75	7.23	2.18	4.6%
14:56	14:49	0.73	0.07		20	4.23	6.43	2.29	4.8%
14:57	14:50	0.70	0.06		21	4.06	6.17	2.39	5.0%
14:58	14:51	0.69	0.06		22	4.00	6.08	2.49	5.2%
14:59	14:52	0.73	0.07		23	4.23	6.43	2.60	5.4%
15:00	14:53	0.74	0.06		24	4.29	6.52	2.71	5.7%
15:01	14:54	0.77	0.06		25	4.46	6.79	2.82	5.9%
15:02	14:55	0.75	0.06		26	4.35	6.61	2.93	6.1%
15:03	14:56	0.76	0.06		27	4.40	6.70	3.05	6.4%
15:04	14:57	0.87	0.07		28	5.04	7.67	3.17	6.6%
15:05	14:58	0.83	0.06		29	4.81	7.32	3.30	6.9%
15:06	14:59	0.79	0.07		30	4.29	6.43	3.40	7.1%
15:07	15:00	0.74	0.08		31	4.29	6.52	3.51	7.3%
15:08	15:01	0.69	0.07		32	4.00	6.08	3.61	7.6%
15:09	15:02	0.61	0.07		33	3.53	5.38	3.70	7.7%
15:10	15:03	0.63	0.07		34	3.65	5.55	3.79	7.9%
15:11	15:04	0.73	0.07		35	4.23	6.43	3.90	8.2%
15:12	15:05	0.77	0.06		36	4.46	6.79	4.02	8.4%
15:13	15:06	0.71	0.07		37	4.11	6.26	4.12	8.6%
15:14	15:07	0.63	0.07		38	3.65	5.55	4.21	8.8%
15:15	15:08	0.52	0.07		39	3.01	4.58	4.29	9.0%
15:16	15:09	0.56	0.06		40	3.24	4.94	4.37	9.1%
15:17	15:10	0.67	0.06		41	3.88	5.91	4.47	9.3%
15:18	15:11	0.72	0.07		42	4.17	6.35	4.57	9.6%
15:19	15:12	0.78	0.08		43	4.52	6.88	4.69	9.8%
15:20	15:13	0.71	0.09		44	4.11	6.26	4.79	10.0%
15:21	15:14	0.64	0.07		45	3.71	5.64	4.89	10.2%
15:22	15:15	0.63	0.07		46	3.65	5.55	4.98	10.4%
15:23	15:16	0.58	0.08		47	3.36	5.11	5.07	10.6%
15:24	15:17	0.57	0.07		48	3.30	5.02	5.15	10.8%
15:25	15:18	0.53	0.07		49	3.07	4.67	5.23	10.9%
15:26	15:19	0.46	0.08		50	2.67	4.05	5.29	11.1%
15:27	15:20	0.51	0.06		51	2.96	4.50	5.37	11.2%
15:28	15:21	0.58	0.05		52	3.36	5.11	5.45	11.4%
15:29	15:22	0.64	0.06		53	3.71	5.64	5.55	11.6%
15:30	15:23	0.61	0.05		54	3.53	5.38	5.64	11.8%
15:31	15:24	0.61	0.07		55	3.53	5.38	5.73	12.0%
15:32	15:25	0.60	0.07		56	3.48	5.29	5.82	12.2%
15:33	15:26	0.61	0.05		57	2.96	4.50	5.89	12.3%
15:34	15:27	0.45	0.07		58	2.61	3.97	5.96	12.5%
15:35	15:28	0.50	0.05		59	2.90	4.41	6.03	12.6%
15:36	15:29	0.34	0.04		60	1.97	3.00	6.08	12.7%
15:37	15:30	0.21	0.05		61	1.22	1.85	6.11	12.8%
15:38	15:31	0.20	0.04		62	1.16	1.76	6.14	12.8%
15:39	15:32	0.17	0.03		63	0.99	1.50	6.17	12.9%
15:40	15:33	0.10	0.04		64	0.58	0.88	6.18	12.9%
15:41	15:34	0.03	0.04		65	0.17	0.26	6.18	12.9%
15:42	15:35	0.00	0.03		66	0.00	0.00	6.18	12.9%
	Maximum	0.89 %w/v	Max.+Dev.	0.95 %w/v	Maximum	5.16 Nm3/hr	7.85 kg/hr	Max. + Dev.	5.66 Nm3/hr

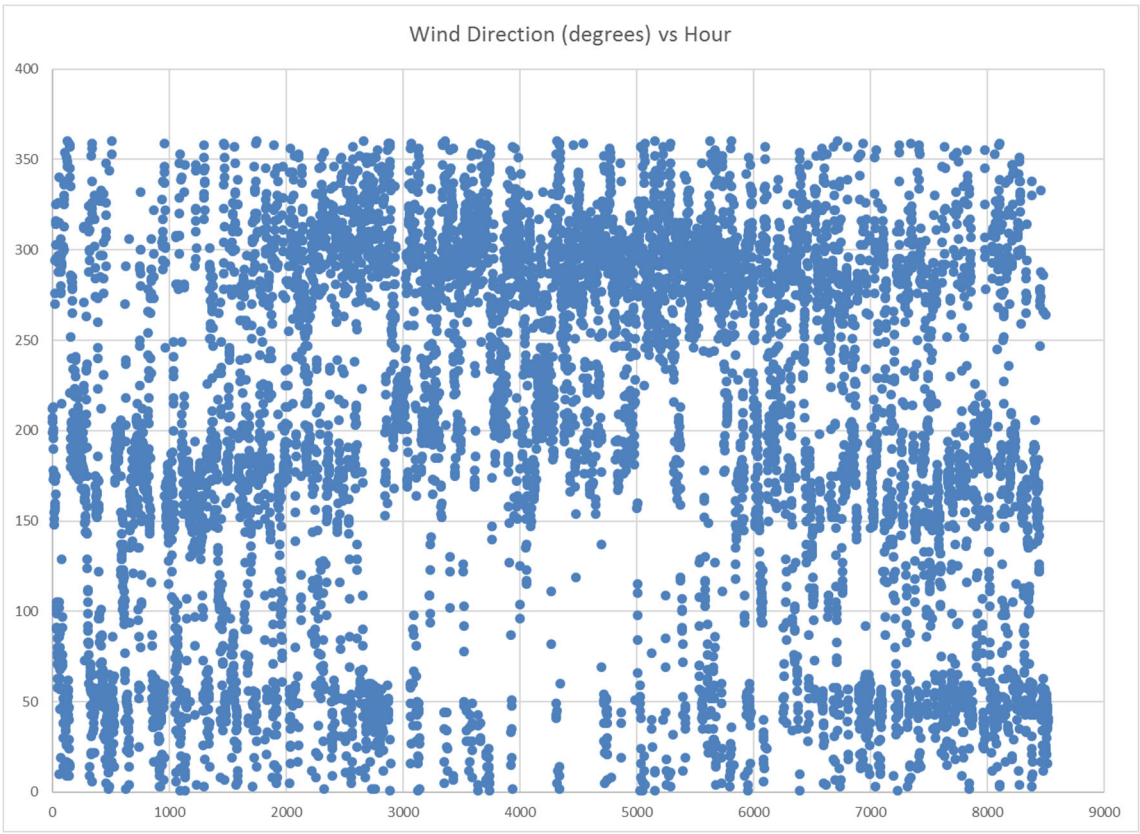
for 512 Nm^3/hr FOS to 25% of LEL	0.843% v/v H_2S 27.6%	for 512 Nm^3/hr FOS to 25% of LEL	0.909% v/v H_2S 18.3%
for 25% of LEL FOS to 511 Nm^3/hr	480 Nm^3/hr 6.5%		517 Nm^3/hr -1.2%

Appendix G – Meteorological analysis

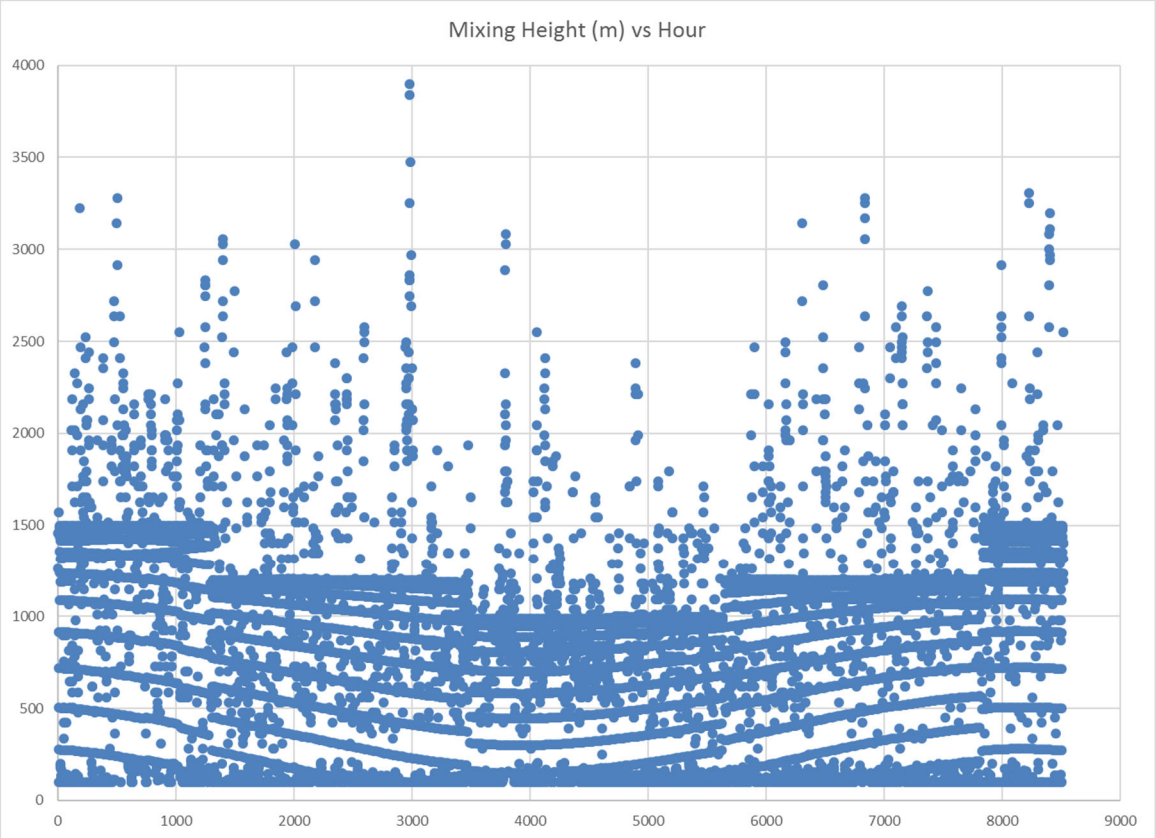
Wind Speed



Wind Direction



Mixing Height



GHD

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12533800-44854-3/https://projectsportal.ghd.com/sites/pp15_01/botanypmbprojectupda/ProjectDocs/12533800-REP_Puma Energy Air Quality Assessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	N Spurrett	E Smith		E Smith		14/10/2020

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Appendix C

AERMOD ready Meteorological data files for Port Botany – NSW

Printed on Recycled Paper.

AERMOD ready Meteorological data files for

Port Botany- NSW

This file was exclusively compiled for **PJRA** By pDs Consultancy.

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pDs

INTRODUCTION

New generation regulatory model AERMOD requires hourly averaged meteorological data from a single site that is preferably within the model domain ('on-site' or site-specific data). However, data from the nearest 'off-site' meteorological station can be used when on-site data are not available, and the off-site data are representative of the area of concern (i.e. the meteorological parameters as well as surface characteristics characterise the transport and dispersion conditions of the location in question).

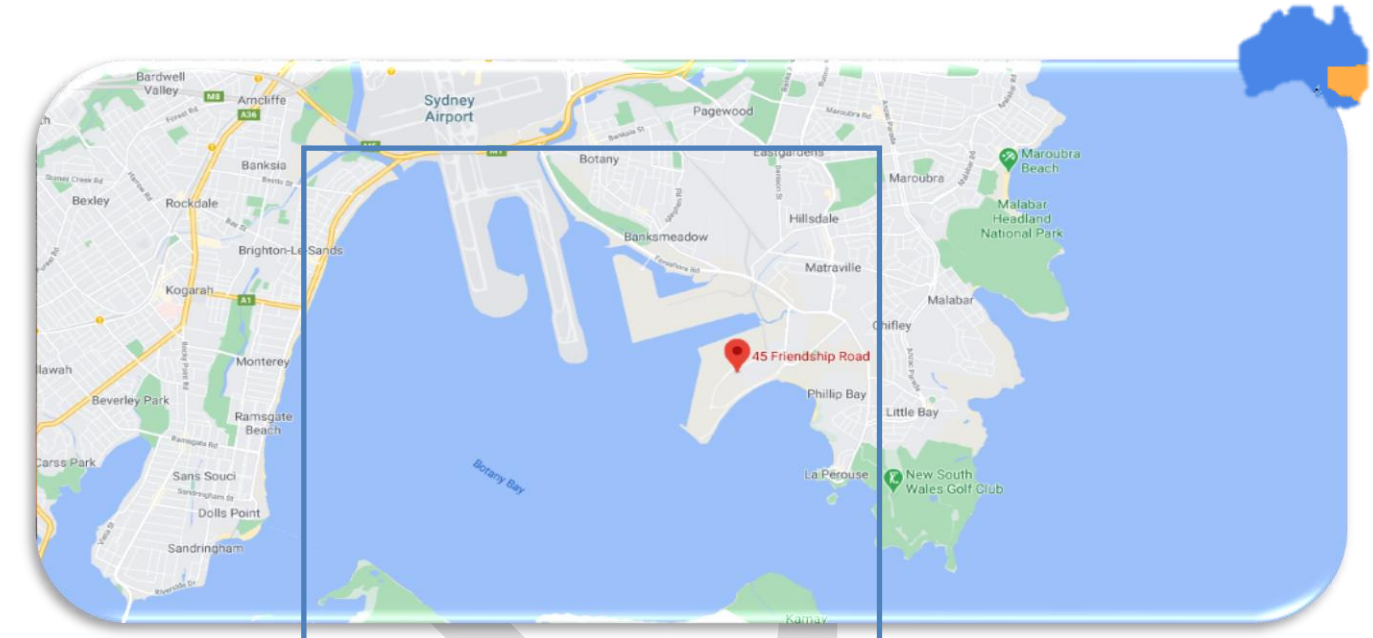
It is also preferable that:

- The compilation of the input meteorological data file is done in accordance with 'best practice', with procedures and algorithms recommended or set by environment regulators/US & VIC EPA.

pDs Consultancy has been engaged by **PJRA** to compile an 'AERMOD-ready' meteorological files for an application site in **Port Botany** in NSW. Sydney Airport (maintained by BoM Australia) data found to be representing this application site.

This input meteorological data files have been compiled basically following the EPA, Victoria's draft guidelines: "Construction of input meteorological data files for EPA Victoria's regulatory air pollution model (AERMOD) (Publication No.1550)".

LOCATIONS OF THE APPLICATION SITE AND THE DATA SITE: 45, FRIENDSHIP ROAD, PORT BOTANY



Application site is within 10 KM radius of the data site



Data Processing

Input Information

Data Used for the compilation

Meteorological Data

1. Mandatory Data (Site-Representative, Sydney Airport)

    i. 10m Wind Direction and Speed
    ii. Ambient Temperature (Screen Level)

2. Supplementary data (Sydney Airport)

    i. Surface Pressure
    ii. 3 Hourly Cloud observations
    iii. Relative Humidity
    iv. Rainfall Rate

3. Upper air Data (BoM's Sydney Airport)

    i. Pressure Levels
    ii. Geopotential Heights
    iii. Temperature
    iv. Dew Point

Data Source

- National Climate Centre, Bureau of Meteorology, Melbourne for all 3 types of data
- Data Source: **Sydney Airport**, NSW
- Period :1 Jan 2015 to 31 Dec 2019 (5 years)-2017 selected

QA/QC ON RAW DATA

I. Hourly averaged winds both direction and speed and temperature examined for gaps and wind stalls
   - Suspected wind stalls (both wind direction and speed) removed and filled appropriately preserving the temporal consistency.
   - Note that BoM Syncrotec Anemometer's lowest detection limit of wind speed is 2 KM/Hour (Wind Speed Threshold)

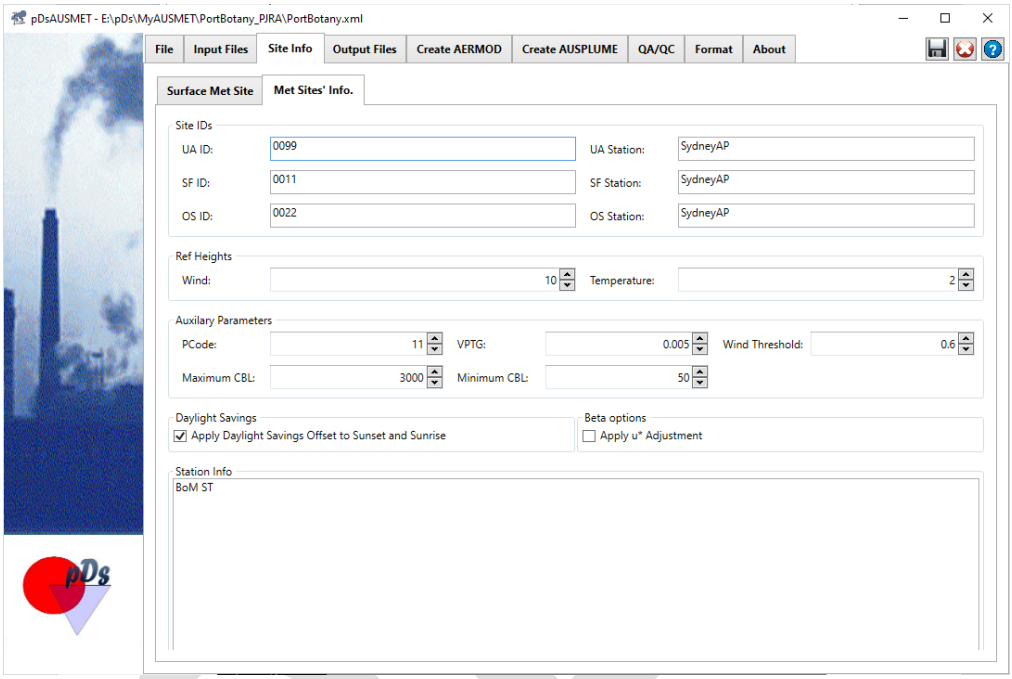
II. Small gaps filled with pervious or following hour records

III. Days with big gaps removed maintaining 90% data recovery

IV. Parameters QA/QCed based on extreme values

V. Gaps in vertical temperature profiles were filled with previous or following day data for the completeness.

METSITE INFORMATION



DATA COVERAGE:

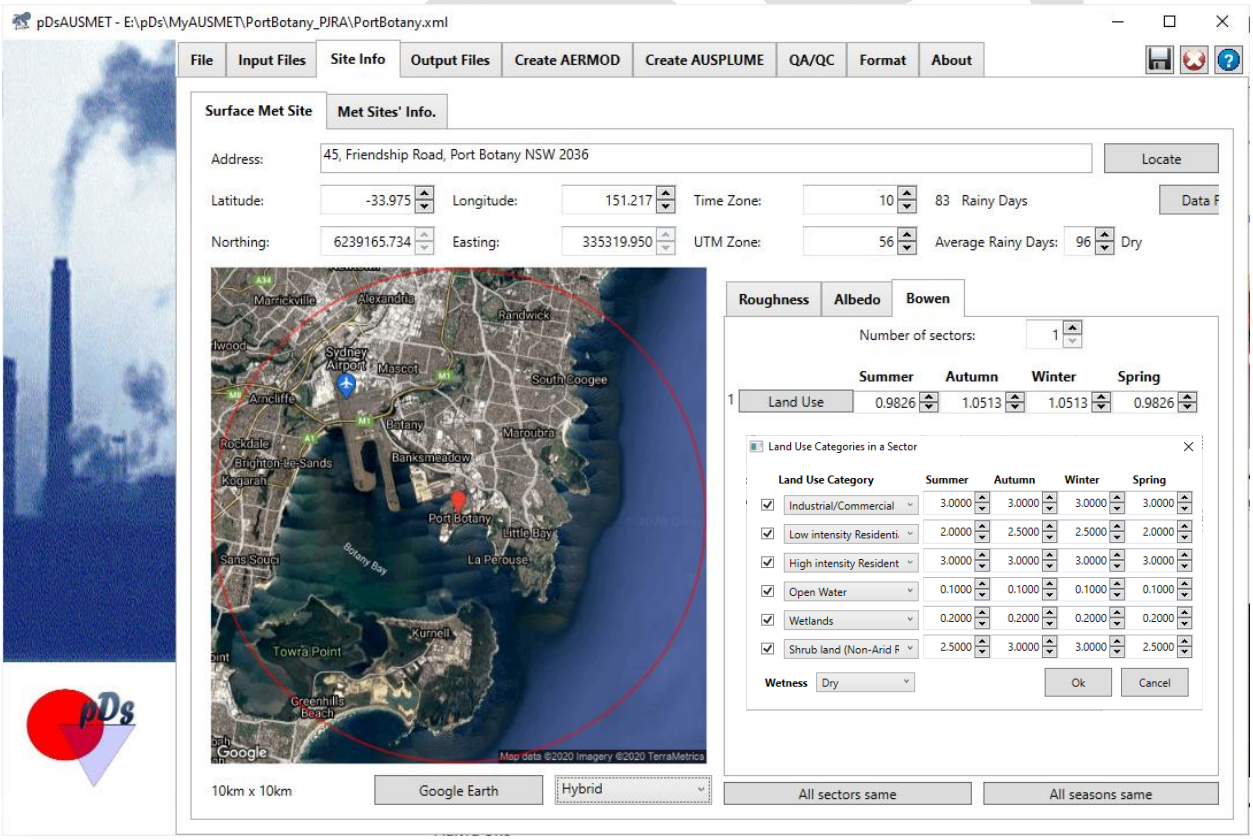
Year	2015	2016	2017	2018	2019
Season					
Summer			100		
Autumn			100		
Winter			100		
Spring			100		
Annual			100		

Annual coverage is 99%. It is meeting regulatory requirement (90% or better). Seasonal coverage is also meeting the requirement.

DETERMINATION OF SURFACE CHARACTERISTICS

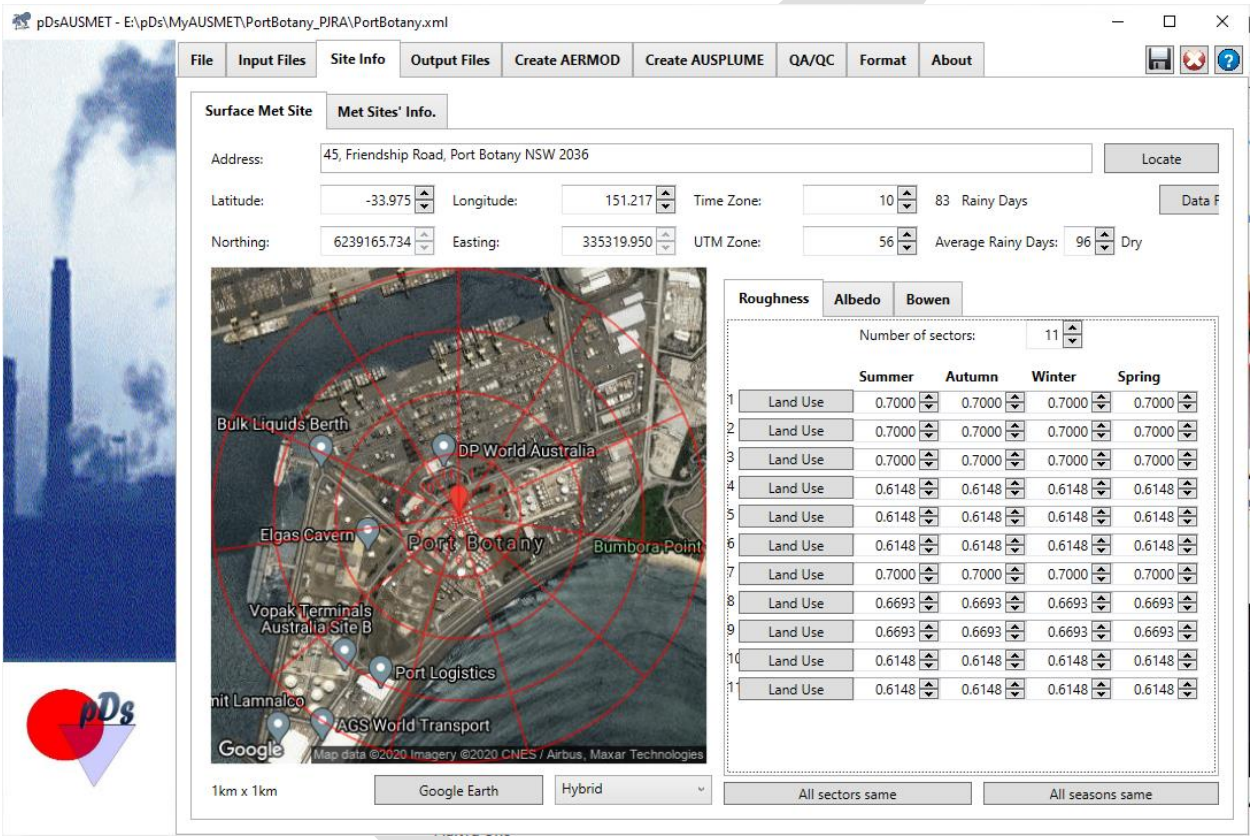
All available surface maps including google maps examined to determine correct land use categories within 10 Km by 10 KM area centring the application site.

Albedo and **Bowen ratio** were determined using land use categories shown below. The year 2017 found to be dry.



SURFACE ROUGHNESS

Sector dependent surface roughness was determined considering 11 sectors. The roughness for each sector was determined professionally examining 4 arc segments (250m).



The following parameters were determined/computed following EPA, VIC and US EPA guidelines.

Sensible Heat flux –Calculated based on cloud observations

I. Friction Velocity (U*)
II. Monin-Obukhov Length (L)
III. Height of the Stable Boundary Layer(SBL)
IV. Vertical Velocity Scale (W*)
V. Height of the Convective Boundary Layer (CBL)

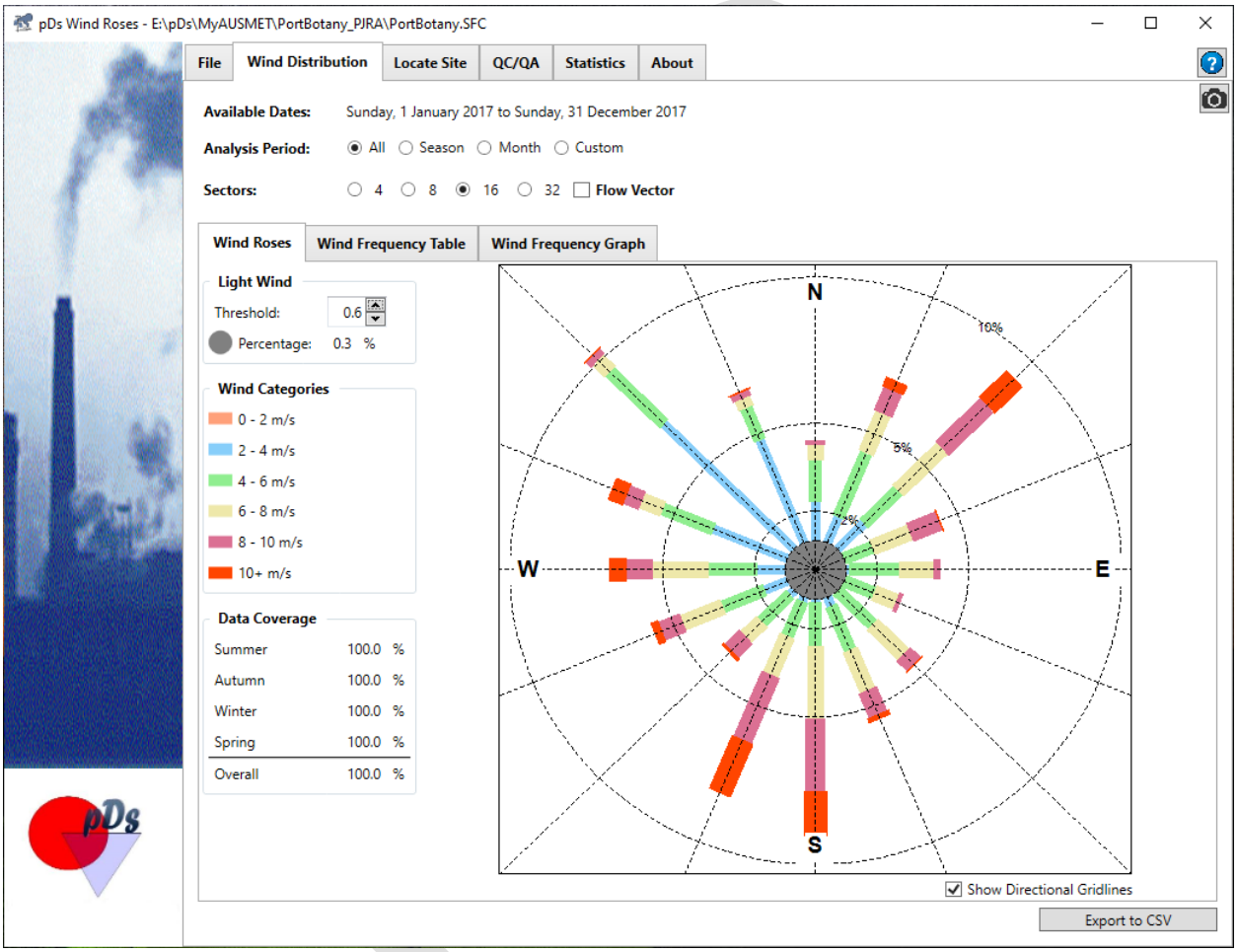
Mixing height (Convective)-CBL

DEFINITION:

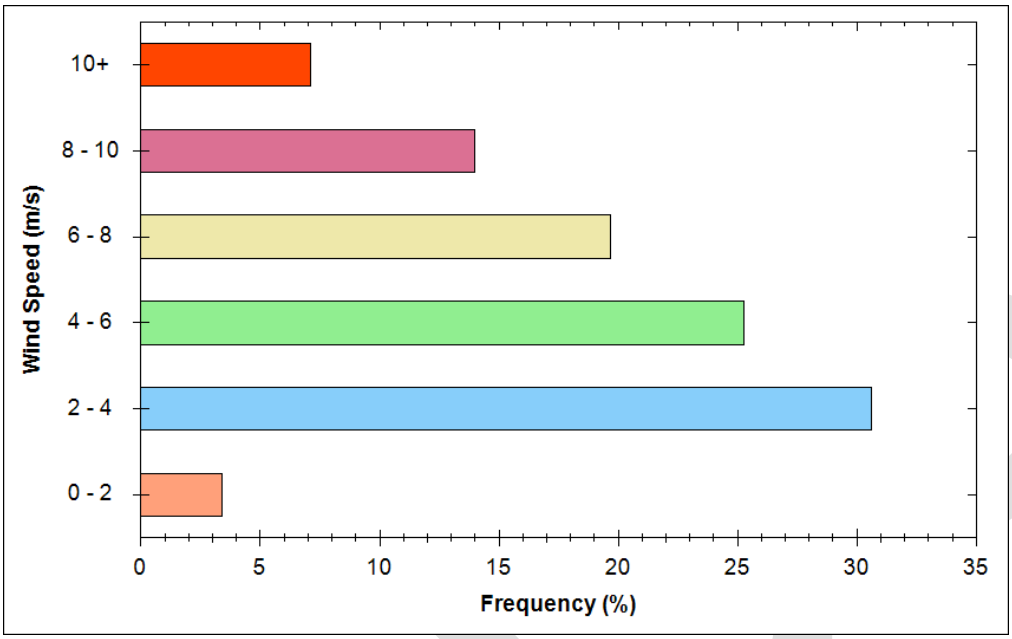
The convective mixing height, the depth of the surface mixed layer is the height of the atmosphere above the ground, which is well mixed due either to mechanical turbulence or convective turbulence. This height was determined by using the methodology of Benkley and Schulman (Journal of Applied Meteorology, Volume 18, 1979,pp 772-780). **Sydney Airport** upper air observation containing temperature and moisture profiles and surface temperature, pressure and relative humidity at **Sydney Airport** were used to determine daytime mixing height.

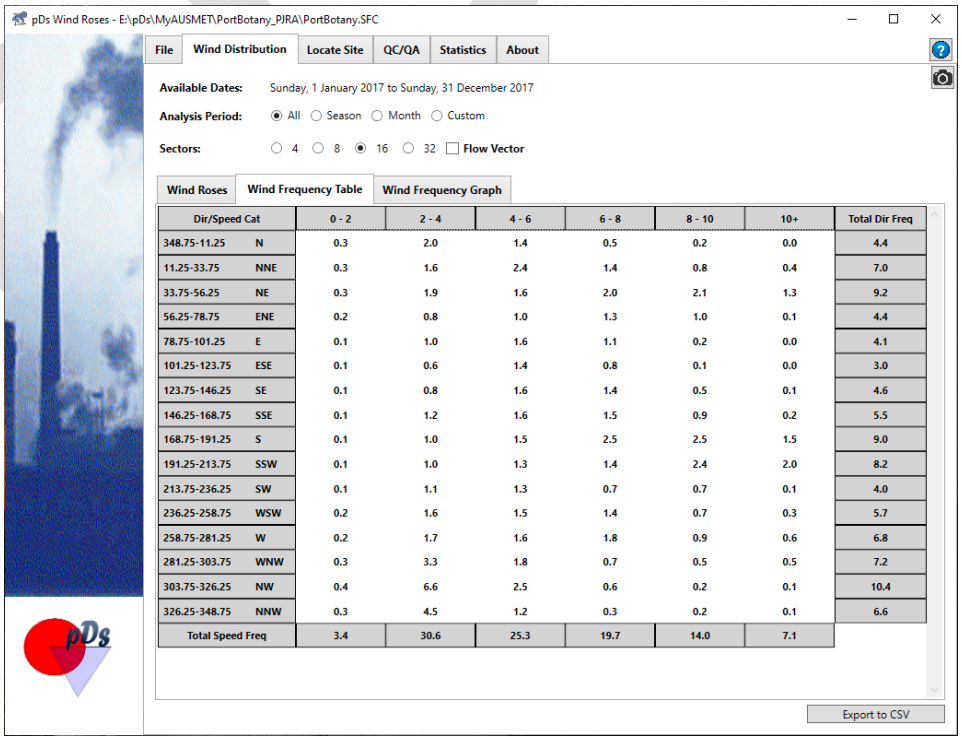
DATA ANALYSIS

ANNUAL WINDROSES FOR SYDNEY AIRPORT



FREQUENCY OF WIND SPEED

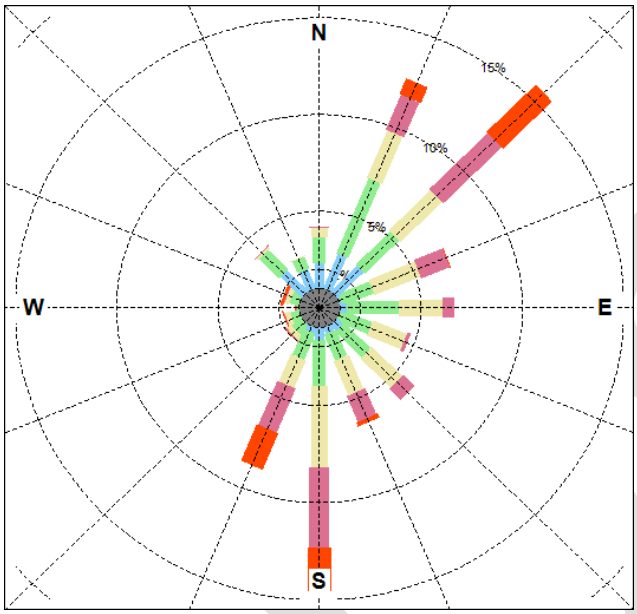


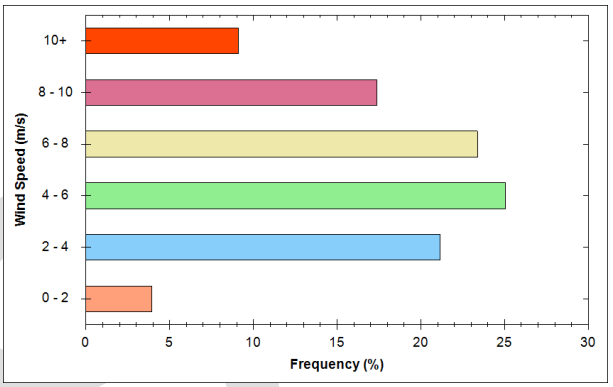


Dir/Speed Cat		0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10+	Total Dir Freq
348.75-11.25	N	0.3	2.0	1.4	0.5	0.2	0.0	4.4
11.25-33.75	NNE	0.3	1.6	2.4	1.4	0.8	0.4	7.0
33.75-56.25	NE	0.3	1.9	1.6	2.0	2.1	1.3	9.2
56.25-78.75	ENE	0.2	0.8	1.0	1.3	1.0	0.1	4.4
78.75-101.25	E	0.1	1.0	1.6	1.1	0.2	0.0	4.1
101.25-123.75	ESE	0.1	0.6	1.4	0.8	0.1	0.0	3.0
123.75-146.25	SE	0.1	0.8	1.6	1.4	0.5	0.1	4.6
146.25-168.75	SSE	0.1	1.2	1.6	1.5	0.9	0.2	5.5
168.75-191.25	S	0.1	1.0	1.5	2.5	2.5	1.5	9.0
191.25-213.75	SSW	0.1	1.0	1.3	1.4	2.4	2.0	8.2
213.75-236.25	SW	0.1	1.1	1.3	0.7	0.7	0.1	4.0
236.25-258.75	WSW	0.2	1.6	1.5	1.4	0.7	0.3	5.7
258.75-281.25	W	0.2	1.7	1.6	1.8	0.9	0.6	6.8
281.25-303.75	WNW	0.3	3.3	1.8	0.7	0.5	0.5	7.2
303.75-326.25	NW	0.4	6.6	2.5	0.6	0.2	0.1	10.4
326.25-348.75	NNW	0.3	4.5	1.2	0.3	0.2	0.1	6.6
Total Speed Freq		3.4	30.6	25.3	19.7	14.0	7.1	

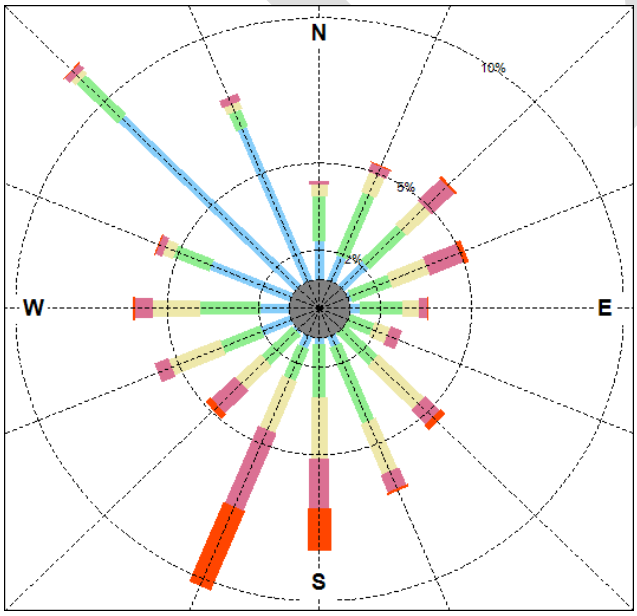
SEASONAL WINDROSES

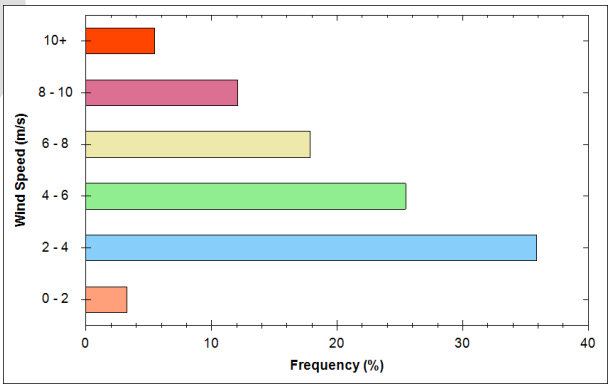
Summer



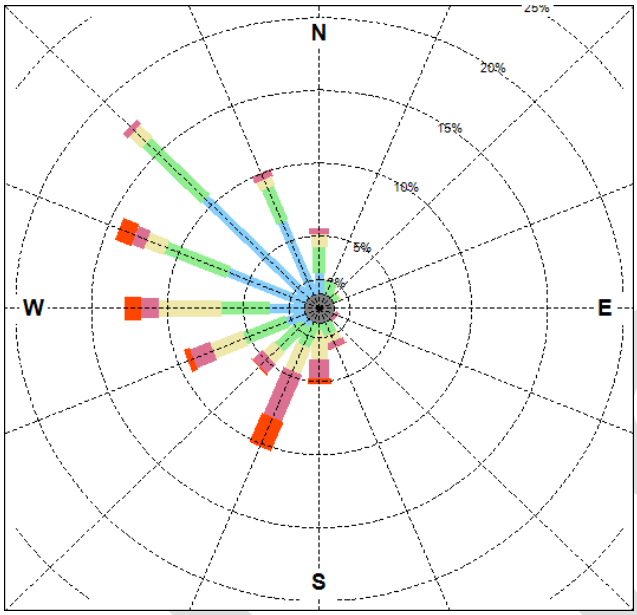


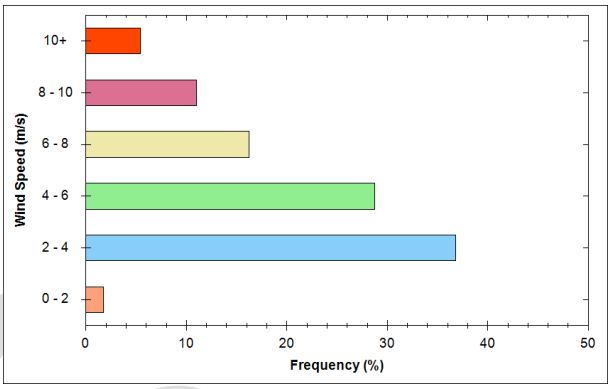
Autumn



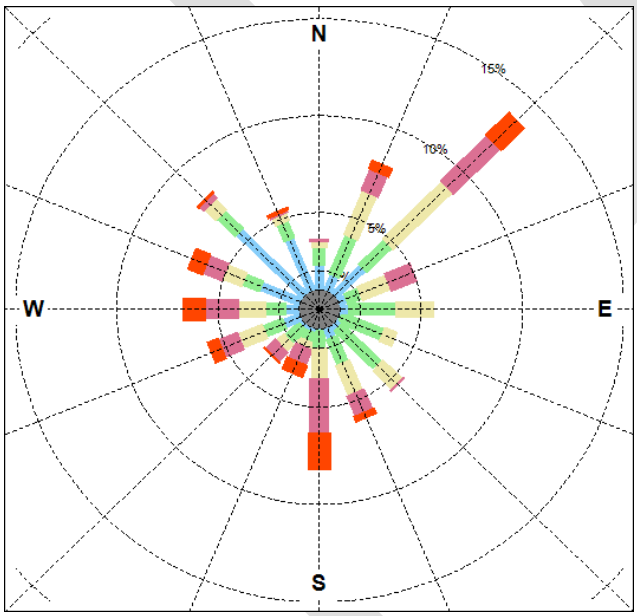


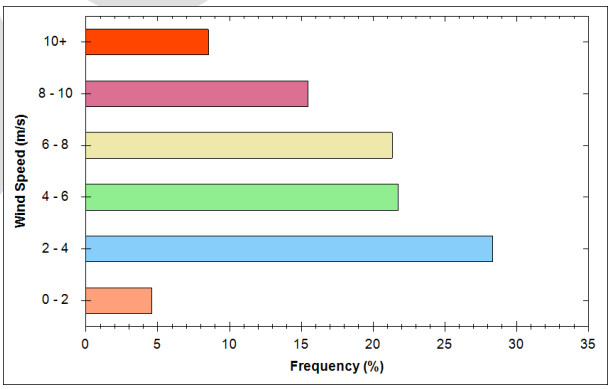
Winter





Spring

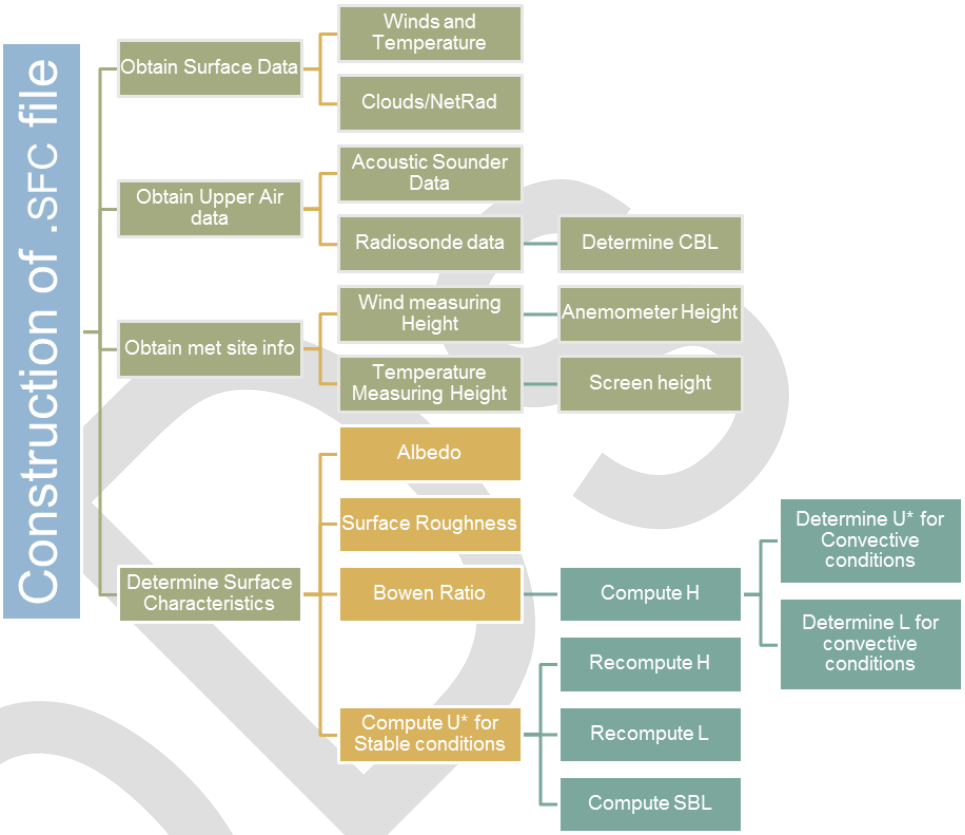


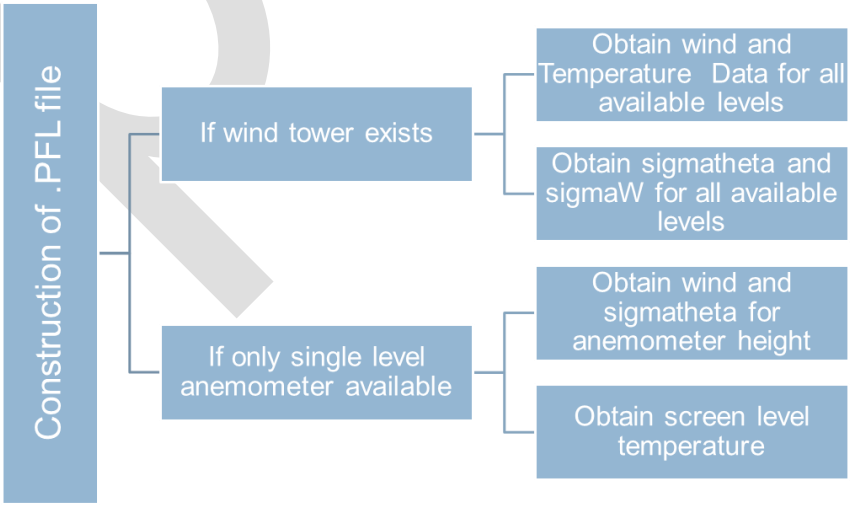


Seasonal variations are clearly depicted.

Appendix

FLOW CHARTS - CONSTRUCTION PROCEDURE





Bibliography

Australian Standard 2923-1987: Standards Association of Australia

Benkley, C.W,& Schulman L.L 1979 :Estimating Hourly Mixing Depths from Historical Meteorological Data :Jl of Applied Meteorology Vol 1 page 772-780

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USEPA 2012, User Guide for the AERMOD Meteorological Processor-AERMET; Addendum, United States Environmental Protection Agency, Washington DC, USA.

USEPA, 2000, Meteorological Monitoring Guidance for Regulatory Modelling Applications, EPA-450/R-99-005.United States Environmental Protection Agency, Washington DC, USA.

USEPA, Office of Air Quality Planning and Standards, AERSURFACE User's Guide, Research Triangle Park, North Carolina, EPA 454/B-08-001

USEPA, Office of Air Quality Planning and Standards, User's Guide for the AERMOD Meteorological Processor (AERMET) and Addendum, Research Triangle Park, North Carolina, EPA 454/B-03-002.

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Appendix D

Historic Wind Roses at Sydney Airport

Printed on Recycled Paper.

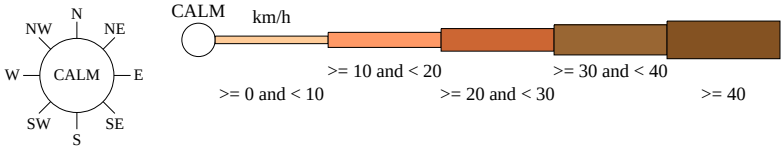
Rose of Wind direction versus Wind speed in km/h (01 Apr 1939 to 11 Aug 2020)

Custom times selected, refer to attached note for details

SYDNEY AIRPORT AMO

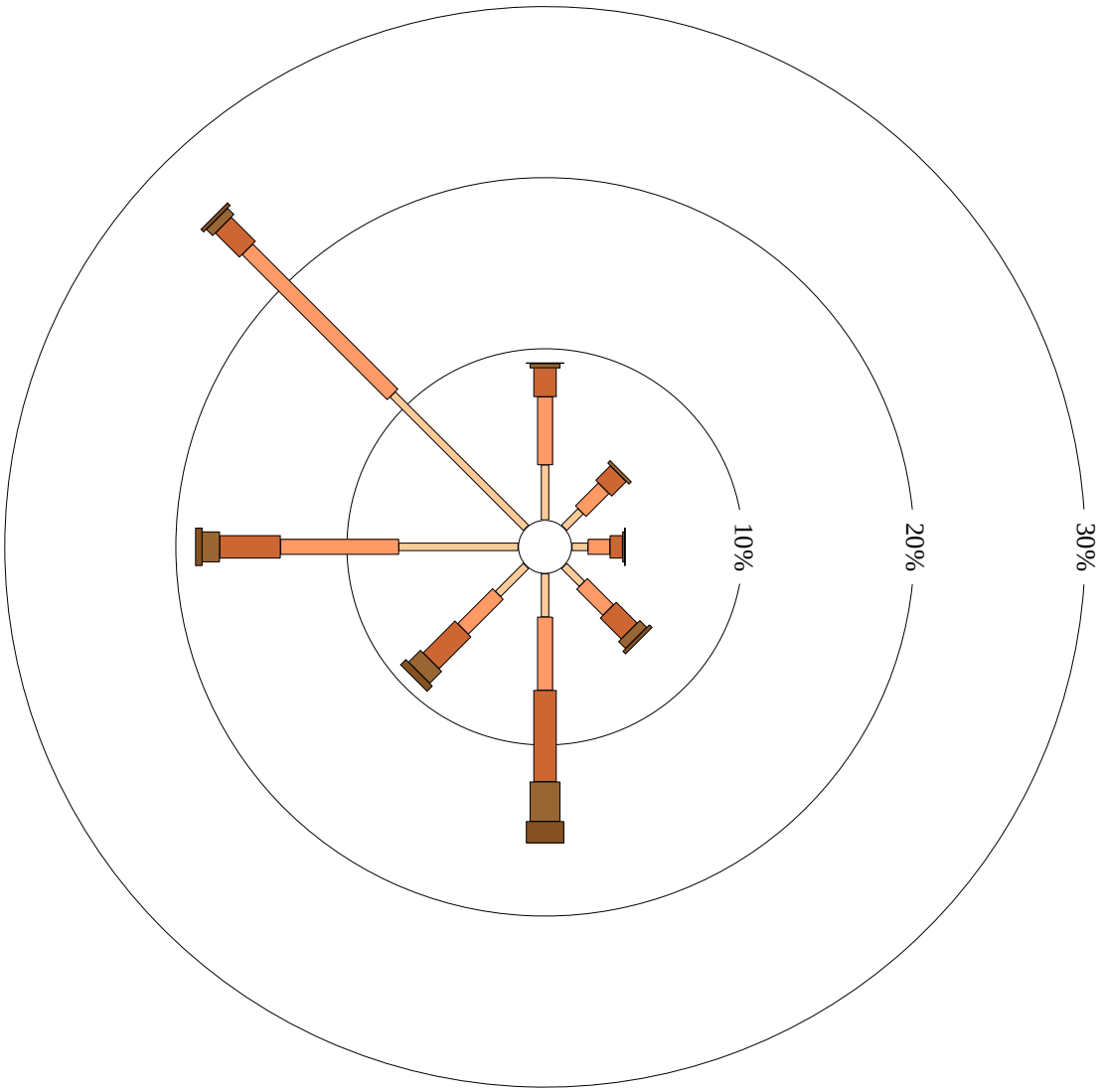
Site No: 066037 • Opened Jan 1929 • Still Open • Latitude: -33.9465° • Longitude: 151.1731° • Elevation 6m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am
29247 Total Observations

Calm 8%



Australian Government
Bureau of Meteorology

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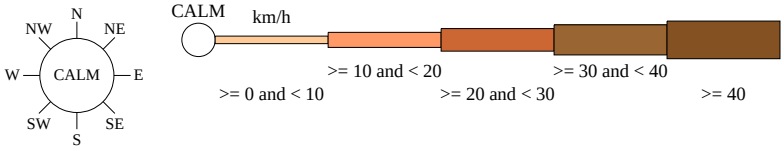
Rose of Wind direction versus Wind speed in km/h (01 Apr 1939 to 11 Aug 2020)

Custom times selected, refer to attached note for details

SYDNEY AIRPORT AMO

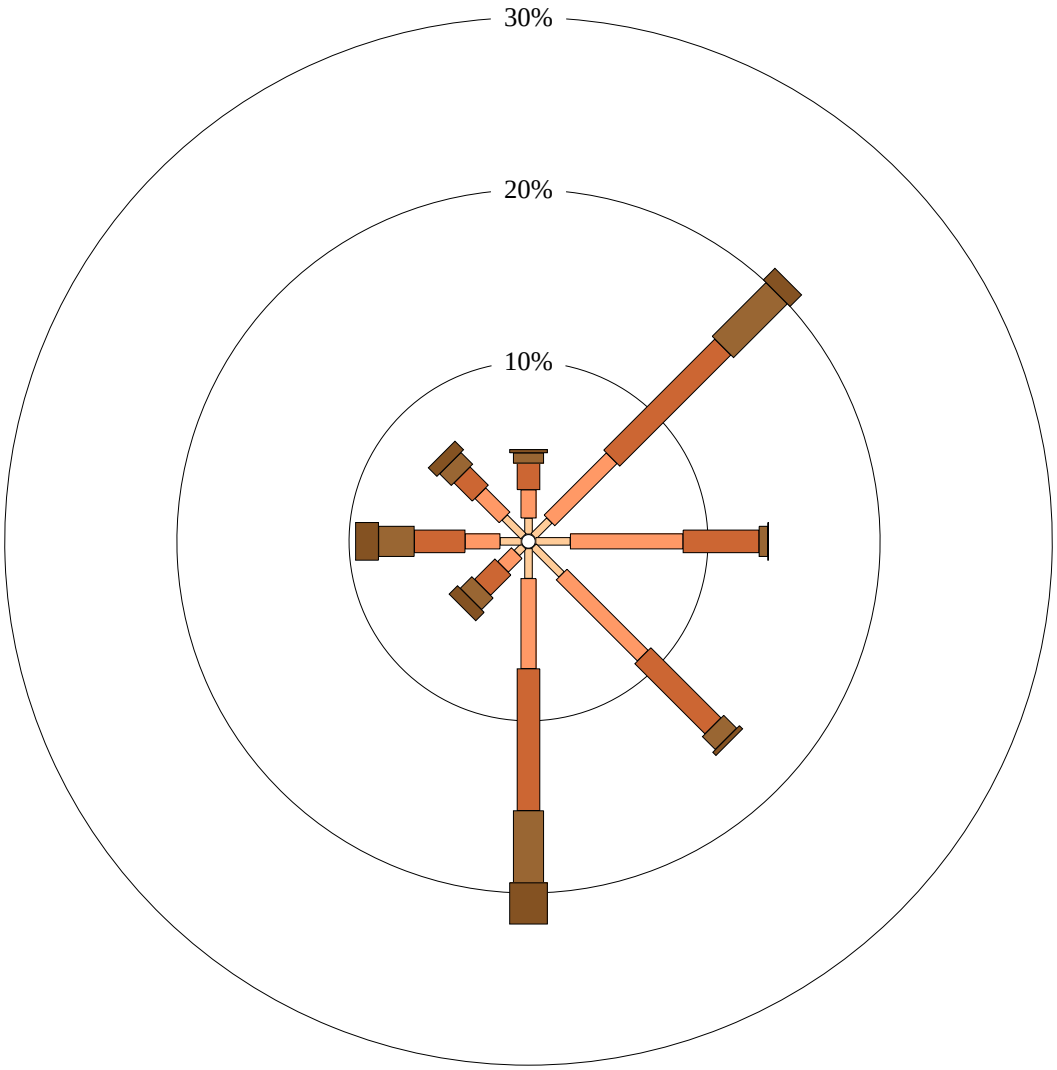
Site No: 066037 • Opened Jan 1929 • Still Open • Latitude: -33.9465° • Longitude: 151.1731° • Elevation 6m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
29323 Total Observations

Calm 2%



Australian Government
Bureau of Meteorology

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Appendix E

CEC Engineers Calculation Sheet

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CEC ENGINEERS
CALCULATION SHEET

Client : Quantem (Terminals Pty Ltd)
Project No. : 200003
Project : 2nd Thermal Oxidiser and Liquid Waste Burning

Calculation No: 200003CAL-002 **Rev 1**

Calculation Title: Thermal Oxidiser VOC Stack Emission Estimate Calculations

Calculation Summary

Calculation Objective:

Estimate the total thermal oxidiser VOC/HAP stack emissions from TO-1 and TO-2 for the worst case scenario
Estimate emissions from combustion system to confirm compliance with EPA requirements and input into stack dispersion modelling (by others)

Basis/Method:

1. Worst case emissions to the thermal oxidisers are estimated through first principal calculation methods and modelling of the bulk tank, ship and truck vapour emissions during specific activities.
2. Worst case emissions from the thermal oxidisers are estimated through first principal methods using calculations methods for the stoichiometric combustion of the VOC's and flammable liquids and mass and energy balances.
3. Both thermal oxidisers operating at the same time TO-1 (existing) and TO-2 (proposed new).
4. The maximum worst case calculation is based on the following scenario (with all loads occurring simultaneously):-
   (i) Worst case VOC-inert stream (tanks diurnal breathing and export from tank T204 to ship at 200m3/hr and collection of benzene vapours)
   (ii) Worst case dilute VOC-Air stream (future) based on collection vapours from 2 off flammable liquid truck fills.
   (iii) Liquid waste burning based on BTX (benzene). Concentration and flowrate estimated to achieve the thermal capacity of the 2nd thermal oxidiser TO-2- (6.5 l/min @ 80% (v/v) benzene)
5. BTX (benzene) was deemed to be the worst case chemical for the modelling emissions. The key reasons are:
   a. It is a hazardous chemical requiring emissions to be reduced by the maximum extent possible.
   b. It has a relatively high vapour pressure and molecular weight and as such the mass loading is generally higher than many other chemicals for the same volumetric vapour rate.
   c. BTX vapour and liquid contain sulphur compounds (primarily hydrogen sulphide {H_2S}) which also make it very odorous. Using BTX maximises the emissions of H_2S to the thermal oxidisers.
6. Contents of tanks are based on data supplied by Terminals.
7. Tanks capacity, diameter and height data supplied by Terminals.
8. Connection of tanks to the existing VOC-nitrogen inert vapour collection system are based on data supplied by Terminals (refer to attachments).
9. Thermal load from VOC/Air Dilute stream is based on CEC Engineers calculation 200003CAL-003.
10. A single thermal oxidiser has currently been installed with a thermal capacity of 15,000 MJ/hr.
11. Proposed 2nd thermal oxidiser will have a thermal capacity of 22,500 MJ/hr.
12. Previously CEC Engineers (refer to calculations 180003CAL-001 and 002 rev 2) estimated that the overall thermal capacity required for the thermal oxidiser was 37,500 MJ/hr. This would be met by installing 2 off thermal oxidisers operating in parallel.

Assumptions:

The assumptions are listed below and in the calculation sheets
Expansion factor for diurnal breathing is based on thermal expansion of vapours plus expansion due to vapour pressure.
Daily emissions are assumed to occur over a 3 hr period.
Tanks assumed to be 25% full.
Temperature of tank contents ranges between 15˚C and 30˚C.
Inerted vapours are 100% saturated.
All tanks listed are breathing diurnally to the VOC-nitrogen inerted vapour collection system.
Maximum hydrogen sulphide (H_2S) concentration in the BTX vapour space 4% v/v -based on past sample analysis - SGS report ENV11869
Maximum hydrogen sulphide (H_2S) concentration in the BTX liquid 0.2% w/w -based on past sample analysis - SGS report ENV11869
Other assumptions are listed in the calculation sheet.

Conclusions/Outcomes:

Refer to the following summary sheets for tabulated results of the emissions from the thermal oxidiser stacks.
Thermal oxidiser TO-1: sheet "Total Output TO-1"
Thermal oxidiser TO-2: sheet "Total Output TO-2"

Design Verification Control

	Originator	Checked
Input Data Correct	FS	AB
Assumptions properly documented	FS	AB
Method of Calculation	FS	AB
Attachments included, clearly labelled and referenced	FS	AB
Results/conclusions clearly summarised	FS	AB

Rev	Issue Description	Date	Originated	Checked	Approved	Client
1	Initial Issue	28/10/2020	FS	AB		

Thermal Oxidiser TO-1
Total Output Stack Emission Estimate

Stack Diameter	1	m
Exit Temperature	980	°C

	Input stream	Total flue vol rate at exit temp	Total flue vol rate at 0°C temp	VOC/HAP discharge rate from combust	VOC/HAP discharge rate from combust	Conc'n of VOC/HAP at stack exit temp	Conc'n of VOC/HAP at 0°C temp	exit velocity
		Am^3/hr	Nm^3/hr	kg/hr	g/min	mg/m^3	mg/m^3	m/sec
	Total TO-1							
A	**Benzene**			**0.0073**	**0.1218**	**0.1370**	**0.6289**	
B	**Hexene**			**0.0111**	**0.1849**	**0.2080**	**0.9545**	
C	**Acetone**			**0.0062**	**0.1038**	**0.1167**	**0.5357**	
D	**Ethanol**			**0.0015**	**0.0256**	**0.0288**	**0.1320**	
E	**Methanol**			**0.0059**	**0.0988**	**0.1112**	**0.5104**	
F	**Styrene**			**0.0000**	**0.0005**	**0.0005**	**0.0024**	
G	**Vinyl Acetate**			**0.0020**	**0.0334**	**0.0376**	**0.1724**	
H	**Methyl Methacrylate**			**0.0000**	**0.0000**	**0.0000**	**0.0000**	
I	**Butyl Acrylates**			**0.0000**	**0.0003**	**0.0004**	**0.0018**	
J	**Methyl Isobutyl Carbinol (MIBC)**			**0.0000**	**0.0000**	**0.0000**	**0.0000**	
	Hydrogen Sulphide (H_2S)	**444**	**97**	**0.0008**	**0.0139**	**0.0156**	**0.0717**	
	Sulphur Dioxide (from combustion of H2S)	**24**	**5**	**14.8789**	**248**	**279**	**1280**	
	Supplementary N2 inerting	**1165**	**254**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	
	Total (VOC-nitrogen inert stream, incl. N2 inerting)-excludes SO2	**53333**	**11620**	**0.035**	**0.583**	**0.656**	**3.010**	**18.9**

Breakdown:
Total (VOC-nitrogen inert stream, incl. N2 inerting)

A	Benzene	10279	2240	0.00731	0.1218	0.2495	1.1451	
B	Hexene	14293	3114	0.00918	0.1530	0.3133	1.4380	
C	Acetone	4201	915	0.00420	0.0700	0.1433	0.6579	
D	Ethanol	1441	314	0.00153	0.0256	0.0524	0.2404	
E	Methanol	4138	902	0.00593	0.0988	0.2025	0.9293	
F	Styrene	40	9	0.00003	0.0005	0.0010	0.0044	
G	Vinyl Acetate	1588	346	0.00200	0.0334	0.0684	0.3140	
H	Methyl Methacrylate	0	0	0.00000	0.0000	0.0000	0.0000	
I	Butyl Acrylates	24	5	0.00002	0.0003	0.0007	0.0033	
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0.00000	0.0000	0.0000	0.0000	
	Hydrogen Sulphide (H_2S)	444	97	0.00083	0.0139	0.0285	0.1306	
	Sulphur Dioxide (from combustion of H2S)	24	5	14.88	247.98	395.59	1815.64	
	Supplementary N2 inerting	1165	254	0.0	0.0000	0.0000	0.0000	
	Total (VOC-nitrogen inert stream, incl. N2 inerting)-excludes SO2	37612	8195	0.031	0.517	0.825	3.787	13.3

VOC-Air

Benzene			0.00000	0.00000	0.000	0.000	
Hexane			0.00191	0.03190	0.122	0.559	
Acetone			0.00203	0.03377	0.129	0.592	
Ethanol			0.00000	0.00000	0.000	0.000	
Methanol			0.00000	0.00000	0.000	0.000	
Vinyl Acetate			0.00000	0.00000	0.000	0.000	
Total (VOC-Air Diluted Stream)	15721	3425	0.00394	0.06567	0.251	1.150	5.6

Thermal Oxidiser TO-2
Total Output Stack Emission Estimate

Stack Diameter	1.25	m	Estimated - TBC by vendor
Exit Temperature	980	°C	

	Input stream	Total flue vol rate at exit temp	Total flue vol rate at 0°C temp	VOC/HAP discharge rate from combust	VOC/HAP discharge rate from combust	Conc'n of VOC/HAP at stack exit temp	Conc'n of VOC/HAP at 0°C temp	exit velocity
		Am^3/hr	Nm^3/hr	kg/hr	g/min	mg/m^3	mg/m^3	m/sec
	Total TO-2							
A	**Benzene**			**0.0345**	**0.1218**	**0.3809**	**1.7482**	
B	**Hexene**			**0.0111**	**0.1849**	**0.1225**	**0.5620**	
C	**Acetone**			**0.0062**	**0.1038**	**0.0687**	**0.3154**	
D	**Ethanol**			**0.0015**	**0.0256**	**0.0169**	**0.0777**	
E	**Methanol**			**0.0059**	**0.0988**	**0.0655**	**0.3005**	
F	**Styrene**			**0.0000**	**0.0005**	**0.0003**	**0.0014**	
G	**Vinyl Acetate**			**0.0020**	**0.0334**	**0.0221**	**0.1015**	
H	**Methyl Methacrylate**			**0.0000**	**0.0000**	**0.0000**	**0.0000**	
I	**Butyl Acrylates**			**0.0000**	**0.0003**	**0.0002**	**0.0011**	
J	**Methyl Isobutyl Carbinol (MIBC)**			**0.0000**	**0.0000**	**0.0000**	**0.0000**	
	Hydrogen Sulphide (H_2S)	**454**	**99**	**0.0009**	**0.0148**	**0.0098**	**0.0450**	
	Sulphur Dioxide (from combustion of H2S)	**24**	**5**	**15.850**	**264**	**175**	**803**	
	Supplementary N2 inerting	**1165**	**254**					
	Total (VOC-nitrogen inert stream, incl. N2 inerting)-excludes SO2	**90580**	**19735**	**0.0622**	**1.0371**	**0.6870**	**3.1529**	**20.5**

Breakdown:

VOC-Nitrogen Inert Stream, incl. N2 inerting

A	Benzene	10279	2240	0.00731	0.1218	0.2495	1.1451	
B	Hexene	14293	3114	0.00918	0.1530	0.3133	1.4380	
C	Acetone	4201	915	0.00420	0.0700	0.1433	0.6579	
D	Ethanol	1441	314	0.00153	0.0256	0.0524	0.2404	
E	Methanol	4138	902	0.00593	0.0988	0.2025	0.9293	
F	Styrene	40	9	0.00003	0.0005	0.0010	0.0044	
G	Vinyl Acetate	1588	346	0.00200	0.0334	0.0684	0.3140	
H	Methyl Methacrylate	0	0	0.00000	0.0000	0.0000	0.0000	
I	Butyl Acrylates	24	5	0.00002	0.0003	0.0007	0.0033	
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0.00000	0.0000	0.0000	0.0000	
	Hydrogen Sulphide (H_2S)	444	97	0.00083	0.0139	0.0285	0.1306	
	Sulphur Dioxide (from combustion of H2S)	24	5	14.88	247.98	395.59	1815.64	
	Supplementary N2 inerting	1165	254					
	Total (VOC-nitrogen inert stream, incl. N2 inerting)-excludes SO2	37612	8195	0.0310	0.5173	0.8252	3.7873	8.5

VOC-Air Stream

	Benzene			0.00000	0.00000	0.000	0.000	
	Hexane			0.00191	0.03190	0.122	0.559	
	Acetone			0.00203	0.03377	0.129	0.592	
	Ethanol			0.00000	0.00000	0.000	0.000	
	Methanol			0.00000	0.00000	0.000	0.000	
	Vinyl Acetate			0.00000	0.00000	0.000	0.000	
	Total (VOC-Air Diluted Stream)	15721	3425	0.00394	0.06567	0.251	1.150	3.6

Liquid Waste Burning Steam

A	Benzene	37235	8113	0.02719	0.45323	0.73010	3.01918	
B	Hexene	0	0	0.00000	0.00000	0.00000	0.00000	
C	Acetone	0	0	0.00000	0.00000	0.00000	0.00000	
D	Ethanol	0	0	0.00000	0.00000	0.00000	0.00000	
E	Methanol	0	0	0.00000	0.00000	0.00000	0.00000	
F	Styrene	0	0	0.00000	0.00000	0.00000	0.00000	
G	Vinyl Acetate	0	0	0.00000	0.00000	0.00000	0.00000	
H	Methyl Methacrylate	0	0	0.00000	0.00000	0.00000	0.00000	
I	Butyl Acrylates	0	0	0.00000	0.00000	0.00000	0.00000	
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0.00000	0.00000	0.00000	0.00000	
	Hydrogen Sulphide (H_2S)	10.1	2.2	0.00005	0.0009	0.0015	0.0060	
	Sulphur Dioxide (from combustion of H2S)	1.54	0.33	0.971	16.183	26.069	119.650	
	Total (VOC)-excludes SO2	37247	8115	0.0272	0.454	0.732	3.358	8.4

Client : Quantem (Terminals Pty Ltd)
Project No. : 200003
Project : 2nd Thermal Oxidiser and Liquid Waste Burning
Calculation No: 200003CAL-002

Calc by FS
Date 28/10/2020
Checked AB

Emission Base Data-Botany Terminal

Worst Case Load

Temperature	30	°C
% Saturated vapour	100%	
% Tank vapour space	75%	
Diurnal breathing time/day	3	hrs

N2 inline inerting	
Truck ship loading- O2 conc initial	21%
Truck ship loading- O2 conc final	5.5%

Product ID	
Benzene	A
Hexene	B
Acetone	C
Ethanol	D
Methanol	E

Product ID	
Styrene	F
Vinyl Acetate	G
Methyl Methacrylate	H
Butyl Acrylates	I
MIBC	J

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1							Note 3	Note 4		Note 5										
Existing Tank Number	Diameter	Height	Nominal Volume	ERV Setting	P Vent Setting	N_2 Setting	Actual Tank Filling Rate	Design Tank filling Rate	Actual Truck Loading Rate	Actual Ship Loading Rate	Design Truck Loading Rate	Design Ship Loading Rate	Calculation Truck/Ship Loading Rate	Product Nominated	Product ID	VOC Vapour Density	Mole Fraction	VOC Conc. at 100 % Sat.	% tank expansion Factor	Tank Diurnal Breathing	VOC mass rate (diurnal)	Maximum outflow to VCS from tank (CEC)	Breathing to TO	Tank fill	Truck/ Ship loading (VOC-nitrogen	Truck/ship vapours inline N2 inerted	Truck/ Ship loading (VOC-Air	Diurnal Breathing to VCS	Tank fill to VCS	Truck/ship loading vapours (VOC-nitrogen	Truck/ship loading N2 inerting	Truck/ship loading vapours (VOC-Air
	m	m	m^3	kPag	kPag	kPag	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr			kg/m^3		kg/m^3		m^3/hr	(max) kg/hr	m^3/hr	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr
Area 1																																
Cluster 1a																																
201	8.6	14.64	850	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	38.4	10.5	238	Y	N	N	N	N	38.4	0	0	0	0
202	8.6	14.64	850	2.5	1.25	0.25	60	200	-	160	-	200	200	Benzene	A	3.18	0.15	0.49	13.6%	29.0	14.1	229	Y	N	N	N	N	29.0	0	0	0	0
203	**8.6**	**14.64**	**850**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**160**	**-**	**200**	**200**	**Styrene**	**F**	**4.24**	**0.01**	**0.05**	**5.9%**	**12.4**	**0.6**	**212**	**Y**	**N**	**N**	**N**	**N**	**12.4**	**0**	**0**	**0**	**0**
204	9.5	14.64	1038	2.5	1.25	0.25	60	200	-	160	-	160	200	Benzene	A	3.18	0.15	0.49	13.6%	35.4	17.3	235	Y	N	Y	Y	N	35.4	0	200	564	0
205	9.5	14.64	1038	2.5	1.25	0.25	60	200	-	160	-	90	200	Benzene	A	3.18	0.15	0.49	13.6%	35.4	17.3	235	Y	N	N	N	N	35.4	0	0	0	0
206	9.5	14.64	1038	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	46.9	12.9	247	Y	N	N	N	N	46.9	0	0	0	0
207	9.5	14.64	1038	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	46.9	12.9	247	Y	N	N	N	N	46.9	0	0	0	0
Sub total Area 1 cluster 1a			6702																	244	85							244.3	**0**	**200**	**564**	**0**
Cluster 1b																																
221	**7.6**	**12.2**	**553**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**160**	**-**	**200**	**200**	**Acetone**	**C**	**2.36**	**0.37**	**0.87**	**27.1%**	**37.5**	**32.6**	**237**	**Y**	**N**	**N**	**N**	**N**	**37.5**	**0**	**0**	**0**	**0**
Sub total Area 1 cluster 1b			553																	37	32.6							37.5	0.0	0.0	0.0	0.0
Cluster 1c																																
223	**6.1**	**10.97**	**321**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**160**	**-**	**200**	**200**	**Acetone**	**C**	**2.36**	**0.37**	**0.87**	**27.1%**	**21.7**	**18.9**	**222**	**Y**	**N**	**N**	**N**	**N**	**21.7**	**0**	**0**	**0**	**0**
230	**7.6**	**12.2**	**553**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**160**	**-**	**200**	**200**	**Acetone**	**C**	**2.36**	**0.37**	**0.87**	**27.1%**	**37.5**	**32.6**	**237**	**Y**	**N**	**N**	**N**	**N**	**37.5**	**0**	**0**	**0**	**0**
Sub total Area 1 cluster 1c			874																	59	51.4							59.2	0.0	0.0	0.0	0.0
Area 1 Total			**8130**																	**341**	**169.5**							**341.0**	**0.0**	**200.0**	**563.6**	**0.0**
Area 2																																
Cluster 1																																
cluster 1a																																
233	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
234	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
241	9.58	17.08	1231	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	35.3	6.7	235	Y	N	N	N	N	35	0	0	0	0
242	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
243	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
251	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	15.9	3.0	216	Y	N	N	N	N	15.9	0	0	0	0
252	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
253	**7.6**	**12.2**	**553**	**2.5**	**1.25**	**0.25**	**-**	**200**	**72**	**-**	**90**	**-**	**90**	**Butyl Acrylates**	**I**	**5.22**	**0.01**	**0.05**	**5.8%**	**8.0**	**0.4**	**208**	**Y**	**N**	**N**	**N**	**N**	**8.0**	**0**	**0**	**0**	**0**
254	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
259	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
260	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	15.9	3.0	216	Y	N	N	N	N	15.9	0	0	0	0
Sub total Area 2 cluster 1a			**6765.6**																	**249.9**	**61.2**							**249.9**	**0.0**	**0.0**	**0.0**	**0.0**
Cluster 1b																																
235	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
240	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
245	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
250	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
255	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	15.9	3.0	216	Y	N	N	N	N	15.9	0	0	0	0
258	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
Sub total Area 2 cluster 1b			**3321**																	**140.8**	**37.3**							**140.8**	**0.0**	**0.0**	**0.0**	**0.0**
Sub total Area 2 cluster 1			**10086**																	**390.7**	**98.6**							**390.7**	**0.0**	**0.0**	**0.0**	**0.0**
Area 2 cluster 2																																
237	10.7	17.08	1536	2.5	1.25	0.25	-	200	72	-	90	-	90	Hexene	B	3.42	0.30	1.01	21.9%	84.0	84.9	284	Y	N	N	N	N	84	0	0	0	0
238	9.58	17.08	1231	2.5	1.25	0.25	-	200	60	-	90	-	90	Hexene	B	3.42	0.30	1.01	21.9%	67.3	68.1	267	Y	N	N	N	N	67	0	0	0	0
244	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Hexene	B	3.42	0.30	1.01	21.9%	30.3	30.6	230	Y	N	N	N	N	30	0	0	0	0
247	**8.74**	**17.08**	**1025**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**140**	**-**	**200**	**200**	**Vinyl Acetate**	**G**	**3.51**	**0.18**	**0.65**	**15.7%**	**40.2**	**26.0**	**240**	**Y**	**N**	**N**	**N**	**N**	**40.2**	**0**	**0**	**0**	**0**
248	8.74	17.08	1025	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	29.4	5.6	229	Y	N	N	N	N	29.4	0	0	0	0
249	8.6	14.64	850	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	24.4	4.6	224	Y	N	N	N	N	24.4	0	0	0	0
256	**7.6**	**12.2**	**553**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**140**	**-**	**200**	**200**	**Vinyl Acetate**	**G**	**3.51**	**0.18**	**0.65**	**15.7%**	**21.7**	**14.1**	**222**	**Y**	**N**	**N**	**N**	**N**	**21.7**	**0**	**0**	**0**	**0**
257	8.6	14.64	850	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	24.4	4.6	224	Y	N	N	N	N	24.4	0	0	0	0
Subtotal Area 2 cluster 2			**7624**																	**321.6**	**238.5**							**321.6**	**0.0**	**0.0**	**0.0**	**0.0**
Area 2 Total			**17710**																	**712.3**	**337.1**							**712.3**	**0.0**	**0.0**	**0.0**	**0.0**
Total			**25840**																	**1053**	**507**							**1053**	**0**	**200**	**564**	**0**

Note 1: Information supplied by TPL
Note 2: Maximum tank filling 200 m3/hr from ship, 90 m3 from truck, maximum tank pump out 90 m3/hr to truck, 200 m3/hr to ship
Note 3 Estimated by CEC elsewhere based 15˚C temperature rise in liquid and vapour
Note 4 Estimated by CEC based on expansion factor and diurnal
Note 5 Summation of diurnal breathing and pump in rate

Client : Quantem (Terminals Pty Ltd)
Project No : 200003
Project : 2nd Thermal Oxidiser and Liquid Waste Burning

Calc by FS
Date 28/10/2020
Checked AB
Rev 1

Calculation No: 200003CAL-002

VOC - Inert Emission Estimate

Worst Case Load

All tanks listed are diurnally breathing simultaneously

BTX ship export + nitrogen inerting

Base Temperature 30 °C
VOC % saturated (VOC/Inert Stream) 100%
VOC % saturated (VOC-AIR Diluted Stream) 50%

H2S scrubber efficiency 0.00%
Refer to Comb Output-Emission Est sheet for input

Stream ID	Input stream	Volumetric rate input stream @ inlet temp m3/hr	Base Temp °C	Molecular formula No of C	No of H	No of O	No of N	No of S	MW	VOC at 100% Saturation	VOC at XX% Saturation	VOC density kg/m3	100% VOC vol rate m3/hr	VOC conc. kg/m3	H2S Mass rate inlet to scrubber kg/hr	H2S Vol rate Comb inlet m3/hr	100% VOC mass rate Comb inlet kg/hr	Heat of Combustion of VOC net (LHV) MJ/kg	Energy MJ/hr
VOC/Inert Stream																			
	Tank Diurnal Breathing																		
A	Benzene	99.8	30	6	6	0			78	15.4%	15.4%	3.18	15.3	0.49			48.7	40.21	1956
B	Hexene	181.6	30	6	14	0			84	29.6%	29.6%	3.42	53.7	1.01			183.6	44.52	8171
C	Acetone	96.7	30	3	6	1			58	36.8%	36.8%	2.36	35.6	0.87			84.0	28.60	2402
D	Ethanol	160.9	30	2	6	1			46	10.2%	10.2%	1.87	16.4	0.19			30.7	26.85	824
E	Methanol	432.0	30	1	4	1			32	21.1%	21.1%	1.30	91.0	0.27			118.6	19.94	2366
F	Styrene	12.4	30	8	8				104	1.1%	1.1%	4.24	0.13	0.05			0.56	40.51	23
G	Vinyl Acetate	61.9	30	4	6	2			86	18.5%	18.5%	3.51	11.4	0.65			40.1	22.65	908
H	Methyl Methacrylate	0.0	30	5	8	2			100	6.2%	6.2%	4.08	0.00	0.25			0.00	26.40	0
I	Butyl Acrylates	8.0	30	7	12	2			128	1.0%	1.0%	5.22	0.08	0.05			0.42	32.24	13
J	Methyl Isobutyl Carbinol (MIBC)	0.0	30						102	0.8%	0.8%	4.16	0.00	0.03			0.00	38.70	0
K	Hydrogen Sulphide (H_2S)	99.8	30		2			1	34	4%	4.0%	1.39	3.99	0.06	5.55	3.99	5.55	15.24	85
	Total Tank Diurnal Breathing	1053	30										223.6	0.48			506.5		16747
	Tank Filling																		
A	Benzene	0.0	30	6	6	0			78	15.4%	15.4%	3.18	0.0	0.49			0.0	40.21	0
B	Hexene	0.0	30	6	14	0			84	29.6%	29.6%	3.42	0.0	1.01			0.0	44.52	0
C	Acetone	0.0	30	3	6	1			58	36.8%	36.8%	2.36	0.0	0.87			0.0	28.60	0
D	Ethanol	0.0	30	2	6	1			46	10.2%	10.2%	1.87	0.0	0.19			0.0	26.85	0
E	Methanol	0.0	30	1	4	1			32	21.1%	21.1%	1.30	0.0	0.27			0.0	19.94	0
F	Styrene	0.0	30	8	8				104	1.1%	1.1%	4.24	0.0	0.05			0.0	40.51	0
G	Vinyl Acetate	0.0	30	4	6	2			86	18.5%	18.5%	3.51	0.0	0.65			0.0	22.65	0
H	Methyl Methacrylate	0.0	30	5	8	2			100	6.2%	6.2%	4.08	0.0	0.25			0.0	26.40	0
I	Butyl Acrylates	0.0	30	7	12	2			128	1.0%	1.0%	5.22	0.0	0.05			0.0	32.24	0
J	Methyl Isobutyl Carbinol (MIBC)	0.0	30						102	0.8%	0.8%	4.16	0.0	0.03			0.0	38.70	0
K	Hydrogen Sulphide (H_2S) note 1	0.0	30		2			1	34	4%	4.0%	1.39	0.00	0.06	0.00	0.00	0.00	15.24	0
	Total Tank Filling	0	30										0.0	#DIV/0!			0.0		0
	Truck/Ship Filling																		
A	Benzene	200.0	30	6	6	0			78	15.4%	15.4%	3.18	30.7	0.49			97.5	40.21	3921
B	Hexene	0.0	30	6	14	0			84	29.6%	29.6%	3.42	0.0	1.01			0.0	44.52	0
C	Acetone	0.0	30	3	6	1			58	36.8%	36.8%	2.36	0.0	0.87			0.0	28.60	0
D	Ethanol	0.0	30	2	6	1			46	10.2%	10.2%	1.87	0.0	0.19			0.0	26.85	0
E	Methanol	0.0	30	1	4	1			32	21.1%	21.1%	1.30	0.0	0.27			0.0	19.94	0
F	Styrene	0.0	30	8	8				104	1.1%	1.1%	4.24	0.0	0.05			0.0	40.51	0
G	Vinyl Acetate	0.0	30	4	6	2			86	18.5%	18.5%	3.51	0.0	0.65			0.0	22.65	0
H	Methyl Methacrylate	0.0	30	5	8	2			100	6.2%	6.2%	4.08	0.0	0.25			0.0	26.40	0
I	Butyl Acrylates	0.0	30	7	12	2			128	1.0%	1.0%	5.22	0.0	0.05			0.0	32.24	0
J	Methyl Isobutyl Carbinol (MIBC)	0.0	30						102	0.8%	0.8%	4.16	0.0	0.03			0.0	38.70	0
K	Hydrogen Sulphide (H_2S)	200.0	30		2			1	34	4%	4.0%	1.39	8.00	0.06	11.12	8.00	11.12	15.24	169
	Supplementary N2 inerting	563.6	30																
	Total Truck/Ship Filling (incl. N2 inerting)	764	30										30.7	0.13			97.5		4090

VOC - Inert Emission Estimate

Worst Case Load

All tanks listed are diurnally breathing simultaneously

BTX ship export + nitrogen inerting

Base Temperature 30 °C
VOC % saturated (VOC/Inert Stream) 100%
VOC % saturated (VOC-AIR Diluted Stream) 50%

H2S scrubber efficiency 0.00%
Refer to Comb Output-Emission Est sheet for input

Stream ID	Input stream	Volumetric rate input stream @ inlet temp m3/hr	Base Temp °C	Molecular formula No of C	No of H	No of O	No of N	No of S	MW	VOC at 100% Saturation	VOC at XX% Saturation	VOC density kg/m3	100% VOC vol rate m3/hr	VOC conc. kg/m3	H2S Mass rate inlet to scrubber kg/hr	H2S Vol rate Comb inlet m3/hr	100% VOC mass rate Comb inlet kg/hr	Heat of Combustion of VOC net (LHV) MJ/kg	Energy MJ/hr
	Total																		
A	Benzene	299.8	30	6	6	0			78	15.4%	15.4%	3.18	46.0	0.49			146.2	40.21	5877
B	Hexene	181.6	30	6	14	0			84	29.6%	29.6%	3.42	53.7	1.01			183.6	44.52	8171
C	Acetone	96.7	30	3	6	1			58	36.8%	36.8%	2.36	35.6	0.87			84.0	28.60	2402
D	Ethanol	160.9	30	2	6	1			46	10.2%	10.2%	1.87	16.4	0.19			30.7	26.85	824
E	Methanol	432.0	30	1	4	1			32	21.1%	21.1%	1.30	91.0	0.27			118.6	19.94	2366
F	Styrene	12.4	30	8	8				104	1.1%	1.1%	4.24	0.13	0.05			0.56	40.51	23
G	Vinyl Acetate	61.9	30	4	6	2			86	18.5%	18.5%	3.51	11.4	0.65			40.1	22.65	908
H	Methyl Methacrylate	0.0	30	5	8	2			100	6.2%	6.2%	4.08	0.00	0.25			0.00	26.40	0
I	Butyl Acrylates	8.0	30	7	12	2			128	1.0%	1.0%	5.22	0.08	0.05			0.42	32.24	13
J	Methyl Isobutyl Carbinol (MIBC)	0.0	30						102	0.8%	0.8%	4.16	0.00	0.03			0.00	38.70	0
K	Hydrogen Sulphide (H_2S)	299.8	30		2			1	34	4%	4.0%	1.39	11.99	0.06	16.67	11.99	16.67	15.24	254
	Supplementary N2 inerting	563.6	30																
	Total (incl. N2 inerting)	1817	30										254.3	0.33			604.1		20837

Note 1 4% H2S v/v based on historical BTX vapour analysis (Terminals Botany)- SGS report ENV11869- dated 20th October 2010

VOC/Air Dilute Stream (MJ/hr)
Thermal load from the VOC/Air dilute stream - Refer to previous CEC calculation 200003CAL-003 2875

Thermal Load Waste Burning (MJ/hr)
Max thermal load from liquid waste burning (6.5 l/min @ 80% (v/v) benzene) -Refer to Separate Calc Sheet LWB-Thermal Load 10644

Total Thermal Load (MJ/hr)
VOC/Inert stream thermal load + VOC/Air dilute stream thermal load +LWB 34356

Total thermal load existing thermal Oxidser TO-1 (MJ/hr) **11856**
Total Thermal Load for 2nd Oxidiser TO-2 (MJ/hr) **22500**

Heat of combustion data (A-G): source: Perry Chemical Engineers Handbook 7th Ed., pg's 2-195 to 2-199, Cmpd No 67, 34, 123, 83, 82, 80, 155
Heat of combustion data (H-J): source: Cameo Chemicals data sheets
Ambient temperature is same as inlet temperature

Client :	**Quantem (Terminals Pty Ltd)**			**Calc by**	**FS**
Project No :	**200003**			**Date**	**28/10/2020**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**			**Checked**	**AB**
Calculation No:	**200003CAL-002**			**Rev**	**1**

VOC-Inert Stack Emission Estimate - Thermal Oxidiser TO-1
Worst Case Load

Input VOC -inert stream split: 50%

Combustor reduction eff (VOC): 99.99%
Scrubber reduction eff (S): 0.00%
Combuster eff for (S): 99.99%
Combustor/Scrubber reduction eff (S): 99.99%
Combustor diameter exit: 1 m Est

Initial flue gas temp: 30
Final flue gas temp: 980

% conversion of H2S to SO3: 5%

Stream ID	Input stream	Input stream rate to TO		Molecular formula					Required for Comb			Required for Comb			Combustion Air	Flue products with excess combustion air (only) at ambient temperature									Average CP air	Flue prod density	Inlet Temp	Outlet Comb Temp	Total flue flowrate	Quench air flowrate	Total flue products with excess combustion & quench air						Total flue vol rate at exit temp	Total flue vol rate at 0oC temp	HAP/VOC discharge rate from combust	HAP/VOC discharge rate from combust	Conc'n of HAP/VOC at stack exit temp	Conc'n of HAP/VOC at 0oC temp	exit velocity
		100% VOC Vol rate	100% VOC mass rate	No of C	No of H	No of O	No of N	No of S	with VOC O_2	N_2	Air	Total O_2	N_2	Air	air inout with 100% excess	CO_2	H_2O	SO_2	N_2	excess O_2	CO_2	H_2O	SO_2	N_2	excess O_2	Total	25C-800C as air @ambient temp					Amb CO_2	Amb H_2O	Amb SO_2/SO_3	Amb N_2	Amb O_2	Amb Total							
		m3/hr	kg/hr	moles/moles of C	moles/moles of H	moles/moles of O	moles/moles of N	moles/moles of S	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	moles/moles or m^3/m^3 of combust VOC					m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	kJ/kg°C	kg/m^3	°C	°C	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	Am^3/hr	Nm^3/hr	kg/hr	g/min	mg/m^3	mg/m^3	m/sec
	Tank Diurnal Breathing (VOC-nitrogen inert stream)																																										
A	Benzene	7.660	24.327	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	57.4	216.1	273.6	547.1	6.0	3.0	0.0	28.2	7.5	46.0	23.0	0	432.2	57.4	**558.6**	1.0727	1.16	30.0	980.0	827.4	268.8	46.0	23.0	0.0	644.6	113.9	**827.4**	**3421.5**	**745.5**	**0.0024**	0.0405	0.0830	0.3812	1.211
B	Hexene	26.834	91.779	6	14	0	0.0	0.0	9.5	35.74	45.24	254.9	959.0	1213.9	2427.9	6	7	0	35.7	9.5	161.0	187.8	0	1918.0	254.9	**2521.8**	1.0727	1.16	30.0	980.0	3456.2	934.4	161.0	187.8	0.0	2656.2	451.2	**3456.2**	**14292.6**	**3114.0**	**0.0092**	0.1530	0.3133	1.4380	5.058
C	Acetone	17.780	41.988	3	6	1	0.0	0.0	4.5	16.93	21.43	80.0	301.0	381.0	762.0	3	3	0	16.9	4.5	53.3	53.3	0	602.0	80.0	**788.7**	1.0727	1.16	30.0	980.0	1016.0	227.3	53.3	53.3	0.0	781.5	127.7	**1016.0**	**4201.3**	**915.4**	**0.0042**	0.0700	0.1433	0.6579	1.487
D	Ethanol	8.191	15.342	2	6	1	0.0	0.0	3.5	13.17	16.67	28.7	107.9	136.5	273.0	2	3	0	13.2	3.5	16.4	24.6	0	215.7	28.7	**285.3**	1.0727	1.16	30.0	980.0	348.4	63.1	16.4	24.6	0.0	265.6	41.9	**348.4**	**1440.9**	**313.9**	**0.0015**	0.0256	0.0524	0.2404	0.510
E	Methanol	45.519	59.308	1	4	1	0.0	0.0	2	7.52	9.52	91.0	342.5	433.5	867.0	1	2	0	7.5	2.0	45.5	91.0	0	685.0	91.0	**912.6**	1.0727	1.16	30.0	980.0	1000.6	88.1	45.5	91.0	0.0	754.5	109.5	**1000.6**	**4137.8**	**901.5**	**0.0059**	0.0988	0.2025	0.9283	1.464
F	Styrene	0.066	0.280	8	8	0	0.0	0.0	10	37.62	47.62	0.7	2.5	3.1	6.3	8	4	0	37.6	10.0	0.5	0.3	0	5.0	0.7	**6.4**	1.0727	1.16	30.0	980.0	9.6	3.2	0.5	0.3	0.0	7.5	1.3	**9.6**	**39.7**	**8.6**	**0.0000**	0.0005	0.0010	0.0044	0.014
G	Vinyl Acetate	5.716	20.037	4	6	2	0.0	0.0	5.5	20.69	26.19	31.4	118.3	149.7	299.4	4	3	0	20.7	5.5	22.9	17.1	0	236.5	31.4	**308.0**	1.0727	1.16	30.0	980.0	383.9	75.9	22.9	17.1	0.0	296.5	47.4	**383.9**	**1587.7**	**345.9**	**0.0020**	0.0334	0.0684	0.3140	0.562
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
I	Butyl Acrylates	0.040	0.209	7	12	2	0.0	0.0	10	37.62	47.62	0.4	1.5	1.9	3.8	7	6	0	37.6	10.0	0.3	0.2	0	3.0	0.4	**3.9**	1.0727	1.16	30.0	980.0	5.7	1.8	0.3	0.2	0.0	4.4	0.8	**5.7**	**23.5**	**5.1**	**0.0000**	0.0003	0.0007	0.0033	0.008
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
K	Hydrogen Sulphide (H_2S)	2.00	2.77	0	2	0	0	1	0.5	1.9	2.4	1.0	3.8	4.8	9.5	0	1	1	1.9	0.5	0.0	2.0	2.0	7.5	1.0	**12.9**	1.0727	1.16	30.0	980.0	35.8	23.3	0.0	2.0	2.0	25.9	5.9	**35.8**	**147.8**	**32.2**	0.0003	0.0046	0.0095	0.0435	0.062
	Total Tank Diurnal Breathing (VOC-nitrogen inert stream)																									**6397.8**	1.0727	1.16	30.0	980.0	7083.6	1685.8	345.9	399.4	2.0	5436.7	899.6	7083.6	29293.0	6382.3	0.026	0.427	0.874	4.012	10.4
	Tank Filling (VOC-inert stream)																																										
A	Benzene	0.000	0.000	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	0.0	0.0	0.0	0.0	6.0	3.0	0.0	28.2	7.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
B	Hexene	0.000	0.000	6	14	0	0.0	0.0	9.5	35.74	45.24	0.0	0.0	0.0	0.0	6	7	0	35.7	9.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
C	Acetone	0.000	0.000	3	6	1	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
D	Ethanol	0.000	0.000	2	6	1	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
E	Methanol	0.000	0.000	1	4	1	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
F	Styrene	0.000	0.000	8	8	0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
G	Vinyl Acetate	0.000	0.000	4	6	2	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
I	Butyl Acrylates	0.000	0.000	7	12	2	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
K	Hydrogen Sulphide (H_2S)	0.000	0.000	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	0.0	0.0	0.0	0.0	0	1	1	1.9	0.5	0.0	0.0	0.0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
	Total Tank Filling (VOC-nitrogen inert stream)																									**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000	0.0000	#DIV/0!	#DIV/0!	0.0
	Truck/Ship Filling (VOC-nitrogen inert stream)																																										
A	Benzene	15.352	48.757	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	115.1	433.2	548.3	1096.6	6.0	3.0	0.0	28.2	7.5	92.1	46.1	0	866.3	115.1	**1119.6**	1.0727	1.16	30.0	980.0	1658.3	538.7	92.1	46.1	0.0	1291.9	228.3	**1658.3**	**6857.6**	**1494.1**	**0.0049**	0.0813	0.1664	0.7640	2.427
B	Hexene	0.000	0.000	6	14	0	0.0	0.0	9.5	35.74	45.24	0.0	0.0	0.0	0.0	6	7	0	35.7	9.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
C	Acetone	0.000	0.000	3	6	1	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
D	Ethanol	0.000	0.000	2	6	1	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
E	Methanol	0.000	0.000	1	4	1	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
F	Styrene	0.000	0.000	8	8	0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
G	Vinyl Acetate	0.000	0.000	4	6	2	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
I	Butyl Acrylates	0.000	0.000	7	12	2	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
K	Hydrogen Sulphide (H_2S)	4.000	5.560	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	2.0	7.5	9.5	19.0	0	1	1	1.9	0.5	0.0	4.0	4.0	15.0	2.0	**25.0**	1.0727	1.16	30.0	980.0	71.7	46.6	0.0	4.0	4.0	51.9	11.8	**71.7**	**296.3**	**64.6**	0.0006	0.0093	0.0190	0.0871	0.105
19	Supplementary N2 inerting												281.8												281.8	281.8												**281.8**	**1165.4**	**253.9**					
	Total Truck/Ship Filling (VOC-nitrogen inert stream, incl. N2 inerting)																									**1426.5**	1.0727	1.16	30.0	980.0	2011.8	585.3	92.1	50.1	4.0	1625.5	240.1	2011.8	8319.3	1812.6	0.005	0.091	0.653	2.997	2.9
	Total (VOC-nitrogen inert stream, incl. N2 inerting)																																										
A	Benzene	23.012	73.084	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	172.6	649.3	821.9	1643.7	6.0	3.0	0.0	28.2	7.5	138.1	69.0	0	1298.5	172.6	**1678.3**	1.0727	1.16	30.0	980.0	2485.7	807.4	138.07	69.04	0.00	1936.42	342.15	**2485.68**	**10279.07**	**2239.57**	**0.0073**	0.122	0.249	1.145	3.637
B	Hexene	26.834	91.779	6	14	0	0.0	0.0	9.5	35.74	45.24	254.9	959.0	1213.9	2427.9	6	7	0	35.7	9.5	161.0	187.8	0	1918.0	254.9	**2521.8**	1.0727	1.16	30.0	980.0	3456.2	934.4	161.01	**187.84**	**0.00**	**2656.23**	**451.16**	**3456.24**	**14292.64**	**3114.04**	**0.0092**	**0.153**	**0.313**	**1.438**	5.058
C	Acetone	17.78	41.99	3.0	6.0	1.0	0.0	0.0	4.5	16.93	21.43	80.0	301.0	381.0	762.0	3	3	0	16.9	4.5	53.3	53.3	0	602.0	80.0	**788.7**	1.0727	1.16	30.0	980.0	1016.0	227.3	53.34	**53.34**	**0.00**	**781.55**	**127.74**	**1015.97**	**4201.35**	**915.38**	**0.0042**	**0.079**	**0.143**	**0.658**	1.487
D	Ethanol	8.19	15.34	2.0	6.0	1.0	0.0	0.0	3.5	13.17	16.67	28.7	107.9	136.5	273.0	2	3	0	13.2	3.5	16.4	24.6	0	215.7	28.7	**285.3**	1.0727	1.16	30.0	980.0	348.4	63.1	16.38	**24.57**	**0.00**	**265.56**	**41.92**	**348.44**	**1440.91**	**313.94**	**0.0015**	**0.026**	**0.052**	**0.240**	0.510
E	Methanol	45.52	59.31	1.0	4.0	1.0	0.0	0.0	2	7.52	9.52	91.0	342.5	433.5	867.0	1	2	0	7.5	2.0	45.5	91.0	0	685.0	91.0	**912.6**	1.0727	1.16	30.0	980.0	1000.6	88.1	45.52	**91.04**	**0.00**	**754.52**	**109.53**	**1000.60**	**4137.80**	**901.53**	**0.0059**	**0.099**	**0.202**	**0.929**	1.464
F	Styrene	0.07	0.28	8.0	8.0	0.0	0.0	0.0	10	37.62	47.62	0.7	2.5	3.1	6.3	8	4	0	37.6	10.0	0.5	0.3	0	5.0	0.7	**6.4**	1.0727	1.16	30.0	980.0	9.6	3.2	0.53	**0.26**	**0.00**	**7.48**	**1.33**	**9.60**	**39.70**	**8.65**	**0.0000**	**0.000**	**0.001**	**0.004**	0.014
G	Vinyl Acetate	5.72	20.04	4.0	6.0	2.0	0.0	0.0	5.5	20.69	26.19	31.4	118.3	149.7	299.4	4	3	0	20.7	5.5	22.9	17.1	0	236.5	31.4	**308.0**	1.0727	1.16	30.0	980.0	383.9	75.9	22.87	**17.15**	**0.00**	**296.54**	**47.39**	**383.94**	**1587.69**	**345.92**	**0.0020**	**0.033**	**0.068**	**0.314**	0.562
H	Methyl Methacrylate	0.00	0.00	5.0	8.0	2.0	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0000**	**0.000**	**0.000**	**0.000**	0.000
I	Butyl Acrylates	0.04	0.21	7.0	12.0	2.0	0.0	0.0	10	37.62	47.62	0.4	1.5	1.9	3.8	7	6	0	37.6	10.0	0.3	0.2	0	3.0	0.4	**3.9**	1.0727	1.16	30.0	980.0	5.7	1.8	0.28	**0.24**	**0.00**	**4.40**	**0.77**	**5.69**	**23.52**	**5.13**	**0.0000**	**0.000**	**0.001**	**0.003**	0.008
J	Methyl Isobutyl Carbinol (MIBC)	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0000**	**0.000**	**0.000**	**0.000**	0.000
K	Hydrogen Sulphide (H_2S)	6.00	8.33	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	3.0	11.3	14.3	28.6	0	1	1	1.9	0.5	0.0	6.0	6.0	22.6	3.0	**37.5**	1.0727	1.16	30.0	980.0	107.4	69.9	0.0	6.0	6.0	77.7	17.7	**107.4**	**444.2**	**96.8**	0.0008	0.0139	0.0285	0.1306	0.157
	Sulphur Dioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					5.7			**5.7**	**23.6**	**5.1**	**14.88**	248.0	395.6	1815.6	
	Sulphur Trioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					0.3			**0.3**	**1.2**	**0.3**	**0.78**	13.1	20.8	95.6	
26	Supplementary N2 inerting												281.8												281.8	281.8												**281.8**	**1165.4**	**253.9**					
	Total (VOC-nitrogen inert stream, incl. N2 inerting) - excludes SO2																									**6824.3**	1.0727	1.16	30.0	980.0	9095.4	2271.1	438.0	449.5	12.0	7062.3	1139.7	9095.4	37612.3	8194.9	0.031	0.517	0.825	3.787	13.3

General

Heat of combustion data: source: Perry Chemical Engineers Handbook 7th Ed., pg's 2-195 to 2-199, cmp no 67,6,123,83, 148, 228

Assume Heat of comb for MMA as per ethyl propionate 26.3 (methane =50.1 MJ/kg)

Ambient temperature is same as inlet temperature

Client : Quantem (Terminals Pty Ltd)
Project No : 200003
Project : 2nd Thermal Oxidiser and Liquid Waste Burning
Calculation No: 200003CAL-002

Calc by FS
Date 28/10/2020
Checked AB
Rev 1

VOC-Inert Stack Emission Estimate - Thermal Oxidiser TO-2
Worst Case Load

Input VOC -inert stream split: 50%

Combustor reduction eff (VOC): 99.99%
Scrubber reduction eff (S): 0.00%
Combuster eff for (S): 99.99%
Combustor/Scrubber reduction eff (S): 99.99%
Combustor diameter exit: 1.25 m

Initial flue gas temp: 30
Final flue gas temp: 980
% conversion of H2S to SO3: 5%
Est-TO Vendor to confirm

Stream ID	Input stream	Input stream rate to TO: 100% VOC Vol rate m3/hr	100% VOC mass rate kg/hr	Molecular formula: No of C	No of H	No of O	No of N	No of S	Required for Comb: with VOC O_2	N_2	Air	Required for Comb: Total O_2	N_2	Air	Combustion Air: air inout with 100% excess m^3/hr
									moles/moles or m^3/m^3 of combust VOC						
	Tank Diurnal Breathing (VOC-nitrogen inert stream)	m3/hr													
A	Benzene	7.660	24.327	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	57.4	216.1	273.6	547.1
B	Hexene	26.834	91.779	6	14	0	0.0	0.0	9.5	35.74	45.24	254.9	959.0	1213.9	2427.9
C	Acetone	17.780	41.988	3	6	1	0.0	0.0	4.5	16.93	21.43	80.0	301.0	381.0	762.0
D	Ethanol	8.191	15.342	2	6	1	0.0	0.0	3.5	13.17	16.67	28.7	107.9	136.5	273.0
E	Methanol	45.519	59.308	1	4	1	0.0	0.0	2	7.52	9.52	91.0	342.5	433.5	867.0
F	Styrene	0.066	0.280	8	8	0	0.0	0.0	10	37.62	47.62	0.7	2.5	3.1	6.3
G	Vinyl Acetate	5.716	20.037	4	6	2	0.0	0.0	5.5	20.69	26.19	31.4	118.3	149.7	299.4
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0
I	Butyl Acrylates	0.040	0.209	7	12	2	0.0	0.0	10	37.62	47.62	0.4	1.5	1.9	3.8
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0
K	Hydrogen Sulphide (H_2S)	2.00	2.77	0	2	0	0	1	0.5	1.9	2.4	1.0	3.8	4.8	9.5
	Total Tank Diurnal Breathing (VOC-nitrogen inert stream)														
	Tank Filling (VOC-inert stream)														
A	Benzene	0.000	0.000	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	0.0	0.0	0.0	0.0
B	Hexene	0.000	0.000	6	14	0	0.0	0.0	9.5	35.74	45.24	0.0	0.0	0.0	0.0
C	Acetone	0.000	0.000	3	6	1	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0
D	Ethanol	0.000	0.000	2	6	1	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0
E	Methanol	0.000	0.000	1	4	1	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0
F	Styrene	0.000	0.000	8	8	0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0
G	Vinyl Acetate	0.000	0.000	4	6	2	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0
I	Butyl Acrylates	0.000	0.000	7	12	2	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0
K	Hydrogen Sulphide (H_2S)	0.000	0.000	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	0.0	0.0	0.0	0.0
	Total Tank Filling (VOC-nitrogen inert stream)														
	Truck/Ship Filling (VOC-nitrogen inert stream)														
A	Benzene	15.352	48.757	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	115.1	433.2	548.3	1096.6
B	Hexene	0.000	0.000	6	14	0	0.0	0.0	9.5	35.74	45.24	0.0	0.0	0.0	0.0
C	Acetone	0.000	0.000	3	6	1	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0
D	Ethanol	0.000	0.000	2	6	1	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0
E	Methanol	0.000	0.000	1	4	1	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0
F	Styrene	0.000	0.000	8	8	0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0
G	Vinyl Acetate	0.000	0.000	4	6	2	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0
I	Butyl Acrylates	0.000	0.000	7	12	2	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0
K	Hydrogen Sulphide (H_2S)	4.000	5.560	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	2.0	7.5	9.5	19.0
19	Supplementary N2 inerting												281.8		
20	Total Truck/Ship Filling (VOC-nitrogen inert stream, incl. N2 inerting)														
	Total (VOC-nitrogen inert stream, incl. N2 inerting)														
A	Benzene	23.012	73.084	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	172.6	649.3	821.9	1643.7
B	Hexene	26.834	91.779	6	14	0	0.0	0.0	9.5	35.74	45.24	254.9	959.0	1213.9	2427.9
C	Acetone	17.78	41.99	3.0	6.0	1.0	0.0	0.0	4.5	16.93	21.43	80.0	301.0	381.0	762.0
D	Ethanol	8.19	15.34	2.0	6.0	1.0	0.0	0.0	3.5	13.17	16.67	28.7	107.9	136.5	273.0
E	Methanol	45.52	59.31	1.0	4.0	1.0	0.0	0.0	2	7.52	9.52	91.0	342.5	433.5	867.0
F	Styrene	0.07	0.28	8.0	8.0	0.0	0.0	0.0	10	37.62	47.62	0.7	2.5	3.1	6.3
G	Vinyl Acetate	5.72	20.04	4.0	6.0	2.0	0.0	0.0	5.5	20.69	26.19	31.4	118.3	149.7	299.4
H	Methyl Methacrylate	0.00	0.00	5.0	8.0	2.0	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0
I	Butyl Acrylates	0.04	0.21	7.0	12.0	2.0	0.0	0.0	10	37.62	47.62	0.4	1.5	1.9	3.8
J	Methyl Isobutyl Carbinol (MIBC)	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0
K	Hydrogen Sulphide (H_2S)	6.00	8.33	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	3.0	11.3	14.3	28.6
	Sulphur Dioxide (from combustion of H2S)														
	Sulphur Trioxide (from combustion of H2S)														
26	Supplementary N2 inerting												281.8		
	Total (VOC-nitrogen inert stream, incl. N2 inerting) - excludes SO2														

Stream ID	Input stream	Flue products with excess combustion air (only) at ambient temp: CO_2	H_2O	SO_2	N_2	excess O_2	CO_2	H_2O	SO_2	N_2	excess O_2	Total m^3/hr	Average CP air 25C-800C kJ/kg°C	Flue prod density as air @ambient temp kg/m³	Inlet Temp °C	Outlet Comb Temp °C	Total flue flowrate m^3/hr	Quench air flowrate m^3/hr	Total flue products with excess combustion & quench air: Amb CO_2 m^3/hr	Amb H_2O m^3/hr	Amb SO_2/SO_3 m^3/hr	Amb N_2 m^3/hr	Amb O_2 m^3/hr	Amb Total m^3/hr	Total flue vol rate at exit temp Am^3/hr	Total flue vol rate at 0oC temp Nm^3/hr	HAP/VOC discharge rate from combust kg/hr	HAP/VOC discharge rate from combust g/min	Conc'n of HAP/VOC at stack exit temp mg/m³	Conc'n of HAP/VOC at 0oC temp mg/m³	exit velocity m/sec
	Tank Diurnal Breathing (VOC-nitrogen inert stream)																													
A	Benzene	6.0	3.0	0.0	28.2	7.5	46.0	23.0	0	432.2	57.4	**558.6**	1.0727	1.16	30.0	980.0	827.4	268.8	46.0	23.0	0.0	644.6	113.9	**827.4**	**3421.5**	**745.5**	**0.0024**	**0.0405**	**0.0830**	**0.4**	0.77
B	Hexene	6	7	0	35.7	9.5	161.0	187.8	0	1918.0	254.9	**2521.8**	1.0727	1.16	30.0	980.0	3456.2	934.4	161.0	187.8	0.0	2656.2	451.2	**3456.2**	**14292.6**	**3114.0**	**0.0092**	**0.1530**	**0.3133**	**1.4**	3.24
C	Acetone	3	3	0	16.9	4.5	53.3	53.3	0	602.0	80.0	**788.7**	1.0727	1.16	30.0	980.0	1016.0	227.3	53.3	53.3	0.0	781.5	127.7	**1016.0**	**4201.3**	**915.4**	**0.0042**	**0.0700**	**0.1433**	**0.7**	0.95
D	Ethanol	2	3	0	13.2	3.5	16.4	24.6	0	215.7	28.7	**285.3**	1.0727	1.16	30.0	980.0	348.4	63.1	16.4	24.6	0.0	265.6	41.9	**348.4**	**1440.9**	**313.9**	**0.0015**	**0.0256**	**0.0524**	**0.2**	0.33
E	Methanol	1	2	0	7.5	2.0	45.5	91.0	0	685.0	91.0	**912.6**	1.0727	1.16	30.0	980.0	1000.6	88.1	45.5	91.0	0.0	754.5	109.5	**1000.6**	**4137.8**	**901.5**	**0.0059**	**0.0988**	**0.2025**	**0.9**	0.94
F	Styrene	8	4	0	37.6	10.0	0.5	0.3	0	5.0	0.7	**6.4**	1.0727	1.16	30.0	980.0	9.6	3.2	0.5	0.3	0.0	7.5	1.3	**9.6**	**39.7**	**8.6**	**0.0000**	**0.0005**	**0.0010**	**0.0**	0.01
G	Vinyl Acetate	4	3	0	20.7	5.5	22.9	17.1	0	236.5	31.4	**308.0**	1.0727	1.16	30.0	980.0	383.9	75.9	22.9	17.1	0.0	296.5	47.4	**383.9**	**1587.7**	**345.9**	**0.0020**	**0.0334**	**0.0684**	**0.3**	0.36
H	Methyl Methacrylate	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	**0.0000**	**0.0000**	**0.0**	0.00
I	Butyl Acrylates	7	6	0	37.6	10.0	0.3	0.2	0	3.0	0.4	**3.9**	1.0727	1.16	30.0	980.0	5.7	1.8	0.3	0.2	0.0	4.4	0.5	**5.7**	**23.5**	**5.1**	**0.0000**	**0.0003**	**0.0007**	**0.0**	0.01
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	**0.0000**	**0.0000**	**0.0**	0.00
K	Hydrogen Sulphide (H_2S)	1	1	1	1.9	0.5	0.0	2.0	2.0	7.5	1.0	**12.5**	1.0727	1.16	30.0	980.0	35.8	23.3	0.0	2.0	2.0	25.9	5.9	**35.8**	**147.8**	**32.2**	**0.0003**	**0.0046**	**0.0095**	**0.0**	0.03
	Total Tank Diurnal Breathing (VOC-nitrogen inert stream)											**5397.8**	1.0727	1.16	30.0	980.0	7083.6	1685.8	345.9	399.4	2.0	5436.7	899.6	7083.6	29293.0	6382.3	0.026	0.427	0.874	4.012	6.6
	Tank Filling (VOC-inert stream)																														
A	Benzene	6.0	3.0	0.0	28.2	7.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
B	Hexene	6	7	0	35.7	9.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
C	Acetone	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
D	Ethanol	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
E	Methanol	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
F	Styrene	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
G	Vinyl Acetate	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
H	Methyl Methacrylate	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
I	Butyl Acrylates	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
K	Hydrogen Sulphide (H_2S)	1	1	1	1.9	0.5	0.0	0.0	0.0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
	Total Tank Filling (VOC-nitrogen inert stream)											**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	#DIV/0!	#DIV/0!	0.00
	Truck/Ship Filling (VOC-nitrogen inert stream)																														
A	Benzene	6.0	3.0	0.0	28.2	7.5	92.1	46.1	0	866.3	115.1	**1119.6**	1.0727	1.16	30.0	980.0	1658.3	538.7	92.1	46.1	0.0	1291.9	228.3	**1658.3**	**6857.6**	**1494.1**	**0.0049**	0.0813	0.1664	0.7640	1.55
B	Hexene	6	7	0	35.7	9.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
C	Acetone	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
D	Ethanol	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
E	Methanol	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
F	Styrene	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
G	Vinyl Acetate	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
H	Methyl Methacrylate	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
I	Butyl Acrylates	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
K	Hydrogen Sulphide (H_2S)	4	4	2	15.0	2.0	0.0	4.0	4.0	15.2	2.0	**25.0**	1.0727	1.16	30.0	980.0	71.7	46.6	0.0	4.0	4.0	51.9	11.8	**71.7**	**296.3**	**64.6**	**0.0006**	0.0093	0.0190	0.0871	0.07
19	Supplementary N2 inerting											281.8					281.8					281.8		**281.8**	**1165.4**	**253.9**					
20	Total Truck/Ship Filling (VOC-nitrogen inert stream, incl. N2 inerting)											**1426.5**	1.0727	1.16	30.0	980.0	2011.8	585.3	92.1	50.1	4.0	1625.5	240.1	2011.8	8319.3	1812.6	0.005	0.091	0.653	2.997	1.9
	Total (VOC-nitrogen inert stream, incl. N2 inerting)																														
A	Benzene	6.0	3.0	0.0	28.2	7.5	138.1	69.0	0	1298.5	172.6	**1678.3**	1.0727	1.16	30.0	980.0	2485.7	807.4	138.07	69.04	0.00	######	342.15	**2485.68**	**10279.07**	**2239.57**	**0.0073**	0.122	0.249	1.145	2.33
B	Hexene	6	7	0	35.7	9.5	161.0	187.8	0	1918.0	254.9	**2521.8**	1.0727	1.16	30.0	980.0	3456.2	934.4	161.01	**187.84**	**0.00**	**######**	**451.16**	**3456.24**	**14292.64**	**3114.04**	**0.0092**	**0.153**	**0.313**	**1.438**	3.24
C	Acetone	3	3	0	16.9	4.5	53.3	53.3	0	602.0	80.0	**788.7**	1.0727	1.16	30.0	980.0	1016.0	227.3	53.34	**53.34**	**0.00**	**781.55**	**127.74**	**1015.97**	**4201.35**	**915.38**	**0.0042**	**0.070**	**0.143**	**0.658**	0.95
D	Ethanol	2	3	0	13.2	3.5	16.4	24.6	0	215.7	28.7	**285.3**	1.0727	1.16	30.0	980.0	348.4	63.1	16.38	**24.57**	**0.00**	**265.56**	**41.92**	**348.44**	**1440.91**	**313.94**	**0.0015**	**0.026**	**0.052**	**0.240**	0.33
E	Methanol	1	2	0	7.5	2.0	45.5	91.0	0	685.0	91.0	**912.6**	1.0727	1.16	30.0	980.0	1000.6	88.1	45.52	**91.04**	**0.00**	**754.52**	**109.53**	**1000.60**	**4137.80**	**901.53**	**0.0059**	**0.099**	**0.202**	**0.929**	0.94
F	Styrene	8	4	0	37.6	10.0	0.5	0.3	0	5.0	0.7	**6.4**	1.0727	1.16	30.0	980.0	9.6	3.2	0.53	**0.26**	**0.00**	**7.48**	**1.33**	**9.60**	**39.70**	**8.65**	**0.0000**	**0.000**	**0.001**	**0.004**	0.01
G	Vinyl Acetate	4	3	0	20.7	5.5	22.9	17.1	0	236.5	31.4	**308.0**	1.0727	1.16	30.0	980.0	383.9	75.9	22.87	**17.15**	**0.00**	**296.54**	**47.39**	**383.94**	**1587.69**	**345.92**	**0.0020**	**0.033**	**0.068**	**0.314**	0.36
H	Methyl Methacrylate	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0000**	**0.000**	**0.000**	**0.000**	0.00
I	Butyl Acrylates	7	6	0	37.6	10.0	0.3	0.2	0	3.0	0.4	**3.9**	1.0727	1.16	30.0	980.0	5.7	1.8	0.28	**0.24**	**0.00**	**4.40**	**0.77**	**5.69**	**23.52**	**5.13**	**0.0000**	**0.000**	**0.001**	**0.003**	0.01
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0000**	**0.000**	**0.000**	**0.000**	0.00
K	Hydrogen Sulphide (H_2S)	6	6	3	22.6	3.0	0.0	6.0	6.0	22.8	3.0	**37.5**	1.0727	1.16	30.0	980.0	107.4	69.9	0.0	6.0	6.0	77.7	17.7	**107.4**	**444.2**	**96.8**	**0.0008**	0.0139	0.0285	0.1306	0.10
	Sulphur Dioxide (from combustion of H2S)												1.0727	1.16	30.0	980.0					5.7			**5.7**	**23.6**	**5.1**	**14.88**	248.0	395.6	1815.6	
	Sulphur Trioxide (from combustion of H2S)												1.0727	1.16	30.0	980.0					0.3			**0.3**	**1.2**	**0.3**	**0.78**	13.1	20.8	95.6	
26	Supplementary N2 inerting											281.8					281.8					281.8		**281.8**	**1165.4**	**253.9**					
	Total (VOC-nitrogen inert stream, incl. N2 inerting) - excludes SO2											**6824.3**	1.0727	1.16	30.0	980.0	9095.4	2271.1	438.0	449.5	12.0	7062.3	1139.7	9101.4	37612.3	8194.9	0.031	0.517	0.825	3.787	8.5

General

Heat of combustion data: source: Perry Chemical Engineers Handbook 7th Ed., pg's 2-195 to 2-199, cmp no 67,6,123,83, 148, 228

Assume Heat of comb for MMA as per ethyl propionate 26.3 (methane =50.1 MJ/kg)

Ambient temperature is same as inlet temperature

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No :	**200003**	**Date**	**28/10/2020**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
Calculation No:	**200003CAL-002**	**Rev**	**1**

LWB Emission Estimate - Thermal Oxidiser TO-2
Worst Case Load

Waste stream flow rate 6.50 l/min
Composition 80% Benzene Liquid Remainder water
% sulphur compounds in Benzene (liquid) 0.20% w/w Based on historical BTX liquid analysis (Terminals Botany)- SGS report ENV11869- dated 20th October 2010

Combustor reduction eff (VOC) 99.99%
Scrubber reduction eff (S) 0.00%
Combuster eff for (S) 99.99%
Combustor/Scrubber reduction eff (S) 99.99%
Combustor diameter exit 1.25 m Est

Initial flue gas temp 30
Final flue gas temp 980

% conversion of H2S to SO3 5%

Stream ID	Input stream	Input stream rate to TO		Molecular formula					Required for Comb			Required for Comb			Combustion Air	Flue products with excess combustion air (only) at ambient temp										Averaae C/P air	Flue prod density	Inlet Temp	Outlet Comb	Total flue flowrate	Quench air flowrate	Total flue products with excess combustion & quench air							Total flue vol rate at	Total flue vol rate at	HAP/VOC discharge	HAP/VOC discharge	Conc'n of HAP/VOC at stack exit temp	Conc'n of HAP/VOC at 0oC temp	exit velocity
		Equivalent 100% VOC vapour rate	Liquid	No of	No of	No of	No of	No of	with VOC			Total			air input with 100% excess					excess						25C-800C	as air @ambient temp		Temp			Amb	Amb	Amb	Amb	Amb	Amb	exit temp	0oC temp	rate from combust	rate from combust			
		Vol rate	mass rate						O_2	N_2	Air	O_2	N_2	Air	O_2	CO_2	H_2O	SO_2	N_2	O_2	CO_2	H_2O	SO_2	N_2	excess O_2	Total						CO_2	H_2O	SO_2/SO_3	N_2	O_2	Total							
		m3/hr	kg/hr	C	H	O	N	S	moles/moles or m^3/m^3 of combust VOC			m^3/hr	m^3/hr	m^3/hr	m^3/hr	moles/moles or m^3/m^3 of combust VOC						m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	kJ/kg°C	kg/m^3	°C	°C	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	Am^3/hr	Nm^3/hr	kg/hr	g/min	mg/m^3	mg/m^3	m/sec
	Total (Waste Stream)																																										
A	Benzene	85.6	271.9	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	642.2	2415.9	3058.1	6116.1	6.0	3.0	0.0	28.2	7.5	513.8	256.9	0	4831.8	642.2	**6244.6**	1.0727	1.16	30.0	980.0	9004.2	2759.6	513.76	256.88	0.00	7012	1222	**9004.2**	**37235**	**8113**	0.027	0.453	0.730	3.019	8.433
B	Hexene			6	14	0	0.0	0.0	9.5	35.74	45.24	0.0	0.0	0.0	0.0	6	7	0	35.7	9.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	**0.000**	0.000
C	Acetone			3.0	6.0	1.0	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	**0.000**	0.000
D	Ethanol			2.0	6.0	1.0	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	**0.000**	0.000
E	Methanol			1.0	4.0	1.0	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	**0.000**	0.000
F	Styrene			8.0	8.0	0.0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	**0.000**	0.000
G	Vinyl Acetate			4.0	6.0	2.0	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	**0.000**	0.000
H	Methyl Methacrylate			5.0	8.0	2.0	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	**0.000**	0.000
I	Butyl Acrylates			7.0	12.0	2.0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	**0.000**	0.000
J	Methyl Isobutyl Carbinol (MIBC)			0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	**0.000**	0.000
K	Hydrogen Sulphide (H_2S) (0.2% w/w benzene)	0.39	0.54	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	0.20	0.74	0.93	1.86	0	1	1	1.9	0.5	0.0	0.4	0.39	1.5	0.2	**2.5**	1.0727	1.16	30.0	980.0	2.5	0.0	0.0	0.4	0.4	1.5	0.2	**2.45**	**10.1**	**2.2**	0.000054	0.0009	0.0015	0.0060	0.002
	Sulphur Dioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					0.4			**0.4**	**1.5**	**0.3**	**0.97**	16.2	26.1	119.6	
	Sulphur Trioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					0.0			**0.0**	**0.1**	**0.0**	**0.05**	0.9	1.4	6.3	
	Total (VOC LWB stream)																									**6247.0**	1.0727	1.16	30.0	980.0	9006.6	2759.6	513.8	257.3	0.8	7013.3	1221.9	9007.0	37246.8	8115.2	0.027	0.454	0.732	3.358	8.4

General

Heat of combustion data: source: Perry Chemical Engineers Handbook 7th Ed., pg's 2-195 to 2-199, cmp no 67,6,123,83, 148, 228

Assume Heat of comb for MMA as per ethyl propionate 26.3 (methane =50.1 MJ/kg)

Ambient temperature is same as inlet temperature

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No :	**200003**	**Date**	**28/10/2020**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
Calculation No:	**200003CAL-002**	**Rev**	**1**

Liquid Waste Burning-Thermal load

80% Benzene, 6.5 L/min Flowrate (Normal Flow)- Thermal Load of Waste Stream at nominal Benzene Conc.

Total Liquid Waste Disposal Rate	**6.50**	**l/min**
Initial temp	5	˚C
Final temp	980	˚C
Heat Capacity of liquid stream/waste	2	kJ/kg/K
Heat Capacity of stack gases	1.166	kJ/kg/K
Density of Air	1.2	kg/m3

Stream ID	Input stream	% V/V	Volumetric rate input stream l/min	Mass rate stream kg/min	MW	Liquid density @25˚C kg/m3	Mass rate kg/hr	Heat of Combustion of VOC net (LHV) MJ/kg	Energy (-ve = generated) (+ve = consumed) MJ/hr	Mol rate kmols/hr	formulae	Mol ratio comb air/waste liquid	Combustion Air kmols/hr	Combustion Air m3/hr	Enthalpy of Evaporation MJ/kg	Sensible Heat + Super heat MJ/kg	Total Energy MJ/kg	Total Energy (-ve = generated) (+ve = consumed) MJ/hr
A	Benzene	80%	5.2	4.53	78	874.00	271.9	40.21	-10933	3.49	C6H6	7.50	125.11	2852.46				-10933
B	Hexene	0.0%	0.0	0.00	84	678.00	0.0	44.52	0	0.00	C6H12	9.00	0.00	0.00				0
C	Acetone	0.0%	0.0	0.00	58	791.00	0.0	28.60	0	0.00	C3H6O	4.50	0.00	0.00				0
D	Ethanol	0.0%	0.0	0.00	46	806.00	0.0	26.85	0	0.00	C2H5OH	3.00	0.00	0.00				0
E	Methanol	0.0%	0.0	0.00	32	791.00	0.0	19.94	0	0.00	CH3OH	1.50	0.00	0.00				0
F	Styrene	0.0%	0.0	0.00	104	906.00	0.0	40.51	0	0.00	C8H8	10.00	0.00	0.00				0
G	Vinyl Acetate	0.0%	0.0	0.00	86	934.00	0.0	22.65	0	0.00	C4H6O2	4.50	0.00	0.00				0
H	Methyl Methacrylate	0.0%	0.0	0.00	100	943.00	0.0	26.40	0	0.00	C5H8O2	6.00	0.00	0.00				0
I	Butyl Acrylates	0.0%	0.0	0.00	128	894.00	0.0	32.24	0	0.00	C7H12O2	9.00	0.00	0.00				0
J	Methyl Isobutyl Carbinol (MIBC)	0.0%	0.0	0.00	102	802.00	0.0	38.70	0	0.00	C6H14O	9.00	0.00	0.00				0
	Water	20%	1.3	1.31	18	997.00	78.6		0						2.26	1.42	3.68	**289**
	Total	100.0%	6.5	5.84			350.56		**-10933**									**-10644**

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No. :	**200003**	**Date**	**28/10/2020**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
		Rev	**1**
Calculation No:	**200003CAL-002**		

Vapour Density, Mole Fraction & Tank Expansion Factor

BENZENE — From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
83.918	-6517.7	-9.3453	7.1182E-06	2

Temperature 30 °C = 303 K

Vapour Pressure 15747 Pa = 15.7 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Benzene Molecular Weight	78	Mole fraction	0.154
Nitrogen Molecular Weight	28	Mole fraction	0.846
			1.00

Therefore Average Molecular Weight 35.7

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.45 kg/m3 Total Flow
Density = 3.18 kg/m3 Benzene vapour

BENZENE — From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
83.918	-6517.7	-9.3453	7.1182E-06	2

Temperature 15 °C = 288 K

Vapour Pressure 7750 Pa = 7.7 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Benzene Molecular Weight	78	Mole fraction	0.076
Nitrogen Molecular Weight	28	Mole fraction	0.924
			1.00

Therefore Average Molecular Weight 31.8

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.36 kg/m3 Total Flow
Density = 3.34 kg/m3 Benzene vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.08	
initial mol fract N2	0.92	
Volume Act	56.66814	
Volume Vol	693.3319	
	750	
Final temp	30	
Final mol fract act	0.15	
Final mol fract N2	0.85	
Volume Act	115.1429	
Volume Vol	634.8571	
	750	
Vapour pressure expansion	8.4%	
Thermal gas expansion	5.2%	
expansion factor	13.6%	

HEXENE — From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
85.3	-6171.7	-9.702	8.9604E-06	2

Temperature 30 °C = 303 K

Vapour Pressure 30314 Pa = 30.3 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Hexene Molecular Weight	84	Mole fraction	0.296
Nitrogen Molecular Weight	28	Mole fraction	0.704
			1.00

Therefore Average Molecular Weight 44.6

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.81 kg/m3 Total Flow
Density = 3.42 kg/m3 Hexene vapour

HEXENE — From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
85.3	-6171.7	-9.702	8.9604E-06	2

Temperature 15 °C = 288 K

Vapour Pressure 15862 Pa = 15.9 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Hexene Molecular Weight	84	Mole fraction	0.155
Nitrogen Molecular Weight	28	Mole fraction	0.845
			1.00

Therefore Average Molecular Weight 36.7

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.57 kg/m3 Total Flow
Density = 3.60 kg/m3 Hexene vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.15	
initial mol fract N2	0.85	
Volume Act	115.9806	
Volume Vol	634.0194	
	750	
Final temp	30	
Final mol fract act	0.30	
Final mol fract N2	0.70	
Volume Act	221.6568	
Volume Vol	528.3432	
	750	
Vapour pressure expansion	16.7%	
Thermal gas expansion	5.2%	
expansion factor	21.9%	

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No. :	**200003**	**Date**	**28/10/2020**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
		Rev	**1**
Calculation No:	**200003CAL-002**		

Vapour Density, Mole Fraction & Tank Expansion Factor

ACETONE From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
69.006	-5599.6	-7.0985	6.2237E-06	2

Temperature 30 °C = 303 K

Vapour Pressure 37719 Pa = 37.7 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Acetone Molecular Weight	58	Mole fraction	0.368
Nitrogen Molecular Weight	28	Mole fraction	0.632
			1

Therefore Average Molecular Weight 39.0

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.59 kg/m3 Total Flow
Density = 2.36 kg/m3 Acetone vapour

ACETONE From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
69.006	-5599.6	-7.0985	6.2237E-06	2

Temperature 15 °C = 288 K

Vapour Pressure 19548 Pa = 19.5 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Acetone Molecular Weight	58	Mole fraction	0.191
Nitrogen Molecular Weight	28	Mole fraction	0.809
			1

Therefore Average Molecular Weight 33.7

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.44 kg/m3 Total Flow
Density = 2.48 kg/m3 Acetone vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.19	
initial mol fract N2	0.81	
Volume Act	142.9372	
Volume Vol	607.0628	
	750	
Final temp	30	
Final mol fract act	0.37	
Final mol fract N2	0.63	
Volume Act	275.8063	
Volume Vol	474.1937	
	750	
Vapour pressure expansion	21.9%	
Thermal gas expansion	5.2%	
expansion factor	27.1%	

ETHANOL From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
74.475	-7164.3	-7.327	3.1340E-06	2

Temperature 30 °C = 303 K

Vapour Pressure 10443 Pa = 10.4 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Ethanol Molecular Weight	46	Mole fraction	0.102
Nitrogen Molecular Weight	28	Mole fraction	0.898
			1

Therefore Average Molecular Weight 29.8

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.21 kg/m3 Total Flow
Density = 1.87 kg/m3 Ethanol vapour

ETHANOL From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
74.475	-7164.3	-7.327	3.1340E-06	2

Temperature 15 °C = 288 K

Vapour Pressure 4300 Pa = 4.3 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Ethanol Molecular Weight	46	Mole fraction	0.042
Nitrogen Molecular Weight	28	Mole fraction	0.958
			1

Therefore Average Molecular Weight 28.8

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.23 kg/m3 Total Flow
Density = 1.97 kg/m3 Ethanol vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.04	
initial mol fract N2	0.96	
Volume Act	31.44251	
Volume Vol	718.5575	
	750	
Final temp	30	
Final mol fract act	0.10	
Final mol fract N2	0.90	
Volume Act	76.35719	
Volume Vol	673.6428	
	750	
Vapour pressure expansion	6.3%	
Thermal gas expansion	5.2%	
expansion factor	11.5%	

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No. :	**200003**	**Date**	**28/10/2020**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
		Rev	**1**
Calculation No:	**200003CAL-002**		

Vapour Density, Mole Fraction & Tank Expansion Factor

METHANOL

C1	C2	C3	C4	C5
81.768	-6876	-8.7078	7.1926E-06	2

Temperature	30	°C
	303	K
Vapour Pressure	21617	Pa
	21.6	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Methanol Molecular Weight	32	Mole fraction	0.211
Nitrogen Molecular Weight	28	Mole fraction	0.789
			1

Therefore Average Molecular Weight 28.8

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.17	kg/m3	Total Flow
Density =	1.30	kg/m3	Methanol vapour

METHANOL From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
81.768	-6876	-8.7078	7.1926E-06	2

Temperature	15	°C
	288	K
Vapour Pressure	9678	Pa
	9.7	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Methanol Molecular Weight	32	Mole fraction	0.094
Nitrogen Molecular Weight	28	Mole fraction	0.906
			1

Therefore Average Molecular Weight 28.4

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.22	kg/m3	Total Flow
Density =	1.37	kg/m3	Methanol vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.09	
initial mol fract N2	0.91	
Volume Act	70.76916	
Volume Vol	679.2308	
	750	
Final temp	30	
Final mol fract act	0.21	
Final mol fract N2	0.79	
Volume Act	158.0642	
Volume Vol	591.9358	
	750	
Vapour pressure expansion	12.9%	
Thermal gas expansion	5.2%	
expansion factor	18.1%	

STYRENE

C1	C2	C3	C4	C5
105.93	-8685.9	-12.42	7.5583E-06	2

Temperature	30	°C
	303	K
Vapour Pressure	1089	Pa
	1.1	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Styrene Molecular Weight	104.15	Mole fraction	0.011
Nitrogen Molecular Weight	28	Mole fraction	0.989
			1

Therefore Average Molecular Weight 28.8

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.17	kg/m3	Total Flow
Density =	4.24	kg/m3	Styrene vapour

STYRENE From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
105.93	-8685.9	-12.42	7.5583E-06	2

Temperature	15	°C
	288	K
Vapour Pressure	430	Pa
	0.4	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Styrene Molecular Weight	104.15	Mole fraction	0.004
Nitrogen Molecular Weight	28	Mole fraction	0.996
			1

Therefore Average Molecular Weight 28.3

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.21	kg/m3	Total Flow
Density =	4.46	kg/m3	Styrene vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.00	
initial mol fract N2	1.00	
Volume Act	3.143507	
Volume Vol	746.8565	
	750	
Final temp	30	
Final mol fract act	0.01	
Final mol fract N2	0.99	
Volume Act	7.96287	
Volume Vol	742.0371	
	750	
Vapour pressure expansion	0.6%	
Thermal gas expansion	5.2%	
expansion factor	5.9%	

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No. :	**200003**	**Date**	**28/10/2020**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
		Rev	**1**
Calculation No:	**200003CAL-002**		

Vapour Density, Mole Fraction & Tank Expansion Factor

VINYL ACETATE

C1	C2	C3	C4	C5
57.406	-5702.8	-5.0307	1.1042E-17	6

Temperature	30	°C	
	303	K	
Vapour Pressure	18946	Pa	
	18.9	kPa	
Tank Pressure	5	"WC	
	1.25	kPag	
System Total	102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

Vinyl Acetate Molecular Weight	86.09	Mole fraction	0.185
Nitrogen Molecular Weight	28	Mole fraction	0.815
			1
Therefore Average Molecular Weight	38.7		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.58	kg/m3	Total Flow
Density =	3.51	kg/m3	Vinyl acetate vapour

VINYL ACETATE From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
57.406	-5702.8	-5.0307	1.1042E-17	6

Temperature	15	°C	
	288	K	
Vapour Pressure	9157	Pa	
	9.2	kPa	
Tank Pressure	5	"WC	
	1.25	kPag	
System Total	102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

Vinyl Acetate Molecular Weight	86.09	Mole fraction	0.089
Nitrogen Molecular Weight	28	Mole fraction	0.911
			1
Therefore Average Molecular Weight	33.2		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.42	kg/m3	Total Flow
Density =	3.69	kg/m3	Vinyl acetate vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.09	
initial mol fract N2	0.91	
Volume Act	66.95524	
Volume Vol	683.0448	
	750	
Final temp	30	
Final mol fract act	0.18	
Final mol fract N2	0.82	
Volume Act	138.5338	
Volume Vol	611.4662	
	750	
Vapour pressure expansion	10.5%	
Thermal gas expansion	5.2%	
expansion factor	15.7%	

METHYL METHACRYLATE

C1	C2	C3	C4	C5
107.36	-8085.3	-12.72	8.3307E-06	2

Temperature	30	°C	
	303	K	
Vapour Pressure	6387	Pa	
	6.4	kPa	
Tank Pressure	5	"WC	
	1.25	kPag	
System Total	102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

MMA Molecular Weight	100.12	Mole fraction	0.062
Nitrogen Molecular Weight	28	Mole fraction	0.938
			1
Therefore Average Molecular Weight	32.5		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.32	kg/m3	Total Flow
Density =	4.08	kg/m3	Metylmetacrylate vapour

METHYL METHACRYLATE From BOC data (Same method as Perry 7th Ed Table 2-6)

C1	C2	C3	C4	C5
107.36	-8085.3	-12.72	8.3307E-06	2

Temperature	15	°C	
	288	K	
Vapour Pressure	2819	Pa	
	2.8	kPa	
Tank Pressure	5	"WC	
	1.25	kPag	
System Total	102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

MMA Molecular Weight	100.12	Mole fraction	0.027
Nitrogen Molecular Weight	28	Mole fraction	0.973
			1
Therefore Average Molecular Weight	30.0		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.28	kg/m3	Total Flow
Density =	4.29	kg/m3	Metylmetacrylate vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.03	
initial mol fract N2	0.97	
Volume Act	20.61324	
Volume Vol	729.3868	
	750	
Final temp	30	
Final mol fract act	0.06	
Final mol fract N2	0.94	
Volume Act	46.70079	
Volume Vol	703.2992	
	750	
Vapour pressure expansion	3.6%	
Thermal gas expansion	5.2%	
expansion factor	8.8%	

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No. :	**200003**	**Date**	**28/10/2020**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
		Rev	**1**
Calculation No:	**200003CAL-002**		

Vapour Density, Mole Fraction & Tank Expansion Factor

BUTYL ACRYLATE

	A	B	C		
	8.141759	2199.925	273.16		
Temperature			30	˚C	
			303	K	
Vapour Pressure			7.68	mmHg	
			1023	Pa	
			1.0	kPa	
Tank Pressure			5	"WC	
			1.25	kPag	
System Total			102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

BA Molecular Weight	128.17	Mole fraction	0.010
Nitrogen Molecular Weight	28	Mole fraction	0.990
			1
Therefore Average Molecular Weight	29.0		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.18	kg/m3	Total Flow
Density =	5.22	kg/m3	Butyl acrylate vapour

BUTYL ACRYLATE From Odor and VOC Control Handbook - H.J Rafson)

	A	B	C		
	8.141759	2199.925	273.16		
Temperature			15	˚C	
			288	K	
Vapour Pressure			3.22	mmHg	
			429	Pa	
			0.4	kPa	
Tank Pressure			5	"WC	
			1.25	kPag	
System Total			102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

BA Molecular Weight	128.17	Mole fraction	0.004
Nitrogen Molecular Weight	28	Mole fraction	0.996
			1
Therefore Average Molecular Weight	28.4		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.22	kg/m3	Total Flow
Density =	5.49	kg/m3	Butyl acrylate vapour

tank vol	1000	m3	
tank empty	0.75		
vap vol	750	m3	
initial temp	15		
initial mol fract act	0.00		
initial mol fract N2	1.00		
Volume Act	3.135541		
Volume Vol	746.8645		
	750		
Final temp	30		
Final mol fract act	0.01		
Final mol fract N2	0.99		
Volume Act	7.482607		
Volume Vol	742.5174		
	750		
Vapour pressure expansion	0.6%		
Thermal gas expansion	5.2%		
expansion factor	5.8%		

METHYL ISOBUTYL CARBINOL (MIBC)

	A	B	C		
	6.63977	1521.88	196.767		
Temperature			30	˚C	
			303	K	
Vapour Pressure			0.85	kPa	
Tank Pressure			5	"WC	
			1.25	kPag	
System Total			102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

MIBC Molecular Weight	102.174	Mole fraction	0.008
Nitrogen Molecular Weight	28	Mole fraction	0.992
			1
Therefore Average Molecular Weight	28.6		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.17	kg/m3	Total Flow
Density =	4.16	kg/m3	Butyl acrylate vapour

METHYL ISOBUTYL CARBINOL (MIBC) From Shell Chemicals Data Sheet

	A	B	C		
	6.63977	1521.88	196.767		
Temperature			15	˚C	
			288	K	
Vapour Pressure			0.28	kPa	
Tank Pressure			5	"WC	
			1.25	kPag	
System Total			102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

MIBC Molecular Weight	102.174	Mole fraction	0.003
Nitrogen Molecular Weight	28	Mole fraction	0.997
			1
Therefore Average Molecular Weight	28.2		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.21	kg/m3	Total Flow
Density =	4.38	kg/m3	Butyl acrylate vapour

tank vol	1000	m3	
tank empty	0.75		
vap vol	750	m3	
initial temp	15		
initial mol fract act	0.00		
initial mol fract N2	1.00		
Volume Act	2.076018		
Volume Vol	747.924		
	750		
Final temp	30		
Final mol fract act	0.01		
Final mol fract N2	0.99		
Volume Act	6.203018		
Volume Vol	743.797		
	750		
Vapour pressure expansion	0.6%		
Thermal gas expansion	5.2%		
expansion factor	5.8%		

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No. :	**200003**	**Date**	**28/10/2020**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
		Rev	**1**
Calculation No:	**200003CAL-002**		

Vapour Density, Mole Fraction & Tank Expansion Factor

Hydrogen Sulphide

Temperature 30 Deg C
303 Deg K

Tank Pressure 6 "WC
1.5 kPag
System Total 102.8 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

H2S Molecular Weight	34	Mole fraction	0.04
Nitrogen Molecular Weight	28	Mole fraction	0.96
			1.00
Therefore Average Molecular Weight	28.2		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.15 Kg/m3 Of Total Flow
Density = 1.39 Kg/m3 Of H2S vapour

Sulphur dioxide

Temperature 30 Deg C
303 Deg K

Tank Pressure 6 "WC
1.5 kPag
System Total 102.8 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

SO2 Molecular Weight 64 Mole fraction

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 2.61 Kg/m3 Of SO2 vapour





Appendix F

Stack Testing Reports

Printed on Recycled Paper.

EML AIR PTY LTD ABN 98 006 878 342
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Our reference: **N90851**

7 May 2013

Terminals Pty Ltd
PO Box 148
MATRAVILLE NSW 2036

Attention Mr Geoff Millard

PORT BOTANY PLANT

Emission Testing Report - APRIL 2013

Tests were performed at the request of Terminals Pty Ltd to determine emissions to air as detailed below;

Test Summary		
Location	Test Date	Test Parameters*
Benzene Combuster	17 April 2013	Total particulate matter, speciated volatile organic compounds (VOC's) including benzene, hydrogen sulfide, sulfur dioxide, nitrogen oxides, carbon monoxide, carbon dioxide, oxygen

* Flow rate, velocity, temperature and moisture were determined unless otherwise stated.

Please refer to the following pages for results, plant operating conditions, test methods, quality assurance / quality control information and definitions.

Heath Thatcher DipAppSc
Client Manager
jw doc:n90851.doc

Zac Xavier BSc BEng
Managing Director

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RESULTS

Date	17/04/2013	**Client**	Terminals Pty Ltd		
Report	N90851	**Stack ID**	Benzene Combustor		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	HT				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested testing to determine emissions to air				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	1300	1.33 m²
Sampling port size, number & depth	4" Flange (x2)	
Access & height of ports	Fixed ladder	12.5 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit cone	2 D
Upstream disturbance	Change in diameter	5 D
No. traverses & points sampled	2	16
Traverse method & compliance	AS4323.1	Compliant but non-ideal

Comments

Flow to Combustor - 670 m³/hr. Online temperature ~990°C

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D

All results reported on a dry basis at NTP

Stack Parameters		
Moisture content, %v/v	1.7	
Gas molecular weight, g/g mole	29.2 (wet)	29.4 (dry)
Gas density at NTP, kg/m³	1.30 (wet)	1.31 (dry)
Gas Flow Parameters		
Temperature, K	1305	
Velocity at sampling plane, m/s	15	
Volumetric flow rate, discharge, m³/s	20	
Volumetric flow rate (wet NTP), m³/s	4.3	
Volumetric flow rate (dry NTP), m³/s	4.2	
Mass flow rate (wet basis), kg/hour	20000	
Velocity difference, %	<1	

Isokinetic	Results	
Sampling time	1045-1205	
	Concentration mg/m³	Mass Rate g/s
Total particulate matter	<0.83	<0.0035

Hydrogen Sulfide	Results	
Sampling time	1105-1205	
	Concentration mg/m³	Mass Rate g/s
Hydrogen sulfide	<0.0039	<0.000016

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Date	17/04/2013	**Client**	Terminals Pty Ltd		
Report	N90851	**Stack ID**	Benzene Combustor		
Licence No.	-	**Location**	Port Botany	**State**	NSW
EML Staff	HT				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested testing to determine emissions to air				

Gases	Average		Minimum		Maximum	
Sampling time	1025-1125		1025-1125		1025-1125	
	Concentration mg/m³	Mass Rate g/s	Concentration mg/m³	Mass Rate g/s	Concentration mg/m³	Mass Rate g/s
Nitrogen oxides (as NO_2)	260	1.1	68	0.29	440	1.9
Sulfur dioxide	630	2.6	<5.7	<0.024	1200	5.1
Carbon monoxide	44	0.19	11	0.047	210	0.87
	Concentration %		Concentration %		Concentration %	
Carbon dioxide	6.6		5.6		7	
Oxygen	5.6		4.3		6.8	

VOC's (as n-Propane)	Results	
Sampling time	1045-1145	
	Concentration mg/m³	Mass Rate g/s
Total	<0.041	<0.00017

VOC's (speciated)	Results	
Sampling time	1045-1145	
	Concentration mg/m³	Mass Rate g/s
Detection limit[1]	<0.043	<0.00018
Benzene	<0.043	<0.00018

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol
Pentane, Hexane, Heptane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane
Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene
Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone
Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene
Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

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PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Terminals Pty Ltd's records for complete process conditions.

Testing was performed during benzene ship discharge operations to provide peak load rate between 1045 and 1210 on Wednesday, 17th April 2013

TEST METHODS

Unless otherwise stated, the following methods meet the requirements of the NSW Office of Environment and Heritage (as specified in the Approved Methods *for the Sampling and Analysis of Air Pollutants in New South Wales, January 2007).* All sampling and analysis was performed by EML Air unless otherwise specified. Specific details of the methods are available upon request.

Parameter	NSW Test Method	Reference Method	Uncertainty*	NATA Accredited	
				Sampling	Analysis
Sample Plane Criteria	TM-1	AS 4323.1	-	✓	NA
Flow rate, temperature and velocity	TM-2	USEPA 2	8%, 2%, 7%	✓	NA
Moisture content	TM-22	USEPA 4	8%	✓	✓
Sulfur dioxide	TM-4	USEPA 6C	12%	✓	✓
Hydrogen sulfide	TM-5	USEPA 11	not specified	✓	✓
Nitrogen oxides (NO_x)	TM-11	USEPA 7E	12%	✓	✓
Particulate matter	TM-15	AS 4323.2	5%	✓	✓
Carbon dioxide	TM-24	USEPA 3A	13%	✓	✓
Oxygen	TM-25	USEPA 3A	13%	✓	✓
Speciated volatile organic compounds	TM-34	USEPA 18	19%	✓	✓

* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

AS – Australian Standard
USEPA – United States Environmental Protection Agency
TM - Test Method

QUALITY ASSURANCE / QUALITY CONTROL INFORMATION

EML Air Pty Ltd is accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources (Accreditation number 2732). Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for EML Air at NATA's website www.nata.asn.au.

EML Air is accredited to Australian Standard 17025 – General Requirements for the Competence of Testing and Calibration Laboratories. Australian Standard 17025 requires that a laboratory have a quality system similar to ISO 9002. More importantly it also requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Quality Assurance Manager.

A formal Quality Control program is in place at EML Air to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

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DEFINITIONS

The following symbols and abbreviations may be used in this test report:

NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
BSP	British standard pipe
NA	Not applicable
D	Duct diameter or equivalent duct diameter for rectangular ducts
<	Less than
>	Greater than
≥	Greater than or equal to
~	Approximately

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ABN 74 474 273 172

Date: 28 August 2013

Report No: 130431r

Terminals Pty Ltd
Gate 38B, 45 Friendship Rd
Port Botany NSW 2036

Emission Testing – August 2013
EPA 4 – Benzene Combustor Inlet/Outlet Testing

Dear Mr G Millard,

Tests were performed 10th August 2013 to determine emissions from the Benzene Combustor Inlet and Outlet at the Port Botany plant of Terminals Pty Ltd.

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Yours faithfully
Emission Testing Consultants



David Corbett Ba/BCom
Client Manager

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NATA Accredited Laboratory Number: 14601
This document is issued in accordance with NATA's accreditation requirements.

LICENCE COMPARISON

EPA No.	Location Description	Pollutant	Unit of measure	Licence limit	Test 1 Concentration	Test 1 Concentration (corrected to 3% O_2)	Test 2 Concentration	Test 2 Concentration (corrected to 3% O_2)
4	Benzene Combustor	Solid particles	milligrams per cubic meter (mg/m^3)	50	< 2	< 4	< 2	< 4
		Nitrogen dioxide	milligrams per cubic meter (mg/m^3)	350	54	110	110	210
		Volatile organic compounds (VOCs)	milligrams per cubic meter (mg/m^3)	20	< 0.7	< 2	< 0.7	< 1
		Hydrogen sulphide	milligrams per cubic meter (mg/m^3)	5	< 0.03	< 0.07	< 0.03	< 0.07

Note: All analytes are below the Licence Limit set by the NSW EPA as per licence 1048 (last amended on 6-May-2013). Results for the Benzene Combustor Outlet (stack) have also been corrected to 3% Oxygen as stipulated in Part 3, Schedule 5 of the *Protection of the Environment Operations (Clean Air) Regulation, (NSW)* 2010.

EXECUTIVE SUMMARY

Emission Testing Consultants (ETC) was engaged by Terminals Pty Ltd to perform emission monitoring as required by their NSW EPA Environment Protection Licence (number 1048). Monitoring was performed at 2 locations, twice, for the following parameters:

Discharge point	Selection of sampling positions	Flow rate	Velocity	Temperature	Moisture	**Particulate matter**	Dry gas Density	Molecular weight	**Carbon dioxide (CO2)**	**Oxygen (O2)**	**Carbon monoxide (CO)**	**Nitrogen oxides (NOx) as NO2**	**Sulphur dioxide (SO2)**	**Hydrogen sulphide (H2S)**	**Volatile organic compounds (VOC)**
EPA 4 - Benzene Combustor Outlet	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Benzene Combustor Inlet	✓	✓	✓	✓	✓		✓	✓	✓	✓					✓

Testing commenced approximately half way through the benzene ship discharge period after notification from Terminals Pty Ltd personnel.

The methodologies chosen by ETC are those stipulated by Terminals Pty Ltd Licence (1048). There were no technical issues in terms of sampling on the days of testing. Plant operating conditions have been noted in the report.

RESULTS

Benzene Combustor Inlet (Test 1)

10 August 2013

Flow Results	Measured MW	EPA 4 - Benzene Combustor (Inlet) Test 1130431	
Time of flow test		2100 & 2213	hrs
Stack dimensions at sampling plane		210	mm
Velocity at sampling plane		6.5	m/s
Average temperature		20	°C
Moisture content		< 1	% v/v
Flow rate at discharge conditions		0.22	m³/sec
Flow rate at wet NTP conditions		0.21	m³/sec
Flow rate at dry NTP conditions		0.21	m³/sec
Dry gas density		1.3	kg/m3
Molecular weight of stack gas, dry basis		29	g/g-mole

Volatile Organic Compound (VOC) Results	EPA 4 - Benzene Combustor (Inlet) Test 113043113	**Sampling Times**	**Concentration at NTP**		**Mass rate**	
Hexane		2110-2210	1.8	mg/m3	0.023	g/min
Cyclohexane		2110-2210	1.5	mg/m3	0.019	g/min
n-Butyl Acetate		2110-2210	13	mg/m3	0.16	g/min
Benzene		2110-2210	4,000	mg/m3	51	g/min
Toluene		2110-2210	160	mg/m3	2.0	g/min
m/p-Xylene		2110-2210	6.9	mg/m3	0.088	g/min
Styrene (Vinyl benzene)		2110-2210	2.3	mg/m3	0.030	g/min
o-Xylene		2110-2210	0.85	mg/m3	0.011	g/min
Total VOCs (as n-propane)		2110-2210	2,300	mg/m3	30	g/min

Note: If not listed above, the following compounds were not detected above the analytical range of the instrument. Please contact ETC should you wish to discuss detection limits of specific undetected compounds; Acetone (2-propanone), Propylene Oxide, Acrylonitrile, Methylene Chloride, MEK (2-butanone), Hexane, Ethyl Acetate, 1,2-dichloroethane, Benzene, Carbon tetrachloride, Cyclohexane, Ethyl Acrylate, Trichloroethene (Trichloroethylene,TCE), 1,4-Dioxane, Epichlorohydrin, MIBK (4-methyl-2-pentanone), Toluene, Tetrachloroethene (Perchloroethylene,PCE), n-Butyl Acetate, Chlorobenzene, Ethylbenzene, m/p-xylene, Styrene (Vinyl benzene), o-xylene, Cyclohexanone, Nonane, Isopropylbenzene (Cumene), DIBK (Diisobutyl Ketone), α-Methylstyrene, Decane, Benzyl Chloride (α-chlorotolune), Benzoyl Chloride, Naphthalene, Dodecane

Refer to "SAMPLE PLANE OBSERVATIONS" on page 9.

EPA 4 – Benzene Combustor Outlet (Test 1)

10 August 2013





Flow Results	Measured MW	EPA 4 - Benzene Combustor (Outlet) Test 1130431	
Time of flow test		2055 & 2215	hrs
Stack dimensions at sampling plane		1010	mm
Velocity at sampling plane		9.5	m/s
Average temperature		771	°C
Moisture content		<1	% v/v
Flow rate at discharge conditions		7.6	m³/sec
Flow rate at wet NTP conditions		2.0	m³/sec
Flow rate at dry NTP conditions		2.0	m³/sec

Volatile Organic Compound (VOC) Results	EPA 4 - Benzene Combustor (Outlet) Test 1130431120	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Hexane		2110-2210	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Cyclohexane		2110-2210	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
n-Butyl Acetate		2110-2210	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Benzene		2110-2210	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Toluene		2110-2210	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Ethybenzene		2110-2210	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
m/p-Xylene		2110-2210	< 0.6	mg/m3	< 1	mg/m³	< 0.07	g/min
Styrene (Vinyl benzene)		2110-2210	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
o-Xylene		2110-2210	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Total VOCs (as n-Propane)		2110-2210	< 0.7	mg/m3	< 2	mg/m³	< 0.09	g/min

Note: In addition to those listed above, the following compounds were not detected above the analytical range of the instrument. Please contact ETC should you wish to discuss detection limits of specific undetected compounds; Acetone (2-propanone), Propylene Oxide, Acrylonitrile, Methylene Chloride, MEK (2-butanone), Hexane, Ethyl Acetate, 1,2-dichloroethane, Benzene, Carbon tetrachloride, Cyclohexane, Ethyl Acrylate, Trichloroethene (Trichloroethylene,TCE), 1,4-Dioxane, Epichlorohydrin, MIBK (4-methyl-2-pentanone), Toluene, Tetrachloroethene (Perchloroethylene,PCE), n-Butyl Acetate, Chlorobenzene, Ethylbenzene, m/p-xylene, Styrene (Vinyl benzene), o-xylene, Cyclohexanone, Nonane, Isopropylbenzene (Cumene), DIBK (Diisobutyl Ketone), α-Methylstyrene, Decane, Benzyl Chloride (α- chlorotolune), Benzoyl Chloride, Naphthalene, Dodecane

Non Isokinetic Sampling Results	EPA 4 - Benzene Combustor (Outlet) Test 1130431120	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Hydrogen sulphide		2105-2206	< 0.03	mg/m3	< 0.07	mg/m3	< 0.004	g/min

Refer to "SAMPLE PLANE OBSERVATIONS" on page 9.

EPA 4 – Benzene Combustor Outlet (Test 1)

10 August 2013

Continuous Analyser Results EPA 4 - Benzene Combustor (Outlet) Test 1130431120	**Sampling Times**	**Concentration at NTP**		**Concentration at 3% O2**		**Mass rate**	
Oxygen (dry basis)	2115-2214	12.4	% v/v	-		-	
Carbon dioxide (dry basis)	2115-2214	3.6	% v/v	-		-	
Dry gas density	2115-2214	1.3	kg/m3	-		-	
Molecular weight of stack gas, dry basis	2115-2214	29	g/g-mole	-		-	
Nitrogen oxides as NO_2	2115-2214	54	mg/m3	110	mg/m3	6.4	g/min
Sulphur dioxide as SO_2	2115-2214	64	mg/m3	140	mg/m3	7.6	g/min
Carbon monoxide as CO	2115-2214	< 2	mg/m3	< 5	mg/m3	< 0.3	g/min

Isokinetic Sampling Results EPA 4 - Benzene Combustor (Outlet) Test 1130431120	**Sampling Times**	**Concentration at NTP**		**Concentration at 3% O2**		**Mass rate**	
Solid Particles	2105-2210	< 2	mg/m3	< 4	mg/m3	< 0.2	g/min
No. of sampling points		*12*					
Length of sampling, min		*60*					
Stack gas molecular weight, g/g-mole (wet)		*29*					
Stack gas density, kg/m^3 at wet NTP		*1.3*					

Refer to "SAMPLE PLANE OBSERVATIONS" on page 9.

Benzene Combustor Inlet (Test 2)

10 August 2013

Flow Results	Measured MW	EPA 4 - Benzene Combustor (Inlet) Test 2 130431	
Time of flow test		2320 & 0030	hrs
Stack dimensions at sampling plane		210	mm
Velocity at sampling plane		6.6	m/s
Average temperature		20	°C
Moisture content		<1	% v/v
Flow rate at discharge conditions		0.23	m^3/sec
Flow rate at wet NTP conditions		0.22	m^3/sec
Flow rate at dry NTP conditions		0.22	m^3/sec
Dry gas density		1.3	kg/m3
Molecular weight of stack gas, dry basis		29	g/g-mole

Volatile Organic Compound (VOC) Results	EPA 4 - Benzene Combustor (Inlet) Test 2 13043113	**Sampling Times**	**Concentration at NTP**		**Mass rate**	
Hexane		2325-0025	3.3	mg/m3	0.042	g/min
Cyclohexane		2325-0025	3.1	mg/m3	0.040	g/min
n-Butyl Acetate		2325-0025	9.1	mg/m3	0.12	g/min
Benzene		2325-0025	6,900	mg/m3	89	g/min
Toluene		2325-0025	290	mg/m3	3.8	g/min
Ethybenzene		2325-0025	0.35	mg/m3	0.0045	g/min
m/p-Xylene		2325-0025	10	mg/m3	0.14	g/min
Styrene (Vinyl benzene)		2325-0025	3.3	mg/m3	0.042	g/min
o-Xylene		2325-0025	1.3	mg/m3	0.016	g/min
Total VOCs (as n-Propane)		2325-0025	4,000	mg/m3	52	g/min

Note: If not listed above, the following compounds were not detected above the analytical range of the instrument. Please contact ETC should you wish to discuss detection limits of specific undetected compounds; Acetone (2-propanone), Propylene Oxide, Acrylonitrile, Methylene Chloride, MEK (2-butanone), Hexane, Ethyl Acetate, 1,2-dichloroethane, Benzene, Carbon tetrachloride, Cyclohexane, Ethyl Acrylate, Trichloroethene (Trichloroethylene,TCE), 1,4-Dioxane, Epichlorohydrin, MIBK (4-methyl-2-pentanone), Toluene, Tetrachloroethene (Perchloroethylene,PCE), n-Butyl Acetate, Chlorobenzene, Ethylbenzene, m/p-xylene, Styrene (Vinyl benzene), o-xylene, Cyclohexanone, Nonane, Isopropylbenzene (Cumene), DIBK (Diisobutyl Ketone), α-Methylstyrene, Decane, Benzyl Chloride (α-chlorotolune), Benzoyl Chloride, Naphthalene, Dodecane

Refer to "SAMPLE PLANE OBSERVATIONS" on page 9.

EPA 4 – Benzene Combustor Outlet (Test 2)

10 August 2013





Flow Results	Measured MW	EPA 4 - Benzene Combustor (Outlet) Test 2 130431	
Time of flow test		2320 & 0030	hrs
Stack dimensions at sampling plane		1010	mm
Velocity at sampling plane		11	m/s
Average temperature		866	°C
Moisture content		<1	% v/v
Flow rate at discharge conditions		8.5	m³/sec
Flow rate at wet NTP conditions		2.0	m³/sec
Flow rate at dry NTP conditions		2.0	m³/sec

Volatile Organic Compound (VOC) Results	EPA 4 - Benzene Combustor (Outlet) Test 2 130431120	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Hexane		2325-0025	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Cyclohexane		2325-0025	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
n-Butyl Acetate		2325-0025	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Benzene		2325-0025	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Toluene		2325-0025	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Ethybenzene		2325-0025	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
m/p-Xylene		2325-0025	< 0.6	mg/m3	< 1	mg/m³	< 0.07	g/min
Styrene (Vinyl benzene)		2325-0025	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
o-Xylene		2325-0025	< 0.3	mg/m3	< 0.6	mg/m³	< 0.03	g/min
Total VOCs (as n-Propane)		2325-0025	< 0.7	mg/m3	< 1	mg/m³	< 0.09	g/min

Note: In addition to those listed above, the following compounds were not detected above the analytical range of the instrument. Please contact ETC should you wish to discuss detection limits of specific undetected compounds; Acetone (2-propanone), Propylene Oxide, Acrylonitrile, Methylene Chloride, MEK (2-butanone), Hexane, Ethyl Acetate, 1,2-dichloroethane, Benzene, Carbon tetrachloride, Cyclohexane, Ethyl Acrylate, Trichloroethene (Trichloroethylene,TCE), 1,4-Dioxane, Epichlorohydrin, MIBK (4-methyl-2-pentanone), Toluene, Tetrachloroethene (Perchloroethylene,PCE), n-Butyl Acetate, Chlorobenzene, Ethylbenzene, m/p-xylene, Styrene (Vinyl benzene), o-xylene, Cyclohexanone, Nonane, Isopropylbenzene (Cumene), DIBK (Diisobutyl Ketone), α-Methylstyrene, Decane, Benzyl Chloride (α- chlorotolune), Benzoyl Chloride, Naphthalene, Dodecane

Non Isokinetic Sampling Results	EPA 4 - Benzene Combustor (Outlet) Test 2 130431120	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Hydrogen sulphide		2325-0025	< 0.03	mg/m3	< 0.07	mg/m3	< 0.004	g/min

Refer to "SAMPLE PLANE OBSERVATIONS" on page 9.

EPA 4 – Benzene Combustor Outlet (Test 2)

10 August 2013

Continuous Analyser Results EPA 4 - Benzene Combustor (Outlet) Test 2 130431120	**Sampling Times**	**Concentration at NTP**		**Concentration at 3% O2**		**Mass rate**	
Oxygen (dry basis)	2329-0028	11.6	% v/v	-		-	
Carbon dioxide (dry basis)	2329-0028	4.2	% v/v	-		-	
Dry gas density	2329-0028	1.3	kg/m3	-		-	
Molecular weight of stack gas, dry basis	2329-0028	29	g/g-mole	-		-	
Nitrogen oxides as NO_2	2329-0028	110	mg/m3	210	mg/m3	13	g/min
Sulphur dioxide as SO_2	2329-0028	99	mg/m3	190	mg/m3	12	g/min
Carbon monoxide as CO	2329-0028	< 2	mg/m3	< 5	mg/m3	< 0.3	g/min

Isokinetic Sampling Results EPA 4 - Benzene Combustor (Outlet) Test 2 130431120	**Sampling Times**	**Concentration at NTP**		**Concentration at 3% O2**		**Mass rate**	
Solid Particles	2320-0025	< 2	mg/m3	< 4	mg/m3	< 0.2	g/min
No. of sampling points		*12*					
Length of sampling, min		*60*					
Stack gas molecular weight, g/g-mole (wet)		*29.1*					
Stack gas density, kg/m ^{3} at wet NTP		*1.3*					

Refer to "SAMPLE PLANE OBSERVATIONS" on page 9.

SAMPLING PLANE OBSERVATIONS

EPA 4 – Benzene Combustor Inlet

The sampling plane had 2 x 4 inch flange port(s). The location was determined to be “ideal” as per AS4323.1. It was more than the required 2 duct diameters upstream from a bend. It was more than the required 6 duct diameters downstream from a junction. The sampling plane passed the flow assessment (items (a) to (f) of AS4323.1) and was therefore “compliant”.

EPA 4 – Benzene Combustor Outlet

The sampling plane had 2 x 4 inch flange port(s). The location was determined to be “ideal” as per AS4323.1. It was more than the required 2 duct diameters upstream from the exit. It was more than the required 6 duct diameters downstream from a junction. The sampling plane passed the flow assessment (items (a) to (f) of AS4323.1) and was therefore “compliant”.

PLANT OPERATING CONDITIONS

Plant operating conditions were supplied by Terminals Pty Ltd personnel. Plant operating conditions were representative of stable operation for the duration of sampling.

Testing was performed during the benzene (BTX) ship loading operation at a time deemed to provide peak load rate.

Test 1 was performed when the Benzene combustor was operating with a combustion zone temperature set point of 790 °C.

Test 2 was performed when the Benzene combustor was operating with a combustion zone temperature set point of 890 °C.

TEST METHODS

The following methods are accredited with the National Association of Testing Authorities (NATA) and are approved for the sampling and analysis of gases unless otherwise stated. Specific details of the methods are available on request.

All sampling and analysis will be conducted in accordance with the test methods (TM) prescribed in NSW EPA's *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales,* Jan 2007 and in accordance with the *Protection of the Environment Operations (Clean Air) Regulation* 2010 unless otherwise specified.

All parameters are reported adjusted to dry NTP conditions unless otherwise stated.

Parameter	Sampling			Analysis			
	NATA	NSW TM Method	Sampling Method	NATA	Analytical Laboratory	Analytical Method	Analytical Laboratory Report Number(s)
Selection of sampling positions	Yes	TM-1	AS4323.1	Yes	NA	NA	130431r
Flow rate	Yes	TM-2	USEPA 2	Yes	NA	NA	130431r
Velocity	Yes	TM-2	USEPA 2	Yes	NA	NA	130431r
Temperature	Yes	TM-2	USEPA 2	Yes	NA	NA	130431r
Moisture	Yes	TM-22	USEPA 4	Yes	NA	NA	130431r
Particulate matter	Yes	TM-15	USEPA 5	Yes	Emission Testing Consultants	USEPA 5	130431r
Dry gas Density	Yes	TM-23	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	130431r
Molecular weight	Yes	TM-23	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	130431r
Carbon dioxide (CO_2)	Yes	TM-24	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	130431r
Oxygen (O_2)	Yes	TM-25	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	130431r
Carbon monoxide (CO)	Yes	TM-32	USEPA 10	Yes	Emission Testing Consultants	USEPA 10	130431r
Nitrogen oxides (NO_x) as NO_2	Yes	TM-11	USEPA 7E	Yes	Emission Testing Consultants	USEPA 7E	130431r
Sulphur dioxide (SO_2)	Yes	TM-4	USEPA 6C	Yes	Emission Testing Consultants	USEPA 6C	130431r
Hydrogen sulphide (H_2S)	Yes	TM-5	USEPA 11	Yes	MGT-LabMark Environmental Pty Ltd	USEPA 11	389203-A
Volatile organic compounds (VOC)	Yes	TM-34	USEPA 18	Yes	SGS Australia Pty Ltd	AN467	63138

DEFINITIONS

The following symbols and abbreviations are used in test reports:

BSP	British standard pipe.
Concentration	Mass of analyte per cubic metre expressed at NTP dry conditions (ng, µg or mg/m^3).
Flow rate at discharge conditions	Volume of gas flow per unit time expressed at discharge temperature, pressure and moisture content (m^3/min).
Flow rate at wet NTP conditions	Volume of gas flow per unit time expressed at 0°C, an absolute pressure of 101.325 kPa and discharge moisture content (m^3/min).
Flow rate at dry NTP conditions	Volume of gas flow per unit time expressed at 0°C, an absolute pressure of 101.325 kPa and 0% moisture content (m^3/min).
Mass rate	Mass of analyte per unit time (µg, mg or g/min).
Moisture content	Percentage of gaseous moisture in the gas expressed on a volume / volume percentage basis. This does not include moisture in the gas stream that is in the liquid phase (free moisture).
NA	Not applicable.
NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
ppm	Parts per million expressed on a volume / volume wet basis.
Sampling plane	Location at which measurements were conducted.
Velocity	Gas velocity expressed at discharge temperature, pressure and moisture content (m/s)
VOC	Any chemical compound based on carbon in the boiling range 36 to 126°C, with a vapour pressure of at least 0.010kPa at 25°C (or having a corresponding volatility under the particular conditions of use) that adsorb onto activated charcoal and desorb into CS_2, or that can be collected in a tedlar bag and be quantitatively recovered, and that are detected by GCMS. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are CO, CO_2, carbonic acid, metallic carbides and carbonate salts.
>	Greater than.

<	Less than the minimum limit of detection using the specified method.
~	Approximately.

Template version 240403

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Emission Testing – July 2013
EPA 4 – Benzene Combustor

Dear Mr G Millard,

Tests were performed 5th July 2013 to determine emissions to air from the Benzene Combustor at the Port Botany plant of Terminals Pty Ltd.

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Yours faithfully
Emission Testing Consultants



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Client Manager

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NATA Accredited Laboratory Number: 14601
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NATA

LICENCE COMPARISON

EPA No.	Location Description	Pollutant	Unit of measure	Licence limit	Detected values	Detected values (corrected to 3% O_2)
4	Benzene Combustor	Solid particles	milligrams per cubic meter (mg/m^3)	50	< 3	< 4
		Nitrogen dioxide	milligrams per cubic meter (mg/m^3)	350	59	88
		Volatile organic compounds (VOCs)	milligrams per cubic meter (mg/m^3)	20	< 0.9	< 1
		Hydrogen sulphide	milligrams per cubic meter (mg/m^3)	5	< 2	< 3

Note: All analytes are below the Licence Limit set by the NSW EPA as per licence 1048 (last amended on 6-May-2013). Results have also been corrected to 3% Oxygen as stipulated in Part 3, Schedule 5 of the *Protection of the Environment Operations (Clean Air) Regulation, (NSW)* 2010.

EXECUTIVE SUMMARY

Emission Testing Consultants (ETC) was engaged by Terminals Pty Ltd to perform emission monitoring as required by their NSW EPA Environment Protection Licence (number 1048). Monitoring was performed on EPA Point 4 – Benzene Combustor for the following parameters:

- Flow rate
- Velocity
- Temperature
- Moisture
- Solid particles
- Dry gas Density
- Molecular weight
- Carbon dioxide (CO_2)
- Oxygen (O_2)
- Carbon monoxide (CO)
- Nitrogen oxides (NO_x) as NO_2
- Sulphur dioxide (SO_2)
- Hydrogen sulphide (H_2S)
- Volatile organic compounds (VOC)

Testing commenced half way through the benzene ship discharge period after notification from Terminals Pty Ltd personnel.

The methodologies chosen by ETC are those stipulated by Terminals Pty Ltd Licence (1048). There were no technical issues in terms of sampling on the days of testing. Plant operating conditions have been noted in the report.

RESULTS

EPA 4 – Benzene Combustor

5 July 2013





Flow Results	Measured MW	EPA 4 - Benzene Combustor 130224	
Time of flow test		1150 & 1315	hrs
Stack dimensions at sampling plane		1010	mm
Velocity at sampling plane		7.3	m/s
Average temperature		954	°C
Moisture content		0.91	% v/v
Flow rate at discharge conditions		5.9	m³/sec
Flow rate at wet NTP conditions		1.3	m³/sec
Flow rate at dry NTP conditions		1.3	m³/sec

Continuous Analyser Results	EPA 4 - Benzene Combustor 130224 78	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Oxygen (dry basis)		1200-1259	8.9	% v/v	-		-	
Carbon dioxide (dry basis)		1200-1259	4.8	% v/v	-		-	
Dry gas density		1200-1259	1.3	kg/m3	-		-	
Molecular weight of stack gas, dry basis		1200-1259	29	g/g-mole	-		-	
Nitrogen oxides as NO_2		1200-1259	59	mg/m3	88	mg/m3	4.6	g/min
Sulphur dioxide as SO_2		1200-1259	51	mg/m3	75	mg/m3	3.9	g/min
Carbon monoxide as CO		1200-1259	11	mg/m3	16	mg/m3	0.86	g/min

EPA 4 – Benzene Combustor

5 July 2013

Isokinetic Sampling Results	EPA 4 - Benzene Combustor 130224 78	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Solid Particles		1155-1301	< 3	mg/m3	< 4	mg/m3	< 0.2	g/min
No. of sampling points			*12*					
Length of sampling, min			*60*					
Stack gas molecular weight, g/g-mole (wet)			*29*					
Stack gas density, kg/m3, at wet NTP			*1.3*					

Non Isokinetic Sampling Results	EPA 4 - Benzene Combustor 130224 78	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Hydrogen sulphide		1201-1311	< 2	mg/m3	< 3	mg/m3	< 0.2	g/min

Volatile Organic Compound (VOC) Results	EPA 4 - Benzene Combustor 130224 78	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Benzene		1210-1310	< 0.4	mg/m3	< 0.5	mg/m³	< 0.03	g/min
Total VOCs (as n-Propane)		1210-1310	< 0.9	mg/m3	< 1	mg/m³	< 0.07	g/min

Note: If not listed above, the following compounds were not detected above the analytical range of the instrument. Please contact ETC should you wish to discuss detection limits of specific undetected compounds; Acetone (2-propanone), Propylene Oxide, Acrylonitrile, Methylene Chloride, MEK (2-butanone), Hexane, Ethyl Acetate, 1,2-dichloroethane, Benzene, Carbon tetrachloride, Cyclohexane, Ethyl Acrylate, Trichloroethene (Trichloroethylene,TCE), 1,4-Dioxane, Epichlorohydrin, MIBK (4-methyl-2-pentanone), Toluene, Tetrachloroethene (Perchloroethylene,PCE), n-Butyl Acetate, Chlorobenzene, Ethylbenzene, m/p-xylene, Styrene (Vinyl benzene), o-xylene, Cyclohexanone, Nonane, Isopropylbenzene (Cumene), DIBK (Diisobutyl Ketone), α-Methylstyrene, Decane, Benzyl Chloride (α-chlorotolune), Benzoyl Chloride, Naphthalene, Dodecane

Refer to "SAMPLE PLANE OBSERVATIONS" on page 5.

SAMPLING PLANE OBSERVATIONS

EPA 4 – Benzene Combustor

The sampling plane had 2 x 4 inch flange port(s). The location was determined to be "ideal" as per AS4323.1. It was more than the required 2 duct diameters upstream from the exit. It was more than the required 6 duct diameters downstream from a junction. The sampling plane passed the flow assessment (items (a) to (f) of AS4323.1) and was therefore "compliant".

PLANT OPERATING CONDITIONS

Plant operating conditions were supplied by Terminals Pty Ltd personnel.
Plant operating conditions were representative of typical operation for the duration of sampling.
Testing was performed during a benzene (BTX) ship loading operation to provide peak load rate between 1200 to 1259 PM on Friday, 5th July 2013.

TEST METHODS

The following methods are accredited with the National Association of Testing Authorities (NATA) and are approved for the sampling and analysis of gases unless otherwise stated. Specific details of the methods are available on request.

All sampling and analysis will be conducted in accordance with the test methods (TM) prescribed in NSW EPA's *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales,* Jan 2007 and in accordance with the *Protection of the Environment Operations (Clean Air) Regulation* 2010 unless otherwise specified.

All parameters are reported adjusted to dry NTP conditions unless otherwise stated.

Parameter	NSW TM Method	Sampling Method	NATA	Analytical Laboratory	Analytical Method	NATA	Analytical Laboratory NATA accreditaion number	Analytical Laboratory Report Number(s)	Analytical Laboratory Report Date(s)
Selection of sampling positions	TM-1	AS4323.1	Yes	NA	NA	Yes	14601	130224r	5/07/2013
Flow rate	TM-2	USEPA 2	Yes	NA	NA	Yes	14601		
Velocity	TM-2	USEPA 2	Yes	NA	NA	Yes	14601		
Temperature	TM-2	USEPA 2	Yes	NA	NA	Yes	14601		
Moisture	TM-22	USEPA 4	Yes	NA	NA	Yes	14601		
Solid particles	TM-15	AS4323.2	Yes	Emission Testing Consultants	AS4323.2	Yes	14601		
Dry gas Density	TM-23	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	Yes	14601		
Molecular weight	TM-23	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	Yes	14601		
Carbon dioxide (CO_2)	TM-24	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	Yes	14601		
Oxygen (O_2)	TM-25	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	Yes	14601		
Carbon monoxide (CO)	TM-32	USEPA 10	Yes	Emission Testing Consultants	USEPA 10	Yes	14601		
Nitrogen oxides (NO_x) as NO_2	TM-11	USEPA 7E	Yes	Emission Testing Consultants	USEPA 7E	Yes	14601		
Sulphur dioxide (SO_2)	TM-4	USEPA 6C	Yes	Emission Testing Consultants	USEPA 6C	Yes	14601		
Hydrogen sulphide (H_2S)	TM-5	USEPA 11	Yes	SGS Australia Pty Ltd	AN513	Yes	2562(4354)	60654	12/07/2013
Volatile organic compounds (VOC)	TM-34	USEPA 18	Yes	SGS Australia Pty Ltd	AN467	Yes	2562(4354)	60654	12/07/2013

DEFINITIONS

The following symbols and abbreviations are used in test reports:

BSP	British standard pipe.
Concentration	Mass of analyte per cubic metre expressed at NTP dry conditions (ng, µg or mg/m^3).
Flow rate at discharge conditions	Volume of gas flow per unit time expressed at discharge temperature, pressure and moisture content (m^3/min).
Flow rate at wet NTP conditions	Volume of gas flow per unit time expressed at 0°C, an absolute pressure of 101.325 kPa and discharge moisture content (m^3/min).
Flow rate at dry NTP conditions	Volume of gas flow per unit time expressed at 0°C, an absolute pressure of 101.325 kPa and 0% moisture content (m^3/min).
Mass rate	Mass of analyte per unit time (µg, mg or g/min).
Moisture content	Percentage of gaseous moisture in the gas expressed on a volume / volume percentage basis. This does not include moisture in the gas stream that is in the liquid phase (free moisture).
NA	Not applicable.
NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
ppm	Parts per million expressed on a volume / volume wet basis.
Sampling plane	Location at which measurements were conducted.
Velocity	Gas velocity expressed at discharge temperature, pressure and moisture content (m/s)
VOC	Any chemical compound based on carbon in the boiling range 36 to 126°C, with a vapour pressure of at least 0.010kPa at 25°C (or having a corresponding volatility under the particular conditions of use) that adsorb onto activated charcoal and desorb into CS_2, or that can be collected in a tedlar bag and be quantitatively recovered, and that are detected by GCMS. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are CO, CO_2, carbonic acid, metallic carbides and carbonate salts.
>	Greater than.

<	Less than the minimum limit of detection using the specified method.
~	Approximately.

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Emission Testing – May 2014
EPA 4 – Benzene Combustor

Dear Mr Michael Selleck,

Tests were performed 22 May 2014 to determine emissions to air from the Benzene Combustor at the 45 Friendship Rd plant of Terminals Pty Ltd.

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DEFINITIONS 6

Yours faithfully
Emission Testing Consultants



Steven Cooper BEng (Env)
Quality Manager

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NATA Accredited Laboratory Number: 14601
This document is issued in accordance with NATA's accreditation requirements.
NATA

LICENCE COMPARISON

EPA No.	Location Description	Pollutant	Unit of measure	Licence limit	Detected Values	Detected Values (corrected to 3% O_2)
4	Benzene Combustor	Solid Particles	milligrams per cubic meter (mg/m^3)	50	<4	<7
		Nitrogen oxides (as NO_2)	milligrams per cubic meter (mg/m^3)	350	78	130
		Volatile organic compounds (VOCs)	milligrams per cubic meter (mg/m^3)	20	<0.7	<1
		Hydrogen Sulphide (H2S)	milligrams per cubic meter (mg/m^3)	5	<2	<4

Note: All analytes highlighted in green are below the Licence Limit set by the NSW EPA as per licence 1048 (last amended on **13/09/2013**).

EXECUTIVE SUMMARY

Emission Testing Consultants (ETC) was engaged by Terminals Pty Ltd to perform emission monitoring as required by their NSW EPA Environment Protection Licence (number 1048). Monitoring was performed at the Benzene Combustor (Outlet), for the following parameters:

Discharge point	Selection of sampling positions	Flow rate	Velocity	Temperature	Moisture	**Particulate matter**	Dry gas Density	Molecular weight	**Carbon dioxide (CO2)**	**Oxygen (O2)**	**Carbon monoxide (CO)**	**Nitrogen oxides (NOx) as NO2**	**Sulphur dioxide (SO2)**	**Hydrogen sulphide (H2S)**	**Volatile organic compounds (VOC)**
EPA 4 - Benzene Combustor	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Testing commenced approximately half way through the benzene ship loading period after notification from Terminals Pty Ltd personnel.

The methodologies chosen by ETC are those stipulated by Terminals Pty Ltd Licence (1048). There were no technical issues in terms of sampling on the days of testing. Plant operating conditions have been noted in the report.

RESULTS

EPA 4 – Benzene Combustor

22 May 2014





Flow Results	Measured MW	EPA 4 - Benzene Combustor 140239	
Date and time of flow test		22/05/2014 11:47	
Date and time of flow test		22/05/2014 12:58	
Stack dimensions at sampling plane		1010	mm
Velocity at sampling plane		4.1	m/s
Average temperature		747	°C
Moisture content	Alt008	2.3	% v/v
Flow rate at discharge conditions		3.3	m³/sec
Flow rate at wet NTP conditions		0.89	m³/sec
Flow rate at dry NTP conditions		0.87	m³/sec

Isokinetic Sampling Results	EPA 4 - Benzene Combustor 140239 52	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Solid Particles		1153-1255	< 4	mg/m3	< 7	mg/m3	< 0.2	g/min
No. of sampling points			*12*					
Length of sampling, min			*60*					
Stack gas molecular weight, g/g-mole (wet)			*28.8*					
Stack gas density, at wet NTP			*1.29*					

Continuous Analyser Results	EPA 4 - Benzene Combustor 140239 52	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Oxygen (dry basis)		1155-1254	10.5	% v/v	-		-	
Carbon dioxide (dry basis)		1155-1254	3.9	% v/v	-		240	kg/hour
Dry gas density		1155-1254	1.3	kg/m3	-		-	
Molecular weight of stack gas, dry basis		1155-1254	29	g/g-mole	-		-	
Nitrogen oxides as NO_2		1155-1254	78	mg/m3	130	mg/m3	4.1	g/min
Sulphur dioxide as SO_2		1155-1254	46	mg/m3	78	mg/m3	2.4	g/min
Carbon monoxide as CO		1155-1254	9.4	mg/m3	16	mg/m3	0.49	g/min

EPA 4 – Benzene Combustor

22 May 2014

Manual Sampling Results	EPA 4 - Benzene Combustor 140239 52	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Hydrogen sulphide		1153-1253	< 2	mg/m3	< 4	mg/m3	< 0.1	g/min

Volatile Organic Compound (VOC) Results	EPA 4 - Benzene Combustor 140239 52	Sampling Times	Concentration at NTP		Concentration at 3% O2		Mass rate	
Total VOC as n-propane		1153-1253	< 0.7	mg/m3	< 1	mg/m3	< 0.04	g/min

Note: If not listed above, the following compounds were not detected above the analytical range of the instrument. Please contact ETC should you wish to discuss detection limits of specific undetected compounds; Acetone (2-propanone), Propylene Oxide, Acrylonitrile, Methylene Chloride, MEK (2-butanone), Hexane, Ethyl Acetate, 1,2-dichloroethane, Benzene, Carbon tetrachloride, Cyclohexane, Ethyl Acrylate, Trichloroethene (Trichloroethylene,TCE), 1,4-Dioxane, Epichlorohydrin, MIBK (4-methyl-2-pentanone), Toluene, Tetrachloroethene (Perchloroethylene,PCE), n-Butyl Acetate, Chlorobenzene, Ethylbenzene, m/p-xylene, Styrene (Vinyl benzene), o-xylene, Cyclohexanone, Nonane, Isopropylbenzene (Cumene), DIBK (Diisobutyl Ketone), α-Methylstyrene, Decane, Benzyl Chloride (α-chlorotolune), Benzoyl Chloride, Naphthalene, Dodecane

Refer to "SAMPLING PLANE OBSERVATIONS" on page 5.

SAMPLING PLANE OBSERVATIONS

EPA 4 – Benzene Combustor (Outlet)

The sampling plane had 2 x 4 inch flange port(s). The location was determined to be "ideal" as per AS4323.1. It was more than the required 2 duct diameters upstream from the exit. It was more than the required 6 duct diameters downstream from a junction. The sampling plane passed the flow assessment (items (a) to (f) of AS4323.1) and was therefore "compliant".

PLANT OPERATING CONDITIONS

Plant operating conditions were supplied by Terminals Pty Ltd personnel. Testing was performed during the benzene (BTX) loading operation of the ship "Golden Accord" at a time deemed to provide peak load rate.

TEST METHODS

The following methods are accredited with the National Association of Testing Authorities (NATA) and are approved for the sampling and analysis of gases unless otherwise stated. Specific details of the methods are available on request.

All sampling and analysis was conducted in accordance with the test methods (TM) prescribed in NSW EPA's *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales,* Jan 2007 and in accordance with the *Protection of the Environment Operations (Clean Air) Regulation* 2010 unless otherwise specified.

All parameters are reported adjusted to dry NTP conditions unless otherwise stated.

Parameter	Sampling			Analysis			
	NATA	NSW TM Method	Sampling Method	NATA	Analytical Laboratory	Analytical Method	Analytical Laboratory Report Number(s)
Selection of sampling positions	Yes	TM-1	AS4323.1	Yes	NA	NA	140239r
Flow rate	Yes	TM-2	USEPA 2	Yes	NA	NA	140239r
Velocity	Yes	TM-2	USEPA 2	Yes	NA	NA	140239r
Temperature	Yes	TM-2	USEPA 2	Yes	NA	NA	140239r
Moisture	Yes	TM-22	USEPA 4	Yes	NA	NA	140239r
Particulate matter	Yes	TM-15	USEPA 5	Yes	Emission Testing Consultants	USEPA 5	140239r
Dry gas Density	Yes	TM-23	USEPA 3	Yes	Emission Testing Consultants	USEPA 3	140239r
Molecular weight	Yes	TM-23	USEPA 3	Yes	Emission Testing Consultants	USEPA 3	140239r
Carbon dioxide (CO_2)	Yes	TM-24	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	140239r
Oxygen (O_2)	Yes	TM-25	USEPA 3A	Yes	Emission Testing Consultants	USEPA 3A	140239r
Carbon monoxide (CO)	Yes	TM-32	USEPA 10	Yes	Emission Testing Consultants	USEPA 10	140239r
Nitrogen oxides (NO_x) as NO_2	Yes	TM-11	USEPA 7E	Yes	Emission Testing Consultants	USEPA 7E	140239r
Sulphur dioxide (SO_2)	Yes	TM-4	USEPA 6C	Yes	Emission Testing Consultants	USEPA 6C	140239r
Hydrogen sulphide (H_2S)	Yes	TM-5	USEPA 11	Yes	SGS Australia Pty Ltd	USEPA 11	SE128239 R0
Volatile organic compounds (VOC)	Yes	TM-34	USEPA 18	Yes	SGS Australia Pty Ltd	AN467	SE128239 R0

DEFINITIONS

The following symbols and abbreviations are used in test reports:

Concentration	Mass of analyte per cubic metre expressed at NTP dry conditions (ng, µg or mg/m^3).
Flow rate at discharge conditions	Volume of gas flow per unit time expressed at discharge temperature, pressure and moisture content (m^3/min).
Flow rate at wet NTP conditions	Volume of gas flow per unit time expressed at 0°C, an absolute pressure of 101.325 kPa and discharge moisture content (m^3/min).
Flow rate at dry NTP conditions	Volume of gas flow per unit time expressed at 0°C, an absolute pressure of 101.325 kPa and 0% moisture content (m^3/min).
Mass rate	Mass of analyte per unit time (µg, mg or g/min).
Moisture content	Percentage of gaseous moisture in the gas expressed on a volume / volume percentage basis. This does not include moisture in the gas stream that is in the liquid phase (free moisture).
NA	Not applicable.
NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Sampling plane	Location at which measurements were conducted.
Velocity	Gas velocity expressed at discharge temperature, pressure and moisture content (m/s)
VOC	Any chemical compound based on carbon in the boiling range 36 to 126°C, with a vapour pressure of at least 0.010kPa at 25°C (or having a corresponding volatility under the particular conditions of use) that adsorb onto activated charcoal and desorb into CS_2, or that can be collected in a tedlar bag and be quantitatively recovered, and that are detected by GCMS. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are CO, CO_2, carbonic acid, metallic carbides and carbonate salts.
>	Greater than.
<	Less than the minimum limit of detection using the specified method.
~	Approximately.

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Report Number R002024

Emission Testing Report

EPA 4 - Benzene Combustor

Terminals Pty Ltd, Port Botany





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and those granted permission by Terminals Pty Ltd.

Document Information

Client Name:	Terminals Pty Ltd
Report Number:	R002024
Date of Issue:	17 December 2015
Attention:	Michael Selleck
Address:	Gate 38B, 45 Friendship Rd PORT BOTANY NSW 2036
Testing Laboratory:	Ektimo (ETC) ABN 74 474 273 172

Report Status

Format	Document Number	Report Date	Prepared By	Reviewed By (1)	Reviewed By (2)
Preliminary Report	-	-	-	-	-
Draft Report	-	-	-	-	-
Final Report	R002024	17/12/2015	JKr	SCo	ADa
Amend Report	-	-	-	-	-

Template Version: 151203

Amendment Record

Document Number	Initiator	Report Date	Section	Reason
Nil	-	-	-	-

Report Authorisation

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NATA Accredited Laboratory
No. 14601

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Accredited for compliance with ISO/IEC 17025. NATA is a signatory to the ILAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports

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5 Test Methods 7

6 Quality Assurance/ Quality Control Information 7

7 Definitions 8

1 EXECUTIVE SUMMARY

Ektimo was engaged by Terminals Pty Ltd to perform emission monitoring as required by their NSW EPA Environment Protection Licence (number 1048).

Results from the testing program indicate that Terminals Pty Ltd was within the requirements of the Licence during the sampling period.

Monitoring was performed as follows;

Location	Test Date	Test Parameters*
EPA 4 – Benzene Combustor	2 December 2015	Solid particles, carbon dioxide, oxygen, carbon monoxide, nitrogen oxides, sulfur dioxide, hydrogen sulfide, speciated volatile organic compounds

* Flow rate, velocity, temperature and moisture were determined unless otherwise stated

Testing commenced approximately half way through the benzene ship loading period after notification from Terminals Pty Ltd personnel.

The methodologies chosen by Ektimo are those recommended by the NSW Office of Environment and Heritage (as specified in the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales, January 2007).

Plant operating conditions have been noted in the report.

2 RESULTS SUMMARY

The following licence comparison table shows that all analytes highlighted in green are below the licence limit set by the NSW EPA as per licence 1048 (last amended on 30/07/2014).

EPA No.	Location Description	Parameter	Units	Licence limit	Detected values 2/12/2015	Detected values (corrected to 3% O2) 2/12/2015
4	Benzene Combustor	Solid Particles	mg/m3	50	<1	<1.8
		Nitrogen oxides (as NO2)	mg/m3	350	47	81
		Volatile organic compounds (VOCs)	mg/m3	20	0.25	0.43
		Hydrogen Sulfide (H2S)	mg/m3	5	<0.0043	<0.0075

3 RESULTS

3.1 EPA 4 – Benzene Combustor

Date	2/12/2015	**Client**	Terminals Pty Ltd		
Report	R002024	**Stack ID**	EPA 4 Benzene Combustor Stack		
Licence No.	1048	**Location**	Port Botany	**State**	NSW
Ektimo Staff	Swo/Dhi				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested testing to determine emissions to air				

Sampling Plane Details		
Sampling plane dimensions	1010 mm	
Sampling plane area	0.801 m²	
Sampling port size, number & depth	4" Flange (x2)	
Access & height of ports	Fixed ladder	9 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	3 D
Upstream disturbance	Change in diameter	2 D
No. traverses & points sampled	2	16
Compliance to AS4323.1	Compliant but non-ideal	

Comments
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D

Stack Parameters		
Moisture content, %v/v	12	
Gas molecular weight, g/g mole	28.0 (wet)	29.3 (dry)
Gas density at STP, kg/m³	1.25 (wet)	1.31 (dry)
% Oxygen correction & Factor	3 %	1.72
Gas Flow Parameters		
Temperature, °C	974	
Velocity at sampling plane, m/s	11	
Volumetric flow rate, discharge, m³/s	8.9	
Volumetric flow rate (wet STP), m³/s	2	
Volumetric flow rate (dry STP), m³/s	1.7	
Mass flow rate (wet basis), kg/hour	8800	
Sampling time, min	80	
Isokinetic rate, %	95	
Velocity difference, %	<1	

Isokinetic	Results		
Sampling time	0825-0955		
	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min
Solid particles	<1	<1.8	<0.11

Hydrogen Sulfide	Results		
Sampling time	0835-0935		
	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min
Hydrogen sulfide	<0.0043	<0.0075	<0.00045

Date	2/12/2015	**Client**	Terminals Pty Ltd		
Report	R002024	**Stack ID**	EPA 4 Benzene Combustor Stack		
Licence No.	1048	**Location**	Port Botany	**State**	NSW
Ektimo Staff	Swo/Dhi				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested testing to determine emissions to air				

Gases	Average			Minimum			Maximum		
Sampling time	842-941			842-941			842-941		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min
Nitrogen oxides (as NO_2)	47	81	4.9	12	21	1.3	92	160	9.6
Sulfur dioxide	37	64	3.9	<5.7	<9.8	<0.59	94	160	9.8
Carbon monoxide	13	23	1.4	8.7	15	0.91	19	32	1.9
	Concentration %			Concentration %			Concentration %		
Carbon dioxide	4.7			4.1			5.1		
Oxygen	10.5			8.9			11.9		

Total VOCs* **(as n-Propane)**	Results		
Sampling time	0830-0930		
	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min
Total	0.25	0.42	0.025

*Total VOCs does not include methane

VOC's (speciated)	Results		
Sampling time	0830-0930		
	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min
Detection limit(1)	<0.062	<0.11	<0.0064
Acetone	0.32	0.56	0.034

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol, Pentane, Hexane, Heptane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane, Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene, Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone, Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene, Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

4 PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Terminals Pty Ltd's records for complete process conditions.

5 TEST METHODS

All sampling and analysis was performed by Ektimo unless otherwise specified. Specific details of the methods are available upon request

Parameter	Test Method	Method Detection Limit	Uncertainty*	NATA Accredited	
				Sampling	Analysis
Sample plane criteria	NSW TM-1	NA	-	✓	NA
Velocity	NSW TM-2	$2ms^{-1}$	7%	✓	NA
Temperature	NSW TM-2	0°C	2%	✓	NA
Flow rate	NSW TM-2	Location	8%	✓	NA
Sulfur dioxide	NSW TM-4	$6mg/m^3$	12%	✓	✓
Hydrogen sulfide	NSW TM-5	$0.5mg/m^3$	not specified	✓	✓
Nitrogen oxides (NO_x)	NSW TM-11	$4mg/m^3$	12%	✓	✓
Solid particles	NSW TM-15	$0.001g/m^3$	5%	✓	✓
Moisture content	NSW TM-22	0.40%	8%	✓	✓
Carbon dioxide	NSW TM-24	0.1%	13%	✓	✓
Oxygen	NSW TM-25	0.1%	13%	✓	✓
Carbon monoxide	NSW TM-32	$0.0025g/m^3$	12%	✓	✓
Speciated volatile organic compounds	NSW TM-34	$0.3mg/m^3$	19%	✓	✓

* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

6 QUALITY ASSURANCE/ QUALITY CONTROL INFORMATION

Ektimo (EML) and Ektimo (ETC) are accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources. Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for Ektimo at NATA's website www.nata.com.au.

Ektimo (EML) and Ektimo (ETC) are accredited by NATA (National Association of Testing Authorities) to ISO/IEC 17025. – General Requirements for the Competence of Testing and Calibration Laboratories. ISO/IEC 17025 requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Compliance Manager.

NATA is a member of APLAC (Asia Pacific Laboratory Accreditation Co-operation) and of ILAC (International Laboratory Accreditation Co-operation). Through the mutual recognition arrangements with both of these organisations, NATA accreditation is recognised world –wide.

A formal Quality Control program is in place at Ektimo to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

7 DEFINITIONS

The following symbols and abbreviations may be used in this test report:

STP	Standard temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
TOC	The sum of all compounds of carbon which contain at least one carbon to carbon bond, plus methane and its derivatives.
OU	The number of odour units per unit of volume. The numerical value of the odour concentration is equal to the number of dilutions to arrive at the odour threshold (50% panel response).
$PM_{2.5}$	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 2.5 microns (µm).
PM_{10}	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 10 microns (µm).
BSP	British standard pipe
NT	Not tested or results not required
NA	Not applicable
D_{50}	'Cut size' of a cyclone defined as the particle diameter at which the cyclone achieves a 50% collection efficiency ie. half of the particles are retained by the cyclone and half are not and pass through it to the next stage. The D_{50} method simplifies the capture efficiency distribution by assuming that a given cyclone stage captures all of the particles with a diameter equal to or greater than the D_{50} of that cyclone and less than the D_{50} of the preceding cyclone.
D	Duct diameter or equivalent duct diameter for rectangular ducts
<	Less than
>	Greater than
≥	Greater than or equal to
~	Approximately
CEM	Continuous Emission Monitoring
CEMS	Continuous Emission Monitoring System
DER	WA Department of Environment & Regulation
DECC	Department of Environment & Climate Change (NSW)
EPA	Environment Protection Authority
FTIR	Fourier Transform Infra Red
NATA	National Association of Testing Authorities
RATA	Relative Accuracy Test Audit
AS	Australian Standard
USEPA	United States Environmental Protection Agency
Vic EPA	Victorian Environment Protection Authority
ISC	Intersociety committee, Methods of Air Sampling and Analysis
ISO	International Organisation for Standardisation
APHA	American public health association, Standard Methods for the Examination of Water and Waste Water
CARB	Californian Air Resources Board
TM	Test Method
OM	Other approved method
CTM	Conditional test method
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
NIOSH	National Institute of Occupational Safety and Health
XRD	X-ray Diffractometry

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Report Number R001400

Emission Testing Report

EPA 4 - Benzene Combustor

Terminals Pty Ltd, Port Botany





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and those granted permission by Terminals Pty Ltd.

Document Information

Client Name:	Terminals Pty Ltd
Report Number:	R001400
Date of Issue:	29 July 2015
Attention:	Michael Selleck
Address:	Gate 38B, 45 Friendship Rd PORT BOTANY NSW 2036
Testing Laboratory:	Ektimo (ETC) ABN 74 474 273 172

Report Status

Format	Document Number	Report Date	Prepared By	Reviewed By (1)	Reviewed By (2)
Preliminary Report	-	-	-	-	-
Draft Report	-	-	-	-	-
Final Report	R001400	29 July 2015	JK	AD	SC
Amend Report	-	-	-	-	-

Template Version: 150615

Amendment Record

Document Number	Initiator	Report Date	Section	Reason
Nil	-	-	-	-

Report Authorisation

Steven Cooper
Client Manager

NATA Accredited Laboratory
No. 14601

Aaron Davis
Operations Manager

Accredited for compliance with ISO/IEC 17025. NATA is a signatory to the ILAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports

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1 LICENCE COMPARISON

EPA	Location Description	Parameter	Units	Licence limit	Detected values 21/07/2015	Detected values (corrected to 3% O_2)
4	Benzene Combustor	Solid Particles	mg/m^3	50	**< 0.94**	< 1.5
		Nitrogen oxides (as NO_2)	mg/m^3	350	**84**	140
		Volatile organic compounds (VOCs)	mg/m^3	20	**<0.073**	<0.12
		Hydrogen Sulfide (H_2S)	mg/m^3	5	**0.0035**	0.0056

Note: All analytes highlighted in green are below the Licence Limit set by the NSW EPA as per licence 1048 (last amended on 30/07/2014).

2 EXECUTIVE SUMMARY

Ektimo was engaged by Terminals Pty Ltd to perform emission monitoring as required by their NSW EPA Environment Protection Licence (number 1048).

Monitoring was performed as follows;

Location	Test Date	Test Parameters*
EPA 4 – Benzene Combustor	21 July 2015	Solid particles, carbon dioxide, oxygen, carbon monoxide, nitrogen oxides, sulfur dioxide, hydrogen sulfide, speciated volatile organic compounds

* Flow rate, velocity, temperature and moisture were determined unless otherwise stated

Testing commenced approximately half way through the benzene ship loading period after notification from Terminals Pty Ltd personnel.

It is noted that during sampling (between 1453 and 1508) a hexane truck was connected to the Combustor Inlet.

The methodologies chosen by Ektimo are those recommended by the NSW Office of Environment and Heritage (as specified in the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales, January 2007).

Plant operating conditions have been noted in the report.

3 RESULTS

3.1 EPA 4 – Benzene Combustor

Date	21/07/2015	**Client**	Terminals Pty Ltd		
Report	R001400	**Stack ID**	EPA 4 - Benzene Combustor		
Licence No.	1048	**Location**	Port Botany	**State**	NSW
Ektimo Staff	Sco/Swo				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested testing to determine emissions to air				

Sampling Plane Details			
Sampling plane dimensions	1010 mm		
Sampling plane area	0.801 m²		
Sampling port size, number & depth	4" Flange (x2)		
Access & height of ports	Fixed ladder	9 m	
Duct orientation & shape	Vertical	Circular	
Downstream disturbance	Exit	3 D	
Upstream disturbance	Change in diameter	2 D	
No. traverses & points sampled	2	16	
Compliance to AS4323.1	Compliant but non-ideal		

Comments

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D
Unless otherwise indicated, the methods cited in this report have been performed without deviation
All results reported on a dry basis at STP

Stack Parameters		
Moisture content, %v/v	8.2	
Gas molecular weight, g/g mole	28.4 (wet)	29.3 (dry)
Gas density at STP, kg/m³	1.27 (wet)	1.31 (dry)
% Oxygen correction & Factor	3 %	1.61
Gas Flow Parameters		
Temperature, °C	940	
Velocity at sampling plane, m/s	7.9	
Volumetric flow rate, discharge, m³/s	6.3	
Volumetric flow rate (wet STP), m³/s	1.4	
Volumetric flow rate (dry STP), m³/s	1.3	
Mass flow rate (wet basis), kg/hour	6500	
Sampling time, min	80	
Isokinetic rate, %	107	
Velocity difference, %	-10	

Isokinetic	Results		
Sampling time	1435-1555		
	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min
Solid particles	<0.94	<1.5	<0.074

Non-isokinetics	Results		
Sampling time	1435-1535		
	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min
Hydrogen sulfide	0.0035	0.0056	0.00027

Gases	Average			Minimum			Maximum		
Sampling time	1436-1535			1436-1535			1436-1535		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Nitrogen oxides (as NO_2)	84	140	6.6	51	83	4	180	300	14
Sulfur dioxide	98	160	7.7	74	120	5.8	130	210	10
Carbon monoxide	18	29	1.4	<2.5	<4	<0.19	32	52	2.5
	Concentration %			Concentration %			Concentration %		
Carbon dioxide	4.9			3.4			5.8		
Oxygen	9.8			5.4			13.3		

Date	21/07/2015	**Client**	Terminals Pty Ltd		
Report	R001400	**Stack ID**	EPA 4 - Benzene Combustor		
Licence No.	1048	**Location**	Port Botany	**State**	NSW
Ektimo Staff	Sco/Swo				
Process Conditions	Please refer to client records.				
Reason for testing:	Client requested testing to determine emissions to air				

Total VOC's		Results		
(as n-Propane)	Sampling time	1435-1535		
		Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min
Total		<0.073	<0.12	<0.0057

VOC's (speciated)	Results		
Sampling time	1435-1535		
	Concentration mg/m³	Corrected to 3%O2 mg/m³	Mass Rate g/min
Detection limit(1)	<0.076	<0.12	<0.0059

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol, Pentane, Hexane, Heptane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, Tetradecane, Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene, Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone, Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene, Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

4 PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Terminals Pty Ltd's records for complete process conditions.

5 TEST METHODS

All sampling and analysis was performed by Ektimo unless otherwise specified. Specific details of the methods are available upon request

Parameter	Test Method	Method Detection Limit	Uncertainty*	NATA Accredited	
				Sampling	Analysis
Sample plane criteria	NSW TM-1	NA	-	✓	NA
Velocity	NSW TM-2	$2ms^{-1}$	7%	✓	NA
Temperature	NSW TM-2	0°C	2%	✓	NA
Flow rate	NSW TM-2	Location	8%	✓	NA
Sulfur dioxide	NSW TM-4	$6mg/m^3$	12%	✓	✓
Hydrogen sulfide	NSW TM-5	$0.5mg/m^3$	not specified	✓	✓
Nitrogen oxides (NO_x)	NSW TM-11	$4mg/m^3$	12%	✓	✓
Solid particles	NSW TM-15	$0.001g/m^3$	5%	✓	✓
Moisture content	NSW TM-22	0.40%	8%	✓	✓
Carbon dioxide	NSW TM-24	0.1%	13%	✓	✓
Oxygen	NSW TM-25	0.1%	13%	✓	✓
Carbon monoxide	NSW TM-32	$0.0025g/m^3$	12%	✓	✓
Speciated volatile organic compounds	NSW TM-34	$0.3mg/m^3$	19%	✓	✓

* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

6 QUALITY ASSURANCE/ QUALITY CONTROL INFORMATION

Ektimo (EML), Ektimo (ETC) and Ektimo (ECS) are accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources. Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for Ektimo at NATA's website www.nata.com.au.

Ektimo (EML), Ektimo (ETC) and Ektimo (ECS) are accredited by NATA (National Association of Testing Authorities) to ISO/IEC 17025. – General Requirements for the Competence of Testing and Calibration Laboratories. ISO/IEC 17025 requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Compliance Manager.

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A formal Quality Control program is in place at Ektimo to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

7 DEFINITIONS

The following symbols and abbreviations may be used in this test report:

STP	Standard temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
TOC	The sum of all compounds of carbon which contain at least one carbon to carbon bond, plus methane and its derivatives.
OU	The number of odour units per unit of volume. The numerical value of the odour concentration is equal to the number of dilutions to arrive at the odour threshold (50% panel response).
$PM_{2.5}$	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 2.5 microns (µm).
PM_{10}	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 10 microns (µm).
BSP	British standard pipe
NT	Not tested or results not required
NA	Not applicable
D_{50}	'Cut size' of a cyclone defined as the particle diameter at which the cyclone achieves a 50% collection efficiency ie. half of the particles are retained by the cyclone and half are not and pass through it to the next stage. The D_{50} method simplifies the capture efficiency distribution by assuming that a given cyclone stage captures all of the particles with a diameter equal to or greater than the D_{50} of that cyclone and less than the D_{50} of the preceding cyclone.
D	Duct diameter or equivalent duct diameter for rectangular ducts
<	Less than
>	Greater than
≥	Greater than or equal to
~	Approximately
CEM	Continuous Emission Monitoring
CEMS	Continuous Emission Monitoring System
DER	WA Department of Environment & Regulation
DECC	Department of Environment & Climate Change (NSW)
EPA	Environment Protection Authority
FTIR	Fourier Transform Infra Red
NATA	National Association of Testing Authorities
RATA	Relative Accuracy Test Audit
AS	Australian Standard
USEPA	United States Environmental Protection Agency
Vic EPA	Victorian Environment Protection Authority
ISC	Intersociety committee, Methods of Air Sampling and Analysis
ISO	International Organisation for Standardisation
APHA	American public health association, Standard Methods for the Examination of Water and Waste Water
CARB	Californian Air Resources Board
TM	Test Method
OM	Other approved method
CTM	Conditional test method
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
NIOSH	National Institute of Occupational Safety and Health
XRD	X-ray Diffractometry

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Report Number R002940

Emission Testing Report

EPA 4 – Benzene Combustor

Terminals Pty Ltd, Port Botany





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and those granted permission by Terminals Pty Ltd.

Document Information

Client Name:	Terminals Pty Ltd
Report Number:	R002940
Date of Issue:	15 August 2016
Attention:	Brent Geeves
Address:	Gate 38B, 45 Friendship Rd PORT BOTANY NSW 2036
Testing Laboratory:	Ektimo (ETC) ABN 74 474 273 172

Report Status

Format	Document Number	Report Date	Prepared By	Reviewed By (1)	Reviewed By (2)
Preliminary Report	-	-	-	-	-
Draft Report	R002940[DRAFT]	9/08/2016	JWe	SWo/DHi	SCo
Final Report	R002940	15/08/2016	JWe	SWo/DHi	SCo
Amend Report	-	-	-	-	-

Template Version: 160728

Amendment Record

Document Number	Initiator	Report Date	Section	Reason
Nil	-	-	-	-

Report Authorisation

Steven Cooper
Client Manager

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No. 14601

Accredited for compliance with ISO/IEC 17025. NATA is a signatory to the ILAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports

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1 EXECUTIVE SUMMARY

Ektimo was engaged by Terminals Pty Ltd to perform emission monitoring as required by their NSW EPA Environment Protection Licence (number 1048).

Results from the testing program indicate that Terminals Pty Ltd was within the requirements of the Licence during the sampling period.

Monitoring was performed as follows:

Location	Test Date	Test Parameters*
EPA 4 – Benzene Combustor	1 August 2016	Speciated volatile organic compounds (VOC's), carbon dioxide, oxygen, carbon monoxide, nitrogen oxides

* Flow rate, velocity, temperature and moisture were determined unless otherwise stated

Sampling was conducted when the benzene combustor was treating displaced gas from a BTEX tanker.

The sampling methodologies chosen by Ektimo are those recommended by the NSW Office of Environment and Heritage (as specified in the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales,* January 2007).

All results are reported on a dry basis at STP. Unless otherwise indicated, the methods cited in this report have been performed without deviation.

Plant operating conditions have been noted in the report.

2 RESULTS SUMMARY

The following licence comparison table shows that all analytes highlighted in green are below the licence limit set by the NSW EPA as per licence 1048 (last amended on 23/02/2016).

EPA No.	Location Description	Parameter	Units	Licence limit	Detected values 01-08-16	Detected values (corrected to 3% O2) 01-08-16
4	Benzene Combustor	Nitrogen oxides (as NO_2)	mg/m3	350	190	280
		Volatile organic compounds (VOCs)	mg/m3	20	<0.1	<0.2
		Benzene	mg/m3	1	<0.1	<0.2

3 RESULTS

3.1 EPA 4 – Benzene Combustor

Date	1-08-2016	**Client**	Terminals Pty Ltd		
Report	R002940	**Stack ID**	EPA 4 - Benzene Combustor Stack		
Licence No.	1048	**Location**	Port Botany	**State**	NSW
Ektimo Staff	Scott Woods				
Process Conditions	Please refer to client records.				

Sampling Plane Details		
Sampling plane dimensions	1010 mm	
Sampling plane area	0.801 m²	
Sampling port size, number	4" Flange (x2)	
Access & height of ports	Fixed ladder	9 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Exit	3 D
Upstream disturbance	Change in diameter	2 D
No. traverses & points sampled	2	16
Compliance of sample plane to AS4323.1	Compliant but non-ideal	

Comments

The sampling plane is deemed to be non-ideal or non-compliant due to the following reasons:

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D

Stack Parameters		
Moisture content, %v/v	8.2	
Gas molecular weight, g/g mole	28.7 (wet)	29.6 (dry)
Gas density at STP, kg/m³	1.28 (wet)	1.32 (dry)
% Oxygen correction & Factor	3 %	1.51
Gas Flow Parameters		
Measurement time (hhmm)	1720	
Temperature, °C	781	
Velocity at sampling plane, m/s	8.7	
Volumetric flow rate, discharge, m³/s	7	
Volumetric flow rate (wet STP), m³/s	1.8	
Volumetric flow rate (dry STP), m³/s	1.7	
Mass flow rate (wet basis), kg/hour	8400	

Gases	Average			Minimum			Maximum		
Sampling time	1721-1819			1721-1819			1721-1819		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Nitrogen oxides (as NO_2)	190	280	19	80	120	8	360	550	36
	Concentration %			Concentration %			Concentration %		
Carbon dioxide	7.1			1.2			12.5		
Oxygen	9.1			0.4			18.7		

Total VOCs*	Results		
(as n-Propane) Sampling time	1720-1820		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Total	<0.1	<0.2	<0.01

VOC's (speciated)	Results		
Sampling time	1720-1820		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Detection limit[1]	<0.1	<0.2	<0.01
Benzene	<0.1	<0.2	<0.01

(1) Unless otherwise reported, the following target compounds were found to be below detection:

Ethanol, Isopropanol, Isobutanol, Butanol, 1-Methoxy-2-propanol, Cyclohexanol, 2-Butoxyethanol, Pentane, Hexane, Heptane, Octane, Nonane, Decane, Undecane, Dodecane, Tridecane, TetradecaneTetradecane, Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Isooctane, Methylcyclohexane, alpha-Pinene, beta-Pinene, d-Limonene, 3-Carene3-Carene, Acetone, Methyl ethyl ketone, Ethyl acetate, Isopropyl acetate, Propyl acetate, MIBK, 2-Hexanone, Butyl acetate, 1-Methoxy-2-propyl acetate, Cyclohexanone, Cyclohexanone, Cellosolve acetate, 2-Butoxyethyl acetate, Ethyldiglycol acetate, Diacetone alcohol, Isophorone, Benzene, Toluene, Ethylbenzene, m+p-Xylene, Styrene, o-Xylene, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, alpha-Methylstyrene, alpha-Methylstyrene, tert-Butylbenzene, 1,2,4-Trimethylbenzene, 1,2,3-Trimethylbenzene, m-Diethylbenzene, o-Diethylbenzene, p-Diethylbenzene, Dichloromethane, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, 1,1-Dichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, Trichloroethene, Tetrachloroethene, Tetrachloroethene, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloroethane, Chlorobenzene, Fluorobenzene

4 PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Terminals Pty Ltd's records for complete process conditions.

5 TEST METHODS

All sampling and analysis was performed by Ektimo unless otherwise specified. Specific details of the methods are available upon request.

Parameter	Sampling Method	Analysis Method	Method Detection Limit	Uncertainty*	NATA Accredited	
					Sampling	Analysis
Sample plane criteria	NSW TM-1	NA	NA	-	✓	NA
Moisture content	NSW TM-22	NSW TM-22	0.4%	19%	✓	✓
Temperature	NSW TM-2	NA	0°C	2%	✓	NA
Flow rate	NSW TM-2	NA	Location specific	8%	✓	NA
Velocity	NSW TM-2	NA	$2ms^{-2}$	7%	✓	NA
Nitrogen oxides (NO_x)	NSW TM-11	NSW TM-11	$4mg/m^3$	12%	✓	✓
Carbon monoxide	NSW TM-32	NSW TM-32	$0.0025g/m^3$	12%	✓	✓
Carbon dioxide	NSW TM-24	NSW TM-24	0.1%	13%	✓	✓
Oxygen	NSW TM-25	NSW TM-25	0.1%	13%	✓	✓
Speciated volatile organic compounds (VOC's)	NSW TM-34	USEPA SW-846 8260	$0.33mg/m^3$	19%	✓	✓[1]

* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

1. Analysis performed by Ektimo (EML Air), NATA accreditation number 2732. Results were reported to Ektimo on 4 August 2016 in report number R002940_SVOCs

6 QUALITY ASSURANCE/ QUALITY CONTROL INFORMATION

Ektimo (EML) and Ektimo (ETC) are accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources. Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for Ektimo at NATA's website www.nata.com.au.

Ektimo (EML) and Ektimo (ETC) are accredited by NATA (National Association of Testing Authorities) to ISO/IEC 17025. – General Requirements for the Competence of Testing and Calibration Laboratories. ISO/IEC 17025 requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Compliance Manager.

NATA is a member of APLAC (Asia Pacific Laboratory Accreditation Co-operation) and of ILAC (International Laboratory Accreditation Co-operation). Through the mutual recognition arrangements with both of these organisations, NATA accreditation is recognised world –wide.

A formal Quality Control program is in place at Ektimo to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

7 DEFINITIONS

The following symbols and abbreviations may be used in this test report:

STP	Standard temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
TOC	The sum of all compounds of carbon which contain at least one carbon to carbon bond, plus methane and its derivatives.
OU	The number of odour units per unit of volume. The numerical value of the odour concentration is equal to the number of dilutions to arrive at the odour threshold (50% panel response).
$PM_{2.5}$	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 2.5 microns (µm).
PM_{10}	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 10 microns (µm).
BSP	British standard pipe
NT	Not tested or results not required
NA	Not applicable
D_{50}	'Cut size' of a cyclone defined as the particle diameter at which the cyclone achieves a 50% collection efficiency ie. half of the particles are retained by the cyclone and half are not and pass through it to the next stage. The D_{50} method simplifies the capture efficiency distribution by assuming that a given cyclone stage captures all of the particles with a diameter equal to or greater than the D_{50} of that cyclone and less than the D_{50} of the preceding cyclone.
D	Duct diameter or equivalent duct diameter for rectangular ducts
<	Less than
>	Greater than
≥	Greater than or equal to
~	Approximately
CEM	Continuous Emission Monitoring
CEMS	Continuous Emission Monitoring System
DER	WA Department of Environment & Regulation
DECC	Department of Environment & Climate Change (NSW)
EPA	Environment Protection Authority
FTIR	Fourier Transform Infra Red
NATA	National Association of Testing Authorities
RATA	Relative Accuracy Test Audit
AS	Australian Standard
USEPA	United States Environmental Protection Agency
Vic EPA	Victorian Environment Protection Authority
ISC	Intersociety committee, Methods of Air Sampling and Analysis
ISO	International Organisation for Standardisation
APHA	American public health association, Standard Methods for the Examination of Water and Waste Water
CARB	Californian Air Resources Board
TM	Test Method
OM	Other approved method
CTM	Conditional test method
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
NIOSH	National Institute of Occupational Safety and Health
XRD	X-ray Diffractometry

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Report Number R003447

Emission Testing Report

EPA 4 – Benzene Combustor

Terminals Pty Ltd, Port Botany





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and those granted permission by Terminals Pty Ltd.

Document Information

Client Name:	Terminals Pty Ltd
Report Number:	R003447
Date of Issue:	24 May 2017
Attention:	Adrian Phillips
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Testing Laboratory:	Ektimo (ETC) ABN 74 474 273 172

Report Status

Format	Document Number	Report Date	Prepared By	Reviewed By (1)	Reviewed By (2)
Preliminary Report	-	-	-	-	-
Draft Report	-	-	-	-	-
Final Report	R003447	24/05/2017	JWe	SCo	ADa
Amend Report	-	-	-	-	-

Template Version: 170407

Amendment Record

Document Number	Initiator	Report Date	Section	Reason
Nil	-	-	-	-

Report Authorisation

Steven Cooper
Client Manager

NATA Accredited Laboratory
No. 14601

Accredited for compliance with ISO/IEC 17025. NATA is a signatory to the ILAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.

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1 EXECUTIVE SUMMARY

Ektimo was engaged by Terminals Pty Ltd to perform emission monitoring as required by their NSW EPA Environment Protection Licence (number 1048).

Monitoring was performed as follows:

Location	Test Date	Test Parameters*
EPA 4 – Benzene Combustor	11 May 2017	Speciated volatile organic compounds (VOC's), carbon dioxide, oxygen, carbon monoxide, nitrogen oxides

* Flow rate, velocity, temperature and moisture were determined unless otherwise stated

The sampling methodologies chosen by Ektimo are those recommended by the NSW Office of Environment and Heritage (as specified in the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales, January 2007*).

All results are reported on a dry basis at STP. Unless otherwise indicated, the methods cited in this report have been performed without deviation.

Plant operating conditions have been noted in the report.

2 RESULTS SUMMARY

The following licence comparison table shows that all analytes highlighted in green are below the licence limit set by the NSW EPA as per licence 1048 (last amended on 07/03/2017).

EPA No.	Location Description	Parameter	Units	Licence limit	Detected values 11/05/17	Detected values (corrected to 3% O2) 11/05/17
4	Benzene Combustor	Nitrogen oxides (as NO_2)	mg/m3	350	76	140
		Volatile organic compounds (VOCs)	mg/m3	20	0.28	0.51
		Benzene	mg/m3	1	<0.06	<0.1

3 RESULTS

3.1 EPA 4 – Benzene Combustor

Date	11/05/2017	**Client**	Terminals Pty Ltd
Report	R003447	**Stack ID**	EPA 4 - Benzene Combustor Stack
Licence No.	1048	**Location**	Port Botany
Ektimo Staff	Steven Cooper & Scott Woods	**State**	NSW
Process Conditions	Ship loaded is the Golden Aspirant		

Sampling Plane Details		
Sampling plane dimensions	1010 mm	
Sampling plane area	0.801 m²	
Sampling port size, number	4" Flange (x2)	
Access & height of ports	Fixed ladder 9 m	
Duct orientation & shape	Vertical Circular	
Downstream disturbance	Exit 3 D	
Upstream disturbance	Change in diameter 2 D	
No. traverses & points sampled	2 16	
Sample plane compliance to AS4323.1	Compliant but non-ideal	

Comments
The sampling plane is deemed to be non-ideal or non-compliant due to the following reasons:
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D

Stack Parameters		
Moisture content, %v/v	5.9	
Gas molecular weight, g/g mole	28.7 (wet)	29.3 (dry)
Gas density at STP, kg/m³	1.28 (wet)	1.31 (dry)
% Oxygen correction & Factor	3 %	1.78
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	1235 & 1350	
Temperature, °C	767	
Temperature, K	1040	
Velocity at sampling plane, m/s	5.1	
Volumetric flow rate, discharge, m³/s	4	
Volumetric flow rate (wet STP), m³/s	1.1	
Volumetric flow rate (dry STP), m³/s	1	
Mass flow rate (wet basis), kg/hour	4900	
Velocity difference, %	-9	

Gas Analyser Results	Average			Minimum			Maximum		
Sampling time	1252-1351			1252-1351			1252-1351		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Combustion Gases									
Nitrogen oxides (as NO_2)	76	140	4.6	72	130	4.4	80	140	4.9
Carbon monoxide	3.1	5.4	0.19	<2	<3	<0.1	5	8.9	0.3
		Concentration %			Concentration %			Concentration %	
Carbon dioxide		4.8			4.6			5	
Oxygen		10.8			10.6			11	

Total VOCs (as n-Propane)	Results		
Sampling time	1246-1346		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Total	0.28	0.51	0.017

VOC (speciated)	Results		
Sampling time	1246-1346		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Detection limit[1]	<0.06	<0.1	<0.003
Benzene	<0.06	<0.1	<0.003
Toluene	0.6	1.1	0.036

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, 1,1-Dichloroethene, Dichloromethane, trans-1,2-Dichloroethene, cis-1,2-Dichloroethene, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Benzene, Carbon tetrachloride, Butanol, 1-Methoxy-2-propanol, Trichloroethene, Toluene, 1,1,2-trichloroethane, Tetrachloroethene, Chlorobenzene, Ethylbenzene, m + p-Xylene, Styrene, o-Xylene, 2-Butoxyethanol, 1,1,2,2-Tetrachloroethane, Isopropylbenzene, Propylbenzene, 1,3,5-trimethylbenzene, tert-Butylbenzene, 1,2,4-trimethylbenzene, 1,2,3-trimethylbenzene, Acetone, Pentane, Acrylonitrile, n-Hexane, Methyl ethyl ketone, Ethyl acetate, Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, Isopropyl acetate, 3-Methylhexane, Ethyl acrylate, Heptane, Methyl methacrylate, Propyl acetate, Methylcyclohexane, MIBK, 2-Hexanone, Octane, Butyl acetate, 1-methoxy-2-propyl acetate, Butyl acrylate, Nonane, Cellosolve acetate, alpha-Pinene, beta-Pinene, Decane, 3-Carene, D-Limonene, Undecane, Dodecane, Tridecane, Tetradecane, Residuals as Toluene

4 PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Terminals Pty Ltd's records for complete process conditions. All testing was conducted while the *Golden Aspirant* was being loaded.

5 TEST METHODS

All sampling and analysis was performed by Ektimo unless otherwise specified. Specific details of the methods are available upon request.

Parameter	Sampling Method	Analysis Method	Uncertainty*	NATA Accredited	
				Sampling	Analysis
Sample plane criteria	NSW TM-1	NA	-	✓	NA
Moisture content	NSW TM-22	NSW TM-22	19%	✓	✓
Temperature	NSW TM-2	NA	2%	✓	NA
Flow rate	NSW TM-2	NA	8%	✓	NA
Velocity	NSW TM-2	NA	7%	✓	NA
Nitrogen oxides (NO_x)	NSW TM-11	NSW TM-11	12%	✓	✓
Carbon monoxide	NSW TM-32	NSW TM-32	12%	✓	✓
Carbon dioxide	NSW TM-24	NSW TM-24	13%	✓	✓
Oxygen	NSW TM-25	NSW TM-25	13%	✓	✓
Speciated volatile organic compounds (VOC's)	NSW TM-34	USEPA SW-846 8260	19%	✓	✓[1]

* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

1. Analysis performed by Ektimo (EML Air), NATA accreditation number 2732. Results were reported to Ektimo on 23 May 2017 in report number R003447_VOCs.

6 QUALITY ASSURANCE/ QUALITY CONTROL INFORMATION

Ektimo (EML) and Ektimo (ETC) are accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources. Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for Ektimo at NATA's website www.nata.com.au.

Ektimo (EML) and Ektimo (ETC) are accredited by NATA (National Association of Testing Authorities) to ISO/IEC 17025. – General Requirements for the Competence of Testing and Calibration Laboratories. ISO/IEC 17025 requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Compliance Manager.

NATA is a member of APLAC (Asia Pacific Laboratory Accreditation Co-operation) and of ILAC (International Laboratory Accreditation Co-operation). Through the mutual recognition arrangements with both of these organisations, NATA accreditation is recognised world –wide.

A formal Quality Control program is in place at Ektimo to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

7 DEFINITIONS

The following symbols and abbreviations may be used in this test report:

STP	Standard temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
TOC	The sum of all compounds of carbon which contain at least one carbon to carbon bond, plus methane and its derivatives.
OU	The number of odour units per unit of volume. The numerical value of the odour concentration is equal to the number of dilutions to arrive at the odour threshold (50% panel response).
$PM_{2.5}$	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 2.5 microns (µm).
PM_{10}	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 10 microns (µm).
BSP	British standard pipe
NT	Not tested or results not required
NA	Not applicable
D_{50}	'Cut size' of a cyclone defined as the particle diameter at which the cyclone achieves a 50% collection efficiency ie. half of the particles are retained by the cyclone and half are not and pass through it to the next stage. The D_{50} method simplifies the capture efficiency distribution by assuming that a given cyclone stage captures all of the particles with a diameter equal to or greater than the D_{50} of that cyclone and less than the D_{50} of the preceding cyclone.
D	Duct diameter or equivalent duct diameter for rectangular ducts
<	Less than
>	Greater than
≥	Greater than or equal to
~	Approximately
CEM	Continuous Emission Monitoring
CEMS	Continuous Emission Monitoring System
DER	WA Department of Environment & Regulation
DECC	Department of Environment & Climate Change (NSW)
EPA	Environment Protection Authority
FTIR	Fourier Transform Infra Red
NATA	National Association of Testing Authorities
RATA	Relative Accuracy Test Audit
AS	Australian Standard
USEPA	United States Environmental Protection Agency
Vic EPA	Victorian Environment Protection Authority
ISC	Intersociety committee, Methods of Air Sampling and Analysis
ISO	International Organisation for Standardisation
APHA	American public health association, Standard Methods for the Examination of Water and Waste Water
CARB	Californian Air Resources Board
TM	Test Method
OM	Other approved method
CTM	Conditional test method
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
NIOSH	National Institute of Occupational Safety and Health
XRD	X-ray Diffractometry

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Report Number R004726

Emission Testing Report

EPA 4 – Benzene Combustor

Terminals Pty Ltd, Port Botany





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Document Information

Client Name:	Terminals Pty Ltd
Report Number:	R004726
Date of Issue:	11 May 2018
Attention:	Ted Wagstaff
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Testing Laboratory:	Ektimo Pty Ltd, ABN 86 600 381 413

Report Status

Format	Document Number	Report Date	Prepared By	Reviewed By (1)	Reviewed By (2)
Preliminary Report	-	-	-	-	-
Draft Report	-	-	-	-	-
Final Report	R004726	11/05/2018	JWe	Dhi	SCo
Amend Report	-	-	-	-	-

Template Version: 220318

Amendment Record

Document Number	Initiator	Report Date	Section	Reason
Nil	-	-	-	-

Report Authorisation

Steven Cooper
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Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.

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1 EXECUTIVE SUMMARY

Ektimo was engaged by Terminals Pty Ltd to perform emission monitoring as required by NSW EPA Environment Protection Licence (number 1048).

Monitoring was performed as follows:

Location	Test Date	Test Parameters*
EPA 4 – Benzene Combustor	21 April 2018	Speciated volatile organic compounds (VOC's), carbon dioxide, oxygen, carbon monoxide, nitrogen oxides

* Flow rate, velocity, temperature and moisture were determined unless otherwise stated

All results are reported on a dry basis at STP. Unless otherwise indicated, the methods cited in this report have been performed without deviation.

Plant operating conditions have been noted in the report.

2 RESULTS SUMMARY

The following licence comparison table shows that all analytes highlighted in green are below the licence limit set by the NSW EPA as per licence 1048 (last amended on 23/11/2017).

Results have also been corrected to 3% Oxygen as stipulated in Schedule 5 of the *Protection of the Environment Operations (Clean Air) Regulation, (NSW)* 2010.

EPA No.	Location Description	Parameter	Units	Licence limit	Detected values 21/04/2018	Detected values (corrected to 3% O2) 21/04/2018
4	Benzene Combustor	Nitrogen oxides (as NO_2)	mg/m3	350	42	88
		Volatile organic compounds (VOCs)	mg/m3	20	0.57	1.2
		Benzene	mg/m3	1	0.053	0.11

3 RESULTS

3.1 EPA 4 – Benzene Combustor

Date	21/04/2018	**Client**	Terminals Pty Ltd
Report	R004726	**Stack ID**	EPA 4 - Benzene Combustor Stack
Licence No.	1048	**Location**	Port Botany
Ektimo Staff	David Hill	**State**	NSW
Process Conditions	Ship loaded is the Golden Creation		180417

Sampling Plane Details		
Sampling plane dimensions	1010 mm	
Sampling plane area	0.801 m²	
Sampling port size, number	4" Flange (x2)	
Access & height of ports	Fixed ladder 9 m	
Duct orientation & shape	Vertical Circular	
Downstream disturbance	Exit 3 D	
Upstream disturbance	Change in diameter 2 D	
No. traverses & points sampled	2 16	
Sample plane compliance to AS4323.1	Compliant but non-ideal	

Comments
The sampling plane is deemed to be non-ideal or non-compliant due to the following reasons:
The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D

Stack Parameters		
Moisture content, %v/v	4.2	
Gas molecular weight, g/g mole	28.9 (wet)	29.3 (dry)
Gas density at STP, kg/m³	1.29 (wet)	1.31 (dry)
% Oxygen correction & Factor	3 %	2.09
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	0732 & 0908	
Temperature, °C	787	
Temperature, K	1060	
Velocity at sampling plane, m/s	7	
Volumetric flow rate, discharge, m³/s	5.6	
Volumetric flow rate (wet STP), m³/s	1.5	
Volumetric flow rate (dry STP), m³/s	1.4	
Mass flow rate (wet basis), kg/hour	6800	
Velocity difference, %	<1	

Gas Analyser Results	Average			Minimum			Maximum		
Sampling time	0747 - 0846			0747 - 0846			0747 - 0846		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Combustion Gases									
Nitrogen oxides (as NO_2)	42	88	3.5	23	47	1.9	91	190	7.6
Carbon monoxide	42	88	3.5	<2	<4	<0.2	1600	3400	140
	Concentration %			Concentration %			Concentration %		
Carbon dioxide	4.5			3.9			5.2		
Oxygen	12.3			11.2			13.2		

Total VOCs (as n-Propane)	Results		
Sampling time	0746-0846		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Total	0.57	1.2	0.048

VOC (speciated)	Results		
Sampling time	0746-0846		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Detection limit(1)	<0.03	<0.07	<0.003
Benzene	0.053	0.11	0.0045
Toluene	0.65	1.3	0.054
m + p-Xylene	0.088	0.18	0.0074
Pentane	0.32	0.67	0.027

(1) Unless otherwise reported, the following target compounds were found to be below detection:
Ethanol, Isopropanol, 1,1-Dichloroethene, Dichloromethane, trans-1,2-Dichloroethene, cis-1,2-Dichloroethene, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Carbon tetrachloride, Butanol, 1-Methoxy-2-propanol, Trichloroethylene, 1,1,2-trichloroethane, Tetrachloroethene, Chlorobenzene, Ethylbenzene, Styrene, o-Xylene, 2-Butoxyethanol, 1,1,2,2-Tetrachloroethane, Isopropylbenzene, Propylbenzene, 1,3,5-trimethylbenzene, tert-Butylbenzene, 1,2,4-trimethylbenzene, 1,2,3-trimethylbenzene, Acetone, Acrylonitrile, n-Hexane, Methyl ethyl ketone, Ethyl acetate, Cyclohexane, 2-Methylhexane, 2,3-Dimethylpentane, Isopropyl acetate, 3-Methylhexane, Ethyl acrylate, Heptane, Methyl methacrylate, Propyl acetate, Methylcyclohexane, MIBK, 2-Hexanone, Octane, Butyl acetate, 1-methoxy-2-propyl acetate, Butyl acrylate, Nonane, Cellosolve acetate, alpha-Pinene, beta-Pinene, Decane, 3-Carene, D-Limonene, Undecane, Dodecane, Tridecane, Tetradecane

4 PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Terminals Pty Ltd's records for complete process conditions. All testing was conducted while the *Golden Creation* was being loaded.

5 TEST METHODS

All sampling and analysis was performed by Ektimo unless otherwise specified. Specific details of the methods are available upon request.

Parameter	Sampling Method	Analysis Method	Uncertainty*	NATA Accredited	
				Sampling	Analysis
Sample plane criteria	NSW TM-1	NA	-	✓	NA
Flow rate, temperature and velocity	NSW TM-2	NA	8%, 2%, 7%	✓	NA
Moisture content	NSW TM-22	NSW TM-22	19%	✓	✓
Carbon dioxide	NSW TM-24	NSW TM-24	13%	✓	✓
Carbon monoxide	NSW TM-32	NSW TM-32	12%	✓	✓
Nitrogen oxides (NO_x)	NSW TM-11	NSW TM-11	12%	✓	✓
Oxygen	NSW TM-25	NSW TM-25	13%	✓	✓
Speciated volatile organic compounds (VOC's)	NSW TM-34	Ektimo 344	19%	✓	✓†

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* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

† Analysis performed by Ektimo, NATA accreditation number 14601. Laboratory analytical results were reported on 3 May 2018 in report number R004726_SVOCs.

6 QUALITY ASSURANCE/QUALITY CONTROL INFORMATION

Ektimo is accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources. Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for Ektimo at NATA's website www.nata.com.au.

Ektimo is accredited by NATA (National Association of Testing Authorities) to ISO/IEC 17025 - Testing. ISO/IEC 17025 - Testing requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Quality Director.

NATA is a member of APLAC (Asia Pacific Laboratory Accreditation Co-operation) and of ILAC (International Laboratory Accreditation Co-operation). Through the mutual recognition arrangements with both of these organisations, NATA accreditation is recognised worldwide.

A formal Quality Control program is in place at Ektimo to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

7 DEFINITIONS

The following symbols and abbreviations may be used in this test report:

~	Approximately
<	Less than
>	Greater than
≥	Greater than or equal to
APHA	American public health association, Standard Methods for the Examination of Water and Waste Water
AS	Australian Standard
BSP	British standard pipe
CARB	Californian Air Resources Board
CEM	Continuous Emission Monitoring
CEMS	Continuous Emission Monitoring System
CTM	Conditional test method
D	Duct diameter or equivalent duct diameter for rectangular ducts
D_{50}	'Cut size' of a cyclone defined as the particle diameter at which the cyclone achieves a 50% collection efficiency ie. half of the particles are retained by the cyclone and half are not and pass through it to the next stage. The D_{50} method simplifies the capture efficiency distribution by assuming that a given cyclone stage captures all of the particles with a diameter equal to or greater than the D_{50} of that cyclone and less than the D_{50} of the preceding cyclone.
DECC	Department of Environment & Climate Change (NSW)
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
DWER	Department of Water and Environmental Regulation
EPA	Environment Protection Authority
FTIR	Fourier Transform Infra Red
ISC	Intersociety committee, Methods of Air Sampling and Analysis
ISO	International Organisation for Standardisation
NA	Not applicable
NATA	National Association of Testing Authorities
NIOSH	National Institute of Occupational Safety and Health
NT	Not tested or results not required
OM	Other approved method
OU	The number of odour units per unit of volume. The numerical value of the odour concentration is equal to the number of dilutions to arrive at the odour threshold (50% panel response).
PM_{10}	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 10 microns (µm).
$PM_{2.5}$	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 2.5 microns (µm).
PSA	Particle size analysis
RATA	Relative Accuracy Test Audit
STP	Standard temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
TM	Test Method
TOC	The sum of all compounds of carbon which contain at least one carbon to carbon bond, plus methane and its derivatives.
USEPA	United States Environmental Protection Agency
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
Vic EPA	Victorian Environment Protection Authority
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
XRD	X-ray Diffractometry

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Report Number R007422

Emission Testing Report

EPA 4 – Benzene Combustor

Terminals Pty Ltd, Port Botany





This document is confidential and is prepared for the exclusive use of Terminals Pty Ltd
and those granted permission by Terminals Pty Ltd.

Document Information

Client Name:	Terminals Pty Ltd
Report Number:	R007422
Date of Issue:	27 May 2019
Attention:	Ted Wagstaff
Address:	Gate 38B, 45 Friendship Rd Port Botany NSW 2036
Testing Laboratory:	Ektimo Pty Ltd, ABN 86 600 381 413

Report Status

Format	Document Number	Report Date	Prepared By	Reviewed By (1)	Reviewed By (2)
Preliminary Report	-	-	-	-	-
Draft Report	-	-	-	-	-
Final Report	R007422	27/05/2019	JWe	SCo	ZPa
Amend Report	-	-	-	-	-

Template Version: 171218

Amendment Record

Document Number	Initiator	Report Date	Section	Reason
Nil	-	-	-	-

Report Authorisation

Steven Cooper
Client Manager

NATA Accredited Laboratory
No. 14601

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.

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4 Plant Operating Conditions 6

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6 Quality Assurance/Quality Control Information 6

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1 EXECUTIVE SUMMARY

Ektimo was engaged by Terminals Pty Ltd to perform emission monitoring as required by NSW EPA Environment Protection Licence (number 1048).

Monitoring was performed as follows:

Location	Test Date	Test Parameters*
EPA 4 – Benzene Combustor	5 May 2019	Speciated volatile organic compounds (VOC's) Carbon dioxide, oxygen, carbon monoxide, nitrogen oxides

* Flow rate, velocity, temperature and moisture were also determined.

All results are reported on a dry basis at STP.

Plant operating conditions have been noted in the report.

2 RESULTS SUMMARY

The following licence comparison table shows that all analytes highlighted in green are below the licence limit set by the NSW EPA as per licence 1048 (last amended on 23/11/2017).

Results have also been corrected to 3% Oxygen as stipulated in Schedule 5 of the *Protection of the Environment Operations (Clean Air) Regulation, (NSW)* 2010.

EPA No.	Location Description	Parameter	Units	Licence limit	Detected values 5/05/2019	Detected values (corrected to 3% O2) 5/05/2019
4	Benzene Combustor	Nitrogen oxides (as NO_2)	mg/m^3	350	69	130
		Volatile organic compounds (VOCs)	mg/m^3	20	<0.06	<0.1
		Benzene	mg/m^3	1	<0.07	<0.1

3 RESULTS

3.1 EPA 4 – Benzene Combustor

Date	5/05/2019	**Client**	Terminals Pty Ltd
Report	R007422	**Stack ID**	EPA 4 - Benzene Combustor Stack
Licence No.	1048	**Location**	Port Botany
Ektimo Staff	Steven Cooper	**State**	NSW
Process Conditions	Ship loaded is the Golden Leader		190430

Sampling Plane Details		
Sampling plane dimensions	1010 mm	
Sampling plane area	0.801 m²	
Sampling port size, number	4" Flange (x2)	
Access & height of ports	Fixed ladder 9 m	
Duct orientation & shape	Vertical Circular	
Downstream disturbance	Exit 3 D	
Upstream disturbance	Change in diameter 2 D	
No. traverses & points sampled	2 16	
Sample plane compliance to AS4323.1	Compliant but non-ideal	

Comments

The sampling plane is deemed to be non-ideal due to the following reasons:

The sampling plane is too near to the upstream disturbance but is greater than or equal to 2D

Stack Parameters		
Moisture content, %v/v	7.4	
Gas molecular weight, g/g mole	28.4 (wet)	29.2 (dry)
Gas density at STP, kg/m³	1.27 (wet)	1.30 (dry)
% Oxygen correction & Factor	3 %	1.94
Gas Flow Parameters		
Flow measurement time(s) (hhmm)	2302 & 0018	
Temperature, °C	780	
Temperature, K	1053	
Velocity at sampling plane, m/s	7.1	
Volumetric flow rate, actual, m³/s	5.7	
Volumetric flow rate (wet STP), m³/s	1.5	
Volumetric flow rate (dry STP), m³/s	1.4	
Mass flow rate (wet basis), kg/hour	6700	
Velocity difference, %	-10	

Gas Analyser Results	Average			Minimum			Maximum		
Sampling time	2313 - 0013			2313 - 0013			2313 - 0013		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Combustion Gases									
Nitrogen oxides (as NO_2)	69	130	5.7	66	130	5.4	73	140	6
Carbon monoxide	2.7	5.2	0.22	<2	<5	<0.2	7.5	15	0.62
	Concentration %			Concentration %			Concentration %		
Carbon dioxide	3.7			3.5			4		
Oxygen	11.7			11			12		

Total VOCs (as n-Propane)	Results		
Lower Bound Sampling time	2310-0010		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Total	<0.06	<0.1	<0.005

VOC (speciated)	Results		
Sampling time	2310-0010		
	Concentration mg/m³	Corrected to 3% O2 mg/m³	Mass Rate g/min
Detection limit[1]	<0.07	<0.1	<0.005
Benzene	<0.07	<0.1	<0.005

(1) Unless otherwise reported, the following target compounds were found to be below detection:

Ethanol, Isopropanol, 1,1-Dichloroethene, Dichloromethane, trans-1,2-Dichloroethene, cis-1,2-Dichloroethene, Chloroform, 1,1,1-Trichloroethane, 1,2-Dichloroethane, Benzene, Carbon tetrachloride, Butanol, 1-Methoxy-2-propanol, Trichloroethylene, Toluene, 1,1,2-Trichloroethane, Tetrachloroethene, Chlorobenzene, Ethylbenzene, m + p-Xylene, Styrene, o-Xylene, 2-Butoxyethanol, 1,1,2,2-Tetrachloroethane, Isopropylbenzene, Propylbenzene, 1,3,5-Trimethylbenzene, 1,2,4-Trimethylbenzene, tert-Butylbenzene, 1,2,3-Trimethylbenzene, Acetone, Pentane, Acrylonitrile, Methyl ethyl ketone, n-Hexane, Ethyl acetate, Cyclohexane, Isopropyl acetate, 2-Methylhexane, 2,3-Dimethylpentane, 3-Methylhexane, Heptane, Ethyl acrylate, Methyl methacrylate, Propyl acetate, Methylcyclohexane, Methyl Isobutyl Ketone, 2-Hexanone, Octane, Butyl acetate, 1-Methoxy-2-propyl acetate, Butyl acrylate, Nonane, Cellosolve acetate, α-Pinene, β-Pinene, Decane, 3-Carene, D-Limonene, Undecane, Dodecane, Tridecane, Tetradecane

4 PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing. See Terminals Pty Ltd 's records for complete process conditions. All testing was conducted with the *Golden Leader* was being loaded.

5 TEST METHODS

All sampling and analysis was performed by Ektimo unless otherwise specified. Specific details of the methods are available upon request.

Parameter	Sampling Method	Analysis Method	Uncertainty*	NATA Accredited	
				Sampling	Analysis
Sample plane criteria	NSW TM-1	NA	-	✓	NA
Flow rate, temperature and velocity	NSW TM-2	NA	8%, 2%, 7%	✓	NA
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Carbon dioxide	NSW TM-24	NSW TM-24	13%	✓	✓
Carbon monoxide	NSW TM-32	NSW TM-32	12%	✓	✓
Nitrogen oxides (NO_x)	NSW TM-11	NSW TM-11	12%	✓	✓
Oxygen	NSW TM-25	NSW TM-25	13%	✓	✓
Speciated volatile organic compounds (VOC's)	NSW TM-34	Ektimo 344	19%	✓	✓†

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* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

† Analysis performed by Ektimo, NATA accreditation number 14601. Laboratory analytical results were reported on 23 May 2019 in report number R007422_SVOCs.

6 QUALITY ASSURANCE/QUALITY CONTROL INFORMATION

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NATA is a member of APLAC (Asia Pacific Laboratory Accreditation Co-operation) and of ILAC (International Laboratory Accreditation Co-operation). Through the mutual recognition arrangements with both of these organisations, NATA accreditation is recognised worldwide.

7 DEFINITIONS

The following symbols and abbreviations may be used in this test report:

% v/v	Volume to volume ratio, dry or wet basis
~	Approximately
<	Less than
>	Greater than
≥	Greater than or equal to
APHA	American public health association, Standard Methods for the Examination of Water and Waste Water
AS	Australian Standard
BSP	British standard pipe
CARB	Californian Air Resources Board
CEM	Continuous Emission Monitoring
CEMS	Continuous Emission Monitoring System
CTM	Conditional test method
D	Duct diameter or equivalent duct diameter for rectangular ducts
D_{50}	'Cut size' of a cyclone defined as the particle diameter at which the cyclone achieves a 50% collection efficiency ie. half of the particles are retained by the cyclone and half are not and pass through it to the next stage. The D_{50} method simplifies the capture efficiency distribution by assuming that a given cyclone stage captures all of the particles with a diameter equal to or greater than the D_{50} of that cyclone and less than the D_{50} of the preceding cyclone.
DECC	Department of Environment & Climate Change (NSW)
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
DWER	Department of Water and Environmental Regulation (WA)
DEHP	Department of Environment and Heritage Protection (QLD)
EPA	Environment Protection Authority
FTIR	Fourier Transform Infra-red
ISC	Intersociety committee, Methods of Air Sampling and Analysis
ISO	International Organisation for Standardisation
Lower Bound	Defines values reported below detection as equal to zero.
Medium Bound	Defines values reported below detection are equal to half the detection limit.
NA	Not applicable
NATA	National Association of Testing Authorities
NIOSH	National Institute of Occupational Safety and Health
NT	Not tested or results not required
OM	Other approved method
OU	The number of odour units per unit of volume. The numerical value of the odour concentration is equal to the number of dilutions to arrive at the odour threshold (50% panel response).
PM_{10}	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 10 microns (µm).
$PM_{2.5}$	Atmospheric suspended particulate matter having an equivalent aerodynamic diameter of less than approximately 2.5 microns (µm).
PSA	Particle size analysis
RATA	Relative Accuracy Test Audit
Semi-quantified VOCs	Unknown VOCs (those not matching a standard compound), are identified by matching the mass spectrum of the chromatographic peak to the NIST Standard Reference Database (version 14.0), with a match quality exceeding 70%. An estimated concentration will be determined by matching the integrated area of the peak with the nearest suitable compound in the analytical calibration standard mixture.
STP	Standard temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
TM	Test Method
TOC	The sum of all compounds of carbon which contain at least one carbon to carbon bond, plus methane and its derivatives.
USEPA	United States Environmental Protection Agency
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
Vic EPA	Victorian Environment Protection Authority
VOC	Any chemical compound based on carbon with a vapour pressure of at least 0.010 kPa at 25°C or having a corresponding volatility under the particular conditions of use. These compounds may contain oxygen, nitrogen and other elements, but specifically excluded are carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.
XRD	X-ray Diffractometry
Upper Bound	Defines values reported below detection are equal to the detection limit.





Appendix G

CEC Calculated Worst Case Emissions for Oxidisers

Printed on Recycled Paper.

CEC ENGINEERS
CALCULATION SHEET

Client : Quantem (Terminals Pty Ltd)
Project No. : 200003
Project : 2nd Thermal Oxidiser and Liquid Waste Burning
Calculation No: 200003CAL-002 **Rev 2**

Calculation Title: Thermal Oxidiser VOC Stack Emission Estimate Calculations

Calculation Summary

Calculation Objective:

Estimate the total thermal oxidiser VOC/HAP stack emissions from TO-1 and TO-2 for the worst case scenario
Estimate emissions from combustion system to confirm compliance with EPA requirements and input into stack dispersion modelling (by others)

Basis/Method:

1. Worst case emissions to the thermal oxidisers are estimated through first principal calculation methods and modelling of the bulk tank, ship and truck vapour emissions during specific activities.
2. Worst case emissions from the thermal oxidisers are estimated through first principal methods using calculations methods for the stoichiometric combustion of the VOC's and flammable liquids and mass and energy balances.
3. Both thermal oxidisers operating at the same time TO-1 (existing) and TO-2 (proposed new).
4. The maximum worst case calculation is based on the following scenario (with all loads occurring simultaneously):-
   (i) Worst case VOC-inert stream (tanks diurnal breathing and export from tank T204 to ship at 200m3/hr and collection of benzene vapours)
   (ii) Worst case dilute VOC-Air stream (future) based on collection vapours from 2 off flammable liquid truck fills.
   (iii) Liquid Waste Burning (LWB) is based on Hexene with minor quantity of residual BTX (benzene) as worst case in the liquid waste. Concentration and flowrate estimated to achieve the thermal capacity of the 2nd thermal oxidiser TO-2- (6.5 l/min @ 91% (v/v) hexene with 0.0205 % (v/v) benzene.
   Note: Benzene is not normally present in the liquid Waste. As a worst case it was assumed that in the event of a TO failure benzene from tank vapour emissions during di-urnal breathing (assumed over 4 hours) would be directed to the carbon beds.
   This small amount of benzene (est by Quantem as 9 kg) would be adsorbed onto the carbon and then de-sorbed and sent to the liquid waste tank were it would be combined with approx. 50,000 l of liquid waste. As such the worst case concentration of benzene in the liquid waste was estimated as 9 kg/50,000 l. Approx. 0.0205 % v/v
5. BTX (benzene) was deemed to be the worst case chemical for the modelling emissions. The key reasons are:
   a. It is a hazardous chemical requiring emissions to be reduced by the maximum extent possible.
   b. It has a relatively high vapour pressure and molecular weight and as such the mass loading is generally higher than many other chemicals for the same volumetric vapour rate.
   c. BTX vapour and liquid contain sulphur compounds (primarily hydrogen sulphide {H_2S}) which also make it very odorous. Using BTX maximises the emissions of H_2S to the thermal oxidisers.
6. Contents of tanks are based on data supplied by Terminals.
7. Tanks capacity, diameter and height data supplied by Terminals.
8. Connection of tanks to the existing VOC-nitrogen inert vapour collection system are based on data supplied by Terminals (refer to attachments).
9. Thermal load from VOC/Air Dilute stream is based on CEC Engineers calculation 200003CAL-003.
10. A single thermal oxidiser has currently been installed with a thermal capacity of 15,000 MJ/hr.
11. Proposed 2nd thermal oxidiser will have a thermal capacity of 22,500 MJ/hr.
12. Previously CEC Engineers (refer to calculations 180003CAL-001 and 002 rev 2) estimated that the overall thermal capacity required for the thermal oxidiser was 37,500 MJ/hr. This would be met by installing 2 off thermal oxidisers operating in parallel.

Assumptions:

The assumptions are listed below and in the calculation sheets
Expansion factor for diurnal breathing is based on thermal expansion of vapours plus expansion due to vapour pressure.
Daily emissions are assumed to occur over a 3 hr period.
Tanks assumed to be 25% full.
Temperature of tank contents ranges between 15˚C and 30˚C.
Inerted vapours are 100% saturated.
All tanks listed are breathing diurnally to the VOC-nitrogen inerted vapour collection system.
Maximum hydrogen sulphide (H_2S) concentration in the BTX vapour space 4% v/v -based on past sample analysis - SGS report ENV11869
Maximum hydrogen sulphide (H_2S) concentration in the BTX liquid 0.2% w/w -based on past sample analysis - SGS report ENV11869
Other assumptions are listed in the calculation sheet.

Conclusions/Outcomes:

Refer to the following summary sheets for tabulated results of the emissions from the thermal oxidiser stacks.
Thermal oxidiser TO-1: sheet "Total Output TO-1"
Thermal oxidiser TO-2: sheet "Total Output TO-2"

Rev 2 changes

Worst case LWB composition change from 80% benzene in liquid waste to 91% v/v hexene + 0.0205% v/v benzene- normally no benzene in liquid waste
Reduce TO-2 exit stack dia from 1.25 m to 1.02 m (to reflect Gasco actual exit stack diameter)
Update to cell formulae references in calc sheet " Total Output TO-2" column " VOC/HAP discharge rate to combust"

Design Verification Control

	Originator	Checked
Input Data Correct	FS	AB
Assumptions properly documented	FS	AB
Method of Calculation	FS	AB
Attachments included, clearly labelled and referenced	FS	AB
Results/conclusions clearly summarised	FS	AB

Rev	Issue Description	Date	Originated	Checked	Approved	Client
2	Liquid Waste Comp Update	13/10/2021	FS	AB		
1	Initial Issue	28/10/2020	FS	AB		

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No :	**200003**	**Date**	**13/10/2021**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
Calculation No:	**200003CAL-002**	**Rev**	**2**

Thermal Oxidiser TO-1
Total Output Stack Emission Estimate

Stack Diameter	1	m
Exit Temperature	980	^{o}C

	Input stream	Total flue vol rate at exit temp	Total flue vol rate at 0°C temp	VOC/HAP discharge rate from combust	VOC/HAP discharge rate from combust	Conc'n of VOC/HAP at stack exit temp	Conc'n of VOC/HAP at 0°C temp	exit velocity
		Am^3/hr	Nm^3/hr	kg/hr	g/min	mg/m^3	mg/m^3	m/sec
	Total TO-1							
A	**Benzene**			**0.0073**	**0.1218**	**0.1370**	**0.6289**	
B	**Hexene**			**0.0111**	**0.1849**	**0.2080**	**0.9545**	
C	**Acetone**			**0.0062**	**0.1038**	**0.1167**	**0.5357**	
D	**Ethanol**			**0.0015**	**0.0256**	**0.0288**	**0.1320**	
E	**Methanol**			**0.0059**	**0.0988**	**0.1112**	**0.5104**	
F	**Styrene**			**0.0000**	**0.0005**	**0.0005**	**0.0024**	
G	**Vinyl Acetate**			**0.0020**	**0.0334**	**0.0376**	**0.1724**	
H	**Methyl Methacrylate**			**0.0000**	**0.0000**	**0.0000**	**0.0000**	
I	**Butyl Acrylates**			**0.0000**	**0.0003**	**0.0004**	**0.0018**	
J	**Methyl Isobutyl Carbinol (MIBC)**			**0.0000**	**0.0000**	**0.0000**	**0.0000**	
	Hydrogen Sulphide (H_2S)	**444**	**97**	**0.0008**	**0.0139**	**0.0156**	**0.0717**	
	Sulphur Dioxide (from combustion of H2S)	**24**	**5**	**14.8789**	**248**	**279**	**1280**	
	Supplementary N2 inerting	**1165**	**254**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	
	Total (VOC-nitrogen inert stream, incl. N2 inerting)-excludes SO2	**53333**	**11620**	**0.035**	**0.583**	**0.656**	**3.010**	**18.9**

Breakdown:
Total (VOC-nitrogen inert stream, incl. N2 inerting)

A	Benzene	10279	2240	0.00731	0.1218	0.2495	1.1451	
B	Hexene	14293	3114	0.00918	0.1530	0.3133	1.4380	
C	Acetone	4201	915	0.00420	0.0700	0.1433	0.6579	
D	Ethanol	1441	314	0.00153	0.0256	0.0524	0.2404	
E	Methanol	4138	902	0.00593	0.0988	0.2025	0.9293	
F	Styrene	40	9	0.00003	0.0005	0.0010	0.0044	
G	Vinyl Acetate	1588	346	0.00200	0.0334	0.0684	0.3140	
H	Methyl Methacrylate	0	0	0.00000	0.0000	0.0000	0.0000	
I	Butyl Acrylates	24	5	0.00002	0.0003	0.0007	0.0033	
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0.00000	0.0000	0.0000	0.0000	
	Hydrogen Sulphide (H_2S)	444	97	0.00083	0.0139	0.0285	0.1306	
	Sulphur Dioxide (from combustion of H2S)	24	5	14.88	247.98	395.59	1815.64	
	Supplementary N2 inerting	1165	254	0.0	0.0000	0.0000	0.0000	
	Total (VOC-nitrogen inert stream, incl. N2 inerting)-excludes SO2	37612	8195	0.031	0.517	0.825	3.787	13.3

VOC-Air

Benzene			0.00000	0.00000	0.000	0.000	
Hexane			0.00191	0.03190	0.122	0.559	
Acetone			0.00203	0.03377	0.129	0.592	
Ethanol			0.00000	0.00000	0.000	0.000	
Methanol			0.00000	0.00000	0.000	0.000	
Vinyl Acetate			0.00000	0.00000	0.000	0.000	
Total (VOC-Air Diluted Stream)	15721	3425	0.00394	0.06567	0.251	1.150	5.6

Thermal Oxidiser TO-2
Total Output Stack Emission Estimate

Stack Diameter	1.02	m	Sized based on vendor advice
Exit Temperature	980	°C	

	Input stream	Total flue vol rate at exit temp	Total flue vol rate at 0°C temp	VOC/HAP discharge rate from combust	VOC/HAP discharge rate from combust	Conc'n of VOC/HAP at stack exit temp	Conc'n of VOC/HAP at 0°C temp	exit velocity
		Am^3/hr	Nm^3/hr	kg/hr	g/min	mg/m^3	mg/m^3	m/sec
	Total TO-2							
A	**Benzene**			**0.0073**	**0.1219**	**0.0808**	**0.3707**	
B	**Hexene**			**0.0353**	**0.5878**	**0.3894**	**1.7873**	
C	**Acetone**			**0.0062**	**0.1038**	**0.0687**	**0.3154**	
D	**Ethanol**			**0.0015**	**0.0256**	**0.0169**	**0.0777**	
E	**Methanol**			**0.0059**	**0.0988**	**0.0655**	**0.3005**	
F	**Styrene**			**0.0000**	**0.0005**	**0.0003**	**0.0014**	
G	**Vinyl Acetate**			**0.0020**	**0.0334**	**0.0221**	**0.1015**	
H	**Methyl Methacrylate**			**0.0000**	**0.0000**	**0.0000**	**0.0000**	
I	**Butyl Acrylates**			**0.0000**	**0.0003**	**0.0002**	**0.0011**	
J	**Methyl Isobutyl Carbinol (MIBC)**			**0.0000**	**0.0000**	**0.0000**	**0.0000**	
	Hydrogen Sulphide (H_2S)	**444**	**97**	**0.0008**	**0.0139**	**0.0092**	**0.0422**	
	Sulphur Dioxide (from combustion of H2S)	**24**	**5**	**14.879**	**248**	**164**	**754**	
	Supplementary N2 inerting	**1165**	**254**					
	Total (VOC-nitrogen inert stream, incl. N2 inerting)-excludes SO2	**90576**	**19734**	**0.0592**	**0.9860**	**0.6532**	**2.9979**	**30.8**
	Breakdown:							
	VOC-Nitrogen Inert Stream, incl. N2 inerting							
A	Benzene	10279	2240	0.00731	0.1218	0.2495	1.1451	
B	Hexene	14293	3114	0.00918	0.1530	0.3133	1.4380	
C	Acetone	4201	915	0.00420	0.0700	0.1433	0.6579	
D	Ethanol	1441	314	0.00153	0.0256	0.0524	0.2404	
E	Methanol	4138	902	0.00593	0.0988	0.2025	0.9293	
F	Styrene	40	9	0.00003	0.0005	0.0010	0.0044	
G	Vinyl Acetate	1588	346	0.00200	0.0334	0.0684	0.3140	
H	Methyl Methacrylate	0	0	0.00000	0.0000	0.0000	0.0000	
I	Butyl Acrylates	24	5	0.00002	0.0003	0.0007	0.0033	
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0.00000	0.0000	0.0000	0.0000	
	Hydrogen Sulphide (H_2S)	444	97	0.00083	0.0139	0.0285	0.1306	
	Sulphur Dioxide (from combustion of H2S)	24	5	14.88	247.98	395.59	1815.64	
	Supplementary N2 inerting	1165	254					
	Total (VOC-nitrogen inert stream, incl. N2 inerting)-excludes SO2	37612	8195	0.0310	0.5173	0.8252	3.7873	12.8
	VOC-Air Stream							
	Benzene			0.00000	0.00000	0.000	0.000	
	Hexane			0.00191	0.03190	0.122	0.559	
	Acetone			0.00203	0.03377	0.129	0.592	
	Ethanol			0.00000	0.00000	0.000	0.000	
	Methanol			0.00000	0.00000	0.000	0.000	
	Vinyl Acetate			0.00000	0.00000	0.000	0.000	
	Total (VOC-Air Diluted Stream)	15721	3425	0.00394	0.06567	0.251	1.150	5.3
	Liquid Waste Burning Steam							
A	Benzene	7	1	0.00001	0.00012	0.00019	0.00086	
B	Hexene	0	0	0.02418	0.40298	0.64923	2.97978	
C	Acetone	0	0	0.00000	0.00000	0.00000	0.00000	
D	Ethanol	0	0	0.00000	0.00000	0.00000	0.00000	
E	Methanol	0	0	0.00000	0.00000	0.00000	0.00000	
F	Styrene	0	0	0.00000	0.00000	0.00000	0.00000	
G	Vinyl Acetate	0	0	0.00000	0.00000	0.00000	0.00000	
H	Methyl Methacrylate	0	0	0.00000	0.00000	0.00000	0.00000	
I	Butyl Acrylates	0	0	0.00000	0.00000	0.00000	0.00000	
J	Methyl Isobutyl Carbinol (MIBC)	0	0	0.00000	0.00000	0.00000	0.00000	
	Hydrogen Sulphide (H_2S)	0.0	0.0	0.00000	0.0000	0.0000	0.0000	
	Sulphur Dioxide (from combustion of H2S)	0.00	0.00	0.000	0.004	0.007	0.031	
	Total (VOC)-excludes SO2	37242	8114	0.0242	0.403	0.649	2.981	12.7

Client : Quantem (Terminals Pty Ltd)
Project No. : 200003
Project : 2nd Thermal Oxidiser and Liquid Waste Burning
Calculation No: 200003CAL-002

Calc by FS
Date 13/10/2021
Checked AB

Emission Base Data-Botany Terminal

Worst Case Load

Temperature	**30**	°C
% Saturated vapour	**100%**	
% Tank vapour space	**75%**	
Diurnal breathing time/day	**3**	hrs

N2 inline inerting

Truck ship loading- O2 conc initial	**21%**
Truck ship loading- O2 conc final	**5.5%**

Product ID	
Benzene	A
Hexene	B
Acetone	C
Ethanol	D
Methanol	E

Product ID	
Styrene	F
Vinyl Acetate	G
Methyl Methacrylate	H
Butyl Acrylates	I
MIBC	J

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1							Note 3	Note 4		Note 5										
Existing Tank Number	Diameter	Height	Nominal Volume	ERV Setting	P Vent Setting	N_2 Setting	Actual Tank Filling Rate	Design Tank filling Rate	Actual Truck Loading Rate	Actual Ship Loading Rate	Design Truck Loading Rate	Design Ship Loading Rate	Calculation Truck/Ship Loading Rate	Product Nominated	Product ID	VOC Vapour Density	Mole Fraction	VOC Conc. at 100 % Sat.	% tank expansion Factor	Tank Diurnal Breathing	VOC mass rate (diurnal)	Maximum outflow to VCS from tank (CEC)	Breathing to TO	Tank fill	Truck/ Ship loading (VOC-nitrogen	Truck/ship vapours inline N2 inerted	Truck/ Ship loading (VOC-Air	Diurnal Breathing to VCS	Tank fill to VCS	Truck/ship loading vapours (VOC-nitrogen	Truck/ship loading N2 inerting	Truck/ship loading vapours (VOC-Air
	m	*m*	m^3	*kPag*	*kPag*	*kPag*	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr			kg/m^3		kg/m^3		m^3/hr	(max) *kg/hr*	m^3/hr	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr
Area 1																																
Cluster 1a																																
201	8.6	14.64	850	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	38.4	10.5	238	Y	N	N	N	N	38.4	0	0	0	0
202	8.6	14.64	850	2.5	1.25	0.25	60	200	-	160	-	200	200	Benzene	A	3.18	0.15	0.49	13.6%	29.0	14.1	229	Y	N	N	N	N	29.0	0	0	0	0
203	**8.6**	**14.64**	**850**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**160**	**-**	**200**	**200**	**Styrene**	**F**	**4.24**	**0.01**	**0.05**	**5.9%**	**12.4**	**0.6**	**212**	**Y**	**N**	**N**	**N**	**N**	**12.4**	**0**	**0**	**0**	**0**
204	9.5	14.64	1038	2.5	1.25	0.25	60	200	-	160	-	160	200	Benzene	A	3.18	0.15	0.49	13.6%	35.4	17.3	235	Y	N	Y	Y	N	35.4	0	200	564	0
205	9.5	14.64	1038	2.5	1.25	0.25	60	200	-	160	-	90	200	Benzene	A	3.18	0.15	0.49	13.6%	35.4	17.3	235	Y	N	N	N	N	35.4	0	0	0	0
206	9.5	14.64	1038	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	46.9	12.9	247	Y	N	N	N	N	46.9	0	0	0	0
207	9.5	14.64	1038	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	46.9	12.9	247	Y	N	N	N	N	46.9	0	0	0	0
Sub total Area 1 cluster 1a			6702																	244	85							244.3	**0**	**200**	**564**	**0**
Cluster 1b																																
221	**7.6**	**12.2**	**553**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**160**	**-**	**200**	**200**	**Acetone**	**C**	**2.36**	**0.37**	**0.87**	**27.1%**	**37.5**	**32.6**	**237**	**Y**	**N**	**N**	**N**	**N**	**37.5**	**0**	**0**	**0**	**0**
Sub total Area 1 cluster 1b			553																	37	32.6							37.5	0.0	0.0	0.0	0.0
Cluster 1c																																
223	**6.1**	**10.97**	**321**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**160**	**-**	**200**	**200**	**Acetone**	**C**	**2.36**	**0.37**	**0.87**	**27.1%**	**21.7**	**18.9**	**222**	**Y**	**N**	**N**	**N**	**N**	**21.7**	**0**	**0**	**0**	**0**
230	**7.6**	**12.2**	**553**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**160**	**-**	**200**	**200**	**Acetone**	**C**	**2.36**	**0.37**	**0.87**	**27.1%**	**37.5**	**32.6**	**237**	**Y**	**N**	**N**	**N**	**N**	**37.5**	**0**	**0**	**0**	**0**
Sub total Area 1 cluster 1c			874																	59	51.4							59.2	0.0	0.0	0.0	0.0
Area 1 Total			**8130**																	**341**	**169.5**							**341.0**	**0.0**	**200.0**	**563.6**	**0.0**
Area 2																																
Cluster 1																																
cluster 1a																																
233	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
234	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
241	9.58	17.08	1231	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	35.3	6.7	235	Y	N	N	N	N	35	0	0	0	0
242	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
243	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
251	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	15.9	3.0	216	Y	N	N	N	N	15.9	0	0	0	0
252	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
253	**7.6**	**12.2**	**553**	**2.5**	**1.25**	**0.25**	**-**	**200**	**72**	**-**	**90**	**-**	**90**	**Butyl Acrylates**	**I**	**5.22**	**0.01**	**0.05**	**5.8%**	**8.0**	**0.4**	**208**	**Y**	**N**	**N**	**N**	**N**	**8.0**	**0**	**0**	**0**	**0**
254	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
259	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
260	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	15.9	3.0	216	Y	N	N	N	N	15.9	0	0	0	0
Sub total Area 2 cluster 1a			**6765.6**																	**249.9**	**61.2**							**249.9**	**0.0**	**0.0**	**0.0**	**0.0**
Cluster 1b																																
235	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
240	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
245	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
250	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
255	7.6	12.2	553	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	15.9	3.0	216	Y	N	N	N	N	15.9	0	0	0	0
258	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Methanol	E	1.30	0.21	0.27	18.1%	25.0	6.9	225	Y	N	N	N	N	25.0	0	0	0	0
Sub total Area 2 cluster 1b			**3321**																	**140.8**	**37.3**							**140.8**	**0.0**	**0.0**	**0.0**	**0.0**
Sub total Area 2 cluster 1			**10086**																	**390.7**	**98.6**							**390.7**	**0.0**	**0.0**	**0.0**	**0.0**
Area 2 cluster 2																																
237	10.7	17.08	1536	2.5	1.25	0.25	-	200	72	-	90	-	90	Hexene	B	3.42	0.30	1.01	21.9%	84.0	84.9	284	Y	N	N	N	N	84	0	0	0	0
238	9.58	17.08	1231	2.5	1.25	0.25	-	200	60	-	90	-	90	Hexene	B	3.42	0.30	1.01	21.9%	67.3	68.1	267	Y	N	N	N	N	67	0	0	0	0
244	7.6	12.2	553	2.5	1.25	0.25	-	200	72	-	90	-	90	Hexene	B	3.42	0.30	1.01	21.9%	30.3	30.6	230	Y	N	N	N	N	30	0	0	0	0
247	**8.74**	**17.08**	**1025**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**140**	**-**	**200**	**200**	**Vinyl Acetate**	**G**	**3.51**	**0.18**	**0.65**	**15.7%**	**40.2**	**26.0**	**240**	**Y**	**N**	**N**	**N**	**N**	**40.2**	**0**	**0**	**0**	**0**
248	8.74	17.08	1025	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	29.4	5.6	229	Y	N	N	N	N	29.4	0	0	0	0
249	8.6	14.64	850	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	24.4	4.6	224	Y	N	N	N	N	24.4	0	0	0	0
256	**7.6**	**12.2**	**553**	**2.5**	**1.25**	**0.25**	**60**	**200**	**-**	**140**	**-**	**200**	**200**	**Vinyl Acetate**	**G**	**3.51**	**0.18**	**0.65**	**15.7%**	**21.7**	**14.1**	**222**	**Y**	**N**	**N**	**N**	**N**	**21.7**	**0**	**0**	**0**	**0**
257	8.6	14.64	850	2.5	1.25	0.25	60	200	-	140	-	200	200	Ethanol	D	1.87	0.10	0.19	11.5%	24.4	4.6	224	Y	N	N	N	N	24.4	0	0	0	0
Subtotal Area 2 cluster 2			**7624**																	**321.6**	**238.5**							**321.6**	**0.0**	**0.0**	**0.0**	**0.0**
Area 2 Total			**17710**																	**712.3**	**337.1**							**712.3**	**0.0**	**0.0**	**0.0**	**0.0**
Total			**25840**																	**1053**	**507**							**1053**	**0**	**200**	**564**	**0**

Note 1: Information supplied by TPL
Note 2: Maximum tank filling 200 m3/hr from ship, 90 m3 from truck, maximum tank pump out 90 m3/hr to truck, 200 m3/hr to ship
Note 3 Estimated by CEC elsewhere based 15˚C temperature rise in liquid and vapour
Note 4 Estimated by CEC based on expansion factor and diurnal
Note 5 Summation of diurnal breathing and pump in rate

Client : Quantem (Terminals Pty Ltd)
Project No : 200003
Project : 2nd Thermal Oxidiser and Liquid Waste Burning

Calc by FS
Date 13/10/2021
Checked AB
Rev 2

Calculation No: 200003CAL-002

VOC - Inert Emission Estimate

Worst Case Load

All tanks listed are diurnally breathing simultaneously

BTX ship export + nitrogen inerting

Base Temperature 30 °C
VOC % saturated (VOC/Inert Stream) 100%
VOC % saturated (VOC-AIR Diluted Stream) 50%

H2S scrubber efficiency 0.00%
Refer to Comb Output-Emission Est sheet for input

Stream ID	Input stream	Volumetric rate input stream @ inlet temp m3/hr	Base Temp °C	Molecular formula No of C	No of H	No of O	No of N	No of S	MW	VOC at 100% Saturation	VOC at XX% Saturation	VOC density kg/m3	100% VOC vol rate m3/hr	VOC conc. kg/m3	H2S Mass rate inlet to scrubber kg/hr	H2S Vol rate Comb inlet m3/hr	100% VOC mass rate Comb inlet kg/hr	Heat of Combustion of VOC net (LHV) MJ/kg	Energy MJ/hr
VOC/Inert Stream																			
	Tank Diurnal Breathing																		
A	Benzene	99.8	30	6	6	0			78	15.4%	15.4%	3.18	15.3	0.49			48.7	40.21	1956
B	Hexene	181.6	30	6	14	0			84	29.6%	29.6%	3.42	53.7	1.01			183.6	44.52	8171
C	Acetone	96.7	30	3	6	1			58	36.8%	36.8%	2.36	35.6	0.87			84.0	28.60	2402
D	Ethanol	160.9	30	2	6	1			46	10.2%	10.2%	1.87	16.4	0.19			30.7	26.85	824
E	Methanol	432.0	30	1	4	1			32	21.1%	21.1%	1.30	91.0	0.27			118.6	19.94	2366
F	Styrene	12.4	30	8	8				104	1.1%	1.1%	4.24	0.13	0.05			0.56	40.51	23
G	Vinyl Acetate	61.9	30	4	6	2			86	18.5%	18.5%	3.51	11.4	0.65			40.1	22.65	908
H	Methyl Methacrylate	0.0	30	5	8	2			100	6.2%	6.2%	4.08	0.00	0.25			0.00	26.40	0
I	Butyl Acrylates	8.0	30	7	12	2			128	1.0%	1.0%	5.22	0.08	0.05			0.42	32.24	13
J	Methyl Isobutyl Carbinol (MIBC)	0.0	30						102	0.8%	0.8%	4.16	0.00	0.03			0.00	38.70	0
K	Hydrogen Sulphide (H_2S)	99.8	30		2			1	34	4%	4.0%	1.39	3.99	0.06	5.55	3.99	5.55	15.24	85
	Total Tank Diurnal Breathing	1053	30										223.6	0.48			506.5		16747
	Tank Filling																		
A	Benzene	0.0	30	6	6	0			78	15.4%	15.4%	3.18	0.0	0.49			0.0	40.21	0
B	Hexene	0.0	30	6	14	0			84	29.6%	29.6%	3.42	0.0	1.01			0.0	44.52	0
C	Acetone	0.0	30	3	6	1			58	36.8%	36.8%	2.36	0.0	0.87			0.0	28.60	0
D	Ethanol	0.0	30	2	6	1			46	10.2%	10.2%	1.87	0.0	0.19			0.0	26.85	0
E	Methanol	0.0	30	1	4	1			32	21.1%	21.1%	1.30	0.0	0.27			0.0	19.94	0
F	Styrene	0.0	30	8	8				104	1.1%	1.1%	4.24	0.0	0.05			0.0	40.51	0
G	Vinyl Acetate	0.0	30	4	6	2			86	18.5%	18.5%	3.51	0.0	0.65			0.0	22.65	0
H	Methyl Methacrylate	0.0	30	5	8	2			100	6.2%	6.2%	4.08	0.0	0.25			0.0	26.40	0
I	Butyl Acrylates	0.0	30	7	12	2			128	1.0%	1.0%	5.22	0.0	0.05			0.0	32.24	0
J	Methyl Isobutyl Carbinol (MIBC)	0.0	30						102	0.8%	0.8%	4.16	0.0	0.03			0.0	38.70	0
K	Hydrogen Sulphide (H_2S) note 1	0.0	30		2			1	34	4%	4.0%	1.39	0.00	0.06	0.00	0.00	0.00	15.24	0
	Total Tank Filling	0	30										0.0	#DIV/0!			0.0		0
	Truck/Ship Filling																		
A	Benzene	200.0	30	6	6	0			78	15.4%	15.4%	3.18	30.7	0.49			97.5	40.21	3921
B	Hexene	0.0	30	6	14	0			84	29.6%	29.6%	3.42	0.0	1.01			0.0	44.52	0
C	Acetone	0.0	30	3	6	1			58	36.8%	36.8%	2.36	0.0	0.87			0.0	28.60	0
D	Ethanol	0.0	30	2	6	1			46	10.2%	10.2%	1.87	0.0	0.19			0.0	26.85	0
E	Methanol	0.0	30	1	4	1			32	21.1%	21.1%	1.30	0.0	0.27			0.0	19.94	0
F	Styrene	0.0	30	8	8				104	1.1%	1.1%	4.24	0.0	0.05			0.0	40.51	0
G	Vinyl Acetate	0.0	30	4	6	2			86	18.5%	18.5%	3.51	0.0	0.65			0.0	22.65	0
H	Methyl Methacrylate	0.0	30	5	8	2			100	6.2%	6.2%	4.08	0.0	0.25			0.0	26.40	0
I	Butyl Acrylates	0.0	30	7	12	2			128	1.0%	1.0%	5.22	0.0	0.05			0.0	32.24	0
J	Methyl Isobutyl Carbinol (MIBC)	0.0	30						102	0.8%	0.8%	4.16	0.0	0.03			0.0	38.70	0
K	Hydrogen Sulphide (H_2S)	200.0	30		2			1	34	4%	4.0%	1.39	8.00	0.06	11.12	8.00	11.12	15.24	169
	Supplementary N2 inerting	563.6	30																
	Total Truck/Ship Filling (incl. N2 inerting)	764	30										30.7	0.13			97.5		4090

VOC - Inert Emission Estimate

Worst Case Load

All tanks listed are diurnally breathing simultaneously

BTX ship export + nitrogen inerting

Base Temperature 30 °C
VOC % saturated (VOC/Inert Stream) 100%
VOC % saturated (VOC-AIR Diluted Stream) 50%

H2S scrubber efficiency 0.00%
Refer to Comb Output-Emission Est sheet for input

Stream ID	Input stream	Volumetric rate input stream @ inlet temp m3/hr	Base Temp °C	Molecular formula No of C	No of H	No of O	No of N	No of S	MW	VOC at 100% Saturation	VOC at XX% Saturation	VOC density kg/m3	100% VOC vol rate m3/hr	VOC conc. kg/m3	H2S Mass rate inlet to scrubber kg/hr	H2S Vol rate Comb inlet m3/hr	100% VOC mass rate Comb inlet kg/hr	Heat of Combustion of VOC net (LHV) MJ/kg	Energy MJ/hr
	Total																		
A	Benzene	299.8	30	6	6	0			78	15.4%	15.4%	3.18	46.0	0.49			146.2	40.21	5877
B	Hexene	181.6	30	6	14	0			84	29.6%	29.6%	3.42	53.7	1.01			183.6	44.52	8171
C	Acetone	96.7	30	3	6	1			58	36.8%	36.8%	2.36	35.6	0.87			84.0	28.60	2402
D	Ethanol	160.9	30	2	6	1			46	10.2%	10.2%	1.87	16.4	0.19			30.7	26.85	824
E	Methanol	432.0	30	1	4	1			32	21.1%	21.1%	1.30	91.0	0.27			118.6	19.94	2366
F	Styrene	12.4	30	8	8				104	1.1%	1.1%	4.24	0.13	0.05			0.56	40.51	23
G	Vinyl Acetate	61.9	30	4	6	2			86	18.5%	18.5%	3.51	11.4	0.65			40.1	22.65	908
H	Methyl Methacrylate	0.0	30	5	8	2			100	6.2%	6.2%	4.08	0.00	0.25			0.00	26.40	0
I	Butyl Acrylates	8.0	30	7	12	2			128	1.0%	1.0%	5.22	0.08	0.05			0.42	32.24	13
J	Methyl Isobutyl Carbinol (MIBC)	0.0	30						102	0.8%	0.8%	4.16	0.00	0.03			0.00	38.70	0
K	Hydrogen Sulphide (H_2S)	299.8	30		2			1	34	4%	4.0%	1.39	11.99	0.06	16.67	11.99	16.67	15.24	254
	Supplementary N2 inerting	563.6	30																
	Total (incl. N2 inerting)	1817	30										254.3	0.33			604.1		20837

Note 1 4% H2S v/v based on historical BTX vapour analysis (Terminals Botany)- SGS report ENV11869- dated 20th October 2010

VOC/Air Dilute Stream (MJ/hr)
Thermal load from the VOC/Air dilute stream - Refer to previous CEC calculation 200003CAL-003 **2875**

Thermal Load Waste Burning (MJ/hr)
Max thermal load from liquid waste burning (6.5 l/min @ 91% (v/v) hexene) -Refer to Separate Calc Sheet LWB-Thermal Load **10644**

Total Thermal Load (MJ/hr)
VOC/Inert stream thermal load + VOC/Air dilute stream thermal load +LWB **34356**

Total thermal load existing thermal Oxidser TO-1 (MJ/hr) **11856**
Total Thermal Load for 2nd Oxidiser TO-2 (MJ/hr) **22500**

Heat of combustion data (A-G): source: Perry Chemical Engineers Handbook 7th Ed., pg's 2-195 to 2-199, Cmpd No 67, 34, 123, 83, 82, 80, 155
Heat of combustion data (H-J): source: Cameo Chemicals data sheets
Ambient temperature is same as inlet temperature

Client :	**Quantem (Terminals Pty Ltd)**			**Calc by**	**FS**
Project No :	**200003**			**Date**	**13/10/2021**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**			**Checked**	**AB**
Calculation No:	**200003CAL-002**			**Rev**	**2**

VOC-Inert Stack Emission Estimate - Thermal Oxidiser TO-1
Worst Case Load

Input VOC -inert stream split	50%	Combustor reduction eff (VOC)	99.99%	Initial flue gas temp	30
		Scrubber reduction eff (S)	0.00%	Final flue gas temp	980
		Combuster eff for (S)	99.99%		
		Combustor/Scrubber reduction eff (S)	99.99%	% conversion of H2S to SO3	5%
		Combustor diameter exit	1 m	Est	

Stream ID	Input stream	Input stream rate to TO		Molecular formula					Required for Comb			Required for Comb			Combustion Air	Flue products with excess combustion air (only) at ambient temp									Average CP air	Flue prod density	Inlet Temp	Outlet Comb Temp	Total flue flowrate	Quench air flowrate	Total flue products with excess combustion & quench air						Total flue vol rate at	Total flue vol rate at	HAP/VOC discharge rate from	HAP/VOC discharge rate from	Conc'n of HAP/VOC at stack exit temp	Conc'n of HAP/VOC at 0oC temp	exit velocity
		100% VOC	100% VOC	No of	No of	No of	No of	No of	with VOC			Total			air input with 100% excess					excess					25C-800C	as air @ambient temp					Amb	Amb	Amb	Amb	Amb	Amb	exit temp	0oC temp	rate from combust	rate from combust			
		Vol rate	mass rate						O_2	N_2	Air	O_2	N_2	Air		CO_2	H_2O	SO_2	N_2	O_2	CO_2	H_2O	SO_2	N_2	excess O_2	Total						CO_2	H_2O	SO_2/SO_3	N_2	O_2	Total							
		m3/hr	kg/hr	C	H	O	N	S	moles/moles O_2 or m^3/m^3 of VOC			moles/moles O_2 or m^3/m^3 of VOC				moles/moles or m^3/m^3 of combust VOC										kJ/kg°C	kg/m³	°C	°C	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	Am³/hr	Nm³/hr	kg/hr	g/min	mg/m³	mg/m³	m/sec
	Tank Diurnal Breathing (VOC-nitrogen inert stream)																																								
A	Benzene	7.660	24.327	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	57.4	216.1	273.6	547.1	6.0	3.0	0.0	28.2	7.5	46.0	23.0	0	432.2	57.4	**558.6**	1.0727	1.16	30.0	980.0	827.4	268.8	46.0	23.0	0.0	644.6	113.9	**827.4**	**3421.5**	**745.5**	**0.0024**	0.0405	0.0830	0.3812	1.211
B	Hexene	26.834	91.779	6	14	0	0.0	0.0	9.5	35.74	45.24	254.9	959.0	1213.9	2427.9	6	7	0	35.7	9.5	161.0	187.8	0	1918.0	254.9	**2521.8**	1.0727	1.16	30.0	980.0	3456.2	934.4	161.0	187.8	0.0	2656.2	451.2	**3456.2**	**14292.6**	**3114.0**	**0.0092**	0.1530	0.3133	1.4380	5.058
C	Acetone	17.780	41.988	3	6	1	0.0	0.0	4.5	16.93	21.43	80.0	301.0	381.0	762.0	3	3	0	16.9	4.5	53.3	53.3	0	602.0	80.0	**788.7**	1.0727	1.16	30.0	980.0	1016.0	227.3	53.3	53.3	0.0	781.5	127.7	**1016.0**	**4201.3**	**915.4**	**0.0042**	0.0700	0.1433	0.6579	1.487
D	Ethanol	8.191	15.342	2	6	1	0.0	0.0	3.5	13.17	16.67	28.7	107.9	136.5	273.0	2	3	0	13.2	3.5	16.4	24.6	0	215.7	28.7	**285.3**	1.0727	1.16	30.0	980.0	348.4	63.1	16.4	24.6	0.0	265.6	41.9	**348.4**	**1440.9**	**313.9**	**0.0015**	0.0256	0.0524	0.2404	0.510
E	Methanol	45.519	59.308	1	4	1	0.0	0.0	2	7.52	9.52	91.0	342.5	433.5	867.0	1	2	0	7.5	2.0	45.5	91.0	0	685.0	91.0	**912.6**	1.0727	1.16	30.0	980.0	1000.6	88.1	45.5	91.0	0.0	754.5	109.5	**1000.6**	**4137.8**	**901.5**	**0.0059**	0.0988	0.2025	0.9293	1.464
F	Styrene	0.066	0.280	8	8	0	0.0	0.0	10	37.62	47.62	0.7	2.5	3.1	6.3	8	4	0	37.6	10.0	0.5	0.3	0	5.0	0.7	**6.4**	1.0727	1.16	30.0	980.0	9.6	3.2	0.5	0.3	0.0	7.5	1.3	**9.6**	**39.7**	**8.6**	**0.0000**	0.0005	0.0010	0.0044	0.014
G	Vinyl Acetate	5.716	20.037	4	6	2	0.0	0.0	5.5	20.69	26.19	31.4	118.3	149.7	299.4	4	3	0	20.7	5.5	22.9	17.1	0	236.5	31.4	**308.0**	1.0727	1.16	30.0	980.0	383.9	75.9	22.9	17.1	0.0	296.5	47.4	**383.9**	**1587.7**	**345.9**	**0.0020**	0.0334	0.0684	0.3140	0.562
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
I	Butyl Acrylates	0.040	0.209	7	12	2	0.0	0.0	10	37.62	47.62	0.4	1.5	1.9	3.8	7	6	0	37.6	10.0	0.3	0.2	0	3.0	0.4	**3.9**	1.0727	1.16	30.0	980.0	5.7	1.8	0.3	0.2	0.0	4.4	0.8	**5.7**	**23.5**	**5.1**	**0.0000**	0.0003	0.0007	0.0033	0.008
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
K	Hydrogen Sulphide (H_2S)	2.00	2.77	0	2	0	0	1	0.5	1.9	2.4	1.0	3.8	4.8	9.5	0	1	1	1.9	0.5	0.0	2.0	2.0	7.5	1.0	**12.5**	1.0727	1.16	30.0	980.0	35.8	23.3	0.0	2.0	2.0	25.9	5.9	**35.8**	**147.8**	**32.2**	0.0003	0.0046	0.0095	0.0435	0.052
	Total Tank Diurnal Breathing (VOC-nitrogen inert stream)																									**5397.8**	1.0727	1.16	30.0	980.0	7083.6	1685.8	345.9	399.4	2.0	5436.7	899.6	7083.6	29293.0	6382.3	0.026	0.427	0.874	4.012	10.4
	Tank Filling (VOC-inert stream)																																									
A	Benzene	0.000	0.000	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	0.0	0.0	0.0	0.0	6.0	3.0	0.0	28.2	7.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
B	Hexene	0.000	0.000	6	14	0	0.0	0.0	9.5	35.74	45.24	0.0	0.0	0.0	0.0	6	7	0	35.7	9.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
C	Acetone	0.000	0.000	3	6	1	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
D	Ethanol	0.000	0.000	2	6	1	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
E	Methanol	0.000	0.000	1	4	1	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
F	Styrene	0.000	0.000	8	8	0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
G	Vinyl Acetate	0.000	0.000	4	6	2	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
I	Butyl Acrylates	0.000	0.000	7	12	2	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
K	Hydrogen Sulphide (H_2S)	0.000	0.000	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	0.0	0.0	0.0	0.0	0	1	1	1.9	0.5	0.0	0.0	0.0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	0.0000	0.0000	0.0000	0.0000	0.000
	Total Tank Filling (VOC-nitrogen inert stream)																									**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	0.000	0.000	#DIV/0!	#DIV/0!	0.0
	Truck/Ship Filling (VOC-nitrogen inert stream)																																									
A	Benzene	15.352	48.757	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	115.1	433.2	548.3	1096.6	6.0	3.0	0.0	28.2	7.5	92.1	46.1	0	866.3	115.1	**1119.6**	1.0727	1.16	30.0	980.0	1658.3	538.7	92.1	46.1	0.0	1291.9	228.3	**1658.3**	**6857.6**	**1494.1**	**0.0049**	0.0813	0.1664	0.7640	2.427
B	Hexene	0.000	0.000	6	14	0	0.0	0.0	9.5	35.74	45.24	0.0	0.0	0.0	0.0	6	7	0	35.7	9.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
C	Acetone	0.000	0.000	3	6	1	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
D	Ethanol	0.000	0.000	2	6	1	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
E	Methanol	0.000	0.000	1	4	1	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
F	Styrene	0.000	0.000	8	8	0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
G	Vinyl Acetate	0.000	0.000	4	6	2	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
I	Butyl Acrylates	0.000	0.000	7	12	2	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.000
K	Hydrogen Sulphide (H_2S)	4.000	5.560	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	2.0	7.5	9.5	19.0	0	1	1	1.9	0.5	0.0	4.0	4.0	15.0	2.0	**25.0**	1.0727	1.16	30.0	980.0	71.7	46.6	0.0	4.0	4.0	51.9	11.8	**71.7**	**296.3**	**64.6**	0.0006	0.0093	0.0190	0.0871	0.105
19	Supplementary N2 inerting												281.8												281.8	281.8	1.0727	1.16	30.0	980.0	281.8					281.8		**281.8**	**1165.4**	**253.9**					
20	Total Truck/Ship Filling (VOC-nitrogen inert stream, incl. N2 inerting)																									**1426.5**	1.0727	1.16	30.0	980.0	2011.8	585.3	92.1	50.1	4.0	1625.5	240.1	2011.8	8319.3	1812.6	0.005	0.091	0.653	2.997	2.9
	Total (VOC-nitrogen inert stream, incl. N2 inerting)																																									
A	Benzene	23.012	73.084	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	172.6	649.3	821.9	1643.7	6.0	3.0	0.0	28.2	7.5	138.1	69.0	0	1298.5	172.6	**1678.3**	1.0727	1.16	30.0	980.0	2485.7	807.4	138.07	69.04	0.00	1936.42	342.15	**2485.68**	**10279.07**	**2239.57**	**0.0073**	0.122	0.249	1.145	3.637
B	Hexene	26.834	91.779	6	14	0	0.0	0.0	9.5	35.74	45.24	254.9	959.0	1213.9	2427.9	6	7	0	35.7	9.5	161.0	187.8	0	1918.0	254.9	**2521.8**	1.0727	1.16	30.0	980.0	3456.2	934.4	161.01	**187.84**	**0.00**	**2656.23**	**451.16**	**3456.24**	**14292.64**	**3114.04**	**0.0092**	**0.153**	**0.313**	**1.438**	5.058
C	Acetone	17.78	41.99	3.0	6.0	1.0	0.0	0.0	4.5	16.93	21.43	80.0	301.0	381.0	762.0	3	3	0	16.9	4.5	53.3	53.3	0	602.0	80.0	**788.7**	1.0727	1.16	30.0	980.0	1016.0	227.3	53.34	**53.34**	**0.00**	**781.55**	**127.74**	**1015.97**	**4201.35**	**915.38**	**0.0042**	**0.070**	**0.143**	**0.658**	1.487
D	Ethanol	8.19	15.34	2.0	6.0	1.0	0.0	0.0	3.5	13.17	16.67	28.7	107.9	136.5	273.0	2	3	0	13.2	3.5	16.4	24.6	0	215.7	28.7	**285.3**	1.0727	1.16	30.0	980.0	348.4	63.1	16.38	**24.57**	**0.00**	**265.56**	**41.92**	**348.44**	**1440.91**	**313.94**	**0.0015**	**0.026**	**0.052**	**0.240**	0.510
E	Methanol	45.52	59.31	1.0	4.0	1.0	0.0	0.0	2	7.52	9.52	91.0	342.5	433.5	867.0	1	2	0	7.5	2.0	45.5	91.0	0	685.0	91.0	**912.6**	1.0727	1.16	30.0	980.0	1000.6	88.1	45.52	**91.04**	**0.00**	**754.52**	**109.53**	**1000.60**	**4137.80**	**901.53**	**0.0059**	**0.099**	**0.202**	**0.929**	1.464
F	Styrene	0.07	0.28	8.0	8.0	0.0	0.0	0.0	10	37.62	47.62	0.7	2.5	3.1	6.3	8	4	0	37.6	10.0	0.5	0.3	0	5.0	0.7	**6.4**	1.0727	1.16	30.0	980.0	9.6	3.2	0.53	**0.26**	**0.00**	**7.48**	**1.33**	**9.60**	**39.70**	**8.65**	**0.0000**	**0.000**	**0.001**	**0.004**	0.014
G	Vinyl Acetate	5.72	20.04	4.0	6.0	2.0	0.0	0.0	5.5	20.69	26.19	31.4	118.3	149.7	299.4	4	3	0	20.7	5.5	22.9	17.1	0	236.5	31.4	**308.0**	1.0727	1.16	30.0	980.0	383.9	75.9	22.87	**17.15**	**0.00**	**296.54**	**47.39**	**383.94**	**1587.69**	**345.92**	**0.0020**	**0.033**	**0.068**	**0.314**	0.562
H	Methyl Methacrylate	0.00	0.00	5.0	8.0	2.0	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0000**	**0.000**	**0.000**	**0.000**	0.000
I	Butyl Acrylates	0.04	0.21	7.0	12.0	2.0	0.0	0.0	10	37.62	47.62	0.4	1.5	1.9	3.8	7	6	0	37.6	10.0	0.3	0.2	0	3.0	0.4	**3.9**	1.0727	1.16	30.0	980.0	5.7	1.8	0.28	**0.24**	**0.00**	**4.40**	**0.77**	**5.69**	**23.52**	**5.13**	**0.0000**	**0.000**	**0.001**	**0.003**	0.008
J	Methyl Isobutyl Carbinol (MIBC)	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0000**	**0.000**	**0.000**	**0.000**	0.000
K	Hydrogen Sulphide (H_2S)	6.00	8.33	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	3.0	11.3	14.3	28.6	0	1	1	1.9	0.5	0.0	6.0	6.0	22.6	3.0	**37.5**	1.0727	1.16	30.0	980.0	107.4	69.9	0.0	6.0	6.0	77.7	17.7	**107.4**	**444.2**	**96.8**	0.0008	0.0139	0.0285	0.1306	0.157
	Sulphur Dioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					5.7			**5.7**	**23.6**	**5.1**	**14.88**	248.0	395.6	1815.6	
	Sulphur Trioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					0.3			**0.3**	**1.2**	**0.3**	**0.78**	13.1	20.8	95.6	
26	Supplementary N2 inerting												281.8												281.8	281.8					281.8					281.8		**281.8**	**1165.4**	**253.9**					
	Total (VOC-nitrogen inert stream, incl. N2 inerting) - excludes SO2																									**6824.3**	1.0727	1.16	30.0	980.0	9095.4	2271.1	438.0	449.5	12.0	7062.3	1139.7	9095.4	37612.3	8194.9	0.031	0.517	0.825	3.787	13.3

General

Heat of combustion data: source: Perry Chemical Engineers Handbook 7th Ed., pg's 2-195 to 2-199, cmp no 67,6,123,83, 148, 228

Assume Heat of comb for MMA as per ethyl propionate 26.3 (methane =50.1 MJ/kg)

Ambient temperature is same as inlet temperature

Client :	**Quantem (Terminals Pty Ltd)**		**Calc by**	**FS**
Project No :	**200003**		**Date**	**13/10/2021**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**		**Checked**	**AB**
Calculation No:	**200003CAL-002**		**Rev**	**2**

VOC-Inert Stack Emission Estimate - Thermal Oxidiser TO-2
Worst Case Load

Input VOC -inert stream split: 50%

Combustor reduction eff (VOC): 99.99%
Scrubber reduction eff (S): 0.00%
Combuster eff for (S): 99.99%
Combustor/Scrubber reduction eff (S): 99.99%
Combustor diameter exit: 1.02 m

Initial flue gas temp: 30
Final flue gas temp: 980

Based on vendor data

% conversion of H2S to SO3: 5%

Stream ID	Input stream	Input stream rate to TO		Molecular formula					Required for Comb			Required for Comb			Combustion Air	Flue products with excess combustion air (only) at ambient temperature											Average CP air	Flue prod density	Inlet Temp	Outlet Comb	Total flue flowrate	Quench air flowrate	Total flue products with excess combustion & quench air							Total flue vol rate at	Total flue vol rate at	HAP/VOC discharge	HAP/VOC discharge	Conc'n of HAP/VOC at stack exit temp	Conc'n of HAP/VOC at 0oC temp	exit velocity
		100% VOC	100% VOC	No of	No of	No of	No of	No of	with VOC			Total			air inout with 100% excess					excess O_2						25C-800C	as air @ambient temp					Amb	Amb	Amb	Amb	Amb	Amb	exit temp	0oC temp	rate from	rate from			
		Vol rate	mass rate	C	H	O	N	S	O_2	N_2	Air	O_2	N_2	Air	Total	CO_2	H_2O	SO_2	N_2	O_2	CO_2	H_2O	SO_2	N_2	excess O_2	Total						CO_2	H_2O	SO_2/SO_3	N_2	O_2	Total			combust	combust				
		m3/hr	kg/hr									m^3/hr	m^3/hr	m^3/hr	m^3/hr					m^3/hr					m^3/hr	kJ/kg°C	kg/m^3	°C	°C	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	m^3/hr	Am^3/hr	Nm^3/hr	kg/hr	g/min	mg/m^3	mg/m^3	m/sec
	Tank Diurnal Breathing (VOC-nitrogen inert stream)	m3/hr																																									
A	Benzene	7.660	24.327	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	57.4	216.1	273.6	547.1	6.0	3.0	0.0	28.2	7.5	46.0	23.0	0	432.2	57.4	**558.6**	1.0727	1.16	30.0	980.0	827.4	268.8	46.0	23.0	0.0	644.6	113.9	**827.4**	**3421.5**	**745.5**	**0.0024**	**0.0405**	**0.0830**	**0.4**	1.16
B	Hexene	26.834	91.779	6	14	0	0.0	0.0	9.5	35.74	45.24	254.9	959.0	1213.9	2427.9	6	7	0	35.7	9.5	161.0	187.8	0	1918.0	254.9	**2521.8**	1.0727	1.16	30.0	980.0	3456.2	934.4	161.0	187.8	0.0	2656.2	451.2	**3456.2**	**14292.6**	**3114.0**	**0.0092**	**0.1530**	**0.3133**	**1.4**	4.86
C	Acetone	17.780	41.988	3	6	1	0.0	0.0	4.5	16.93	21.43	80.0	301.0	381.0	762.0	3	3	0	16.9	4.5	53.3	53.3	0	602.0	80.0	**788.7**	1.0727	1.16	30.0	980.0	1016.0	227.3	53.3	53.3	0.0	781.5	127.7	**1016.0**	**4201.3**	**915.4**	**0.0042**	**0.0700**	**0.1433**	**0.7**	1.43
D	Ethanol	8.191	15.342	2	6	1	0.0	0.0	3.5	13.17	16.67	28.7	107.9	136.5	273.0	2	3	0	13.2	3.5	16.4	24.6	0	215.7	28.7	**285.3**	1.0727	1.16	30.0	980.0	348.4	63.1	16.4	24.6	0.0	265.6	41.9	**348.4**	**1440.9**	**313.9**	**0.0015**	**0.0256**	**0.0524**	**0.2**	0.49
E	Methanol	45.519	59.308	1	4	1	0.0	0.0	2	7.52	9.52	91.0	342.5	433.5	867.0	1	2	0	7.5	2.0	45.5	91.0	0	685.0	91.0	**912.6**	1.0727	1.16	30.0	980.0	1000.6	88.1	45.5	91.0	0.0	754.5	109.5	**1000.6**	**4137.8**	**901.5**	**0.0059**	**0.0988**	**0.2025**	**0.9**	1.41
F	Styrene	0.066	0.280	8	8	0	0.0	0.0	10	37.62	47.62	0.7	2.5	3.1	6.3	8	4	0	37.6	10.0	0.5	0.3	0	5.0	0.7	**6.4**	1.0727	1.16	30.0	980.0	9.6	3.2	0.5	0.3	0.0	7.5	1.3	**9.6**	**39.7**	**8.6**	**0.0000**	**0.0005**	**0.0010**	**0.0**	0.01
G	Vinyl Acetate	5.716	20.037	4	6	2	0.0	0.0	5.5	20.69	26.19	31.4	118.3	149.7	299.4	4	3	0	20.7	5.5	22.9	17.1	0	236.5	31.4	**308.0**	1.0727	1.16	30.0	980.0	383.9	75.9	22.9	17.1	0.0	296.5	47.4	**383.9**	**1587.7**	**345.9**	**0.0020**	**0.0334**	**0.0684**	**0.3**	0.54
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	**0.0000**	**0.0000**	**0.0**	0.00
I	Butyl Acrylates	0.040	0.209	7	12	2	0.0	0.0	10	37.62	47.62	0.4	1.5	1.9	3.8	7	6	0	37.6	10.0	0.3	0.2	0	3.0	0.4	**3.9**	1.0727	1.16	30.0	980.0	5.7	1.8	0.3	0.2	0.0	4.4	0.8	**5.7**	**23.5**	**5.1**	**0.0000**	**0.0003**	**0.0007**	**0.0**	0.01
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	**0.0000**	**0.0000**	**0.0**	0.00
K	Hydrogen Sulphide (H_2S)	2.00	2.77	0	2	0	0	1	0.5	1.9	2.4	1.0	3.8	4.8	9.5	0	1	1	1.9	0.5	0.0	2.0	2.0	7.5	1.0	**12.5**	1.0727	1.16	30.0	980.0	35.8	23.3	0.0	2.0	2.0	25.9	5.9	**35.8**	**147.8**	**32.2**	**0.0003**	**0.0046**	**0.0095**	**0.0**	0.05
	Total Tank Diurnal Breathing (VOC-nitrogen inert stream)																									**5397.8**	1.0727	1.16	30.0	980.0	7083.6	1685.8	345.9	399.4	2.0	5436.7	899.6	7083.6	29293.0	6382.3	0.026	0.427	0.874	4.012	10.0
	Tank Filling (VOC-inert stream)																																										
A	Benzene	0.000	0.000	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	0.0	0.0	0.0	0.0	6.0	3.0	0.0	28.2	7.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
B	Hexene	0.000	0.000	6	14	0	0.0	0.0	9.5	35.74	45.24	0.0	0.0	0.0	0.0	6	7	0	35.7	9.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
C	Acetone	0.000	0.000	3	6	1	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
D	Ethanol	0.000	0.000	2	6	1	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
E	Methanol	0.000	0.000	1	4	1	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
F	Styrene	0.000	0.000	8	8	0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
G	Vinyl Acetate	0.000	0.000	4	6	2	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
I	Butyl Acrylates	0.000	0.000	7	12	2	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
K	Hydrogen Sulphide (H_2S)	0.000	0.000	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	0.0	0.0	0.0	0.0	0	1	1	1.9	0.5	0.0	0.0	0.0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
	Total Tank Filling (VOC-nitrogen inert stream)																									**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	#DIV/0!	#DIV/0!	0.00
	Truck/Ship Filling (VOC-nitrogen inert stream)																																										
A	Benzene	15.352	48.757	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	115.1	433.2	548.3	1096.6	6.0	3.0	0.0	28.2	7.5	92.1	46.1	0	866.3	115.1	**1119.6**	1.0727	1.16	30.0	980.0	1658.3	538.7	92.1	46.1	0.0	1291.9	228.3	**1658.3**	**6857.6**	**1494.1**	**0.0049**	0.0813	0.1664	0.7640	2.33
B	Hexene	0.000	0.000	6	14	0	0.0	0.0	9.5	35.74	45.24	0.0	0.0	0.0	0.0	6	7	0	35.7	9.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
C	Acetone	0.000	0.000	3	6	1	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
D	Ethanol	0.000	0.000	2	6	1	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
E	Methanol	0.000	0.000	1	4	1	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
F	Styrene	0.000	0.000	8	8	0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
G	Vinyl Acetate	0.000	0.000	4	6	2	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
H	Methyl Methacrylate	0.000	0.000	5	8	2	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
I	Butyl Acrylates	0.000	0.000	7	12	2	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
J	Methyl Isobutyl Carbinol (MIBC)	0.000	0.000	0	0	0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	**0.0000**	0.0000	0.0000	0.0000	0.00
K	Hydrogen Sulphide (H_2S)	4.000	5.560	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	2.0	7.5	9.5	19.0	0	1	1	1.9	0.5	0.0	4.0	4.0	15.0	2.0	**25.0**	1.0727	1.16	30.0	980.0	71.7	46.6	0.0	4.0	4.0	51.9	11.8	**71.7**	**296.3**	**64.6**	**0.0006**	0.0093	0.0190	0.0871	0.10
19	Supplementary N2 inerting												281.8												281.8	281.8	1.0727	1.16	30.0	980.0	281.8					281.8		**281.8**	**1165.4**	**253.9**					
20	Total Truck/Ship Filling (VOC-nitrogen inert stream, incl. N2 inerting)																									**1426.5**	1.0727	1.16	30.0	980.0	2011.8	585.3	92.1	50.1	4.0	1625.5	240.1	2011.8	8319.3	1812.6	0.005	0.091	0.653	2.997	2.8
	Total (VOC-nitrogen inert stream, incl. N2 inerting)																																										
A	Benzene	23.012	73.084	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	172.6	649.3	821.9	1643.7	6.0	3.0	0.0	28.2	7.5	138.1	69.0	0	1298.5	172.6	**1678.3**	1.0727	1.16	30.0	980.0	2485.7	807.4	138.07	69.04	0.00	######	342.15	**2485.68**	**10279.07**	**2239.57**	**0.0073**	0.122	0.249	1.145	3.50
B	Hexene	26.834	91.779	6	14	0	0.0	0.0	9.5	35.74	45.24	254.9	959.0	1213.9	2427.9	6	7	0	35.7	9.5	161.0	187.8	0	1918.0	254.9	**2521.8**	1.0727	1.16	30.0	980.0	3456.2	934.4	161.01	**187.84**	**0.00**	######	**451.16**	**3456.24**	**14292.64**	**3114.04**	**0.0092**	**0.153**	**0.313**	**1.438**	4.86
C	Acetone	17.78	41.99	3.0	6.0	1.0	0.0	0.0	4.5	16.93	21.43	80.0	301.0	381.0	762.0	3	3	0	16.9	4.5	53.3	53.3	0	602.0	80.0	**788.7**	1.0727	1.16	30.0	980.0	1016.0	227.3	53.34	**53.34**	**0.00**	**781.55**	**127.74**	**1015.97**	**4201.35**	**915.38**	**0.0042**	**0.070**	**0.143**	**0.658**	1.43
D	Ethanol	8.19	15.34	2.0	6.0	1.0	0.0	0.0	3.5	13.17	16.67	28.7	107.9	136.5	273.0	2	3	0	13.2	3.5	16.4	24.6	0	215.7	28.7	**285.3**	1.0727	1.16	30.0	980.0	348.4	63.1	16.38	**24.57**	**0.00**	**265.56**	**41.92**	**348.44**	**1440.91**	**313.94**	**0.0015**	**0.026**	**0.052**	**0.240**	0.49
E	Methanol	45.52	59.31	1.0	4.0	1.0	0.0	0.0	2	7.52	9.52	91.0	342.5	433.5	867.0	1	2	0	7.5	2.0	45.5	91.0	0	685.0	91.0	**912.6**	1.0727	1.16	30.0	980.0	1000.6	88.1	45.52	**91.04**	**0.00**	**754.52**	**109.53**	**1000.60**	**4137.80**	**901.53**	**0.0059**	**0.099**	**0.202**	**0.929**	1.41
F	Styrene	0.07	0.28	8.0	8.0	0.0	0.0	0.0	10	37.62	47.62	0.7	2.5	3.1	6.3	8	4	0	37.6	10.0	0.5	0.3	0	5.0	0.7	**6.4**	1.0727	1.16	30.0	980.0	9.6	3.2	0.53	**0.26**	**0.00**	**7.48**	**1.33**	**9.60**	**39.70**	**8.65**	**0.0000**	**0.000**	**0.001**	**0.004**	0.01
G	Vinyl Acetate	5.72	20.04	4.0	6.0	2.0	0.0	0.0	5.5	20.69	26.19	31.4	118.3	149.7	299.4	4	3	0	20.7	5.5	22.9	17.1	0	236.5	31.4	**308.0**	1.0727	1.16	30.0	980.0	383.9	75.9	22.87	**17.15**	**0.00**	**296.54**	**47.39**	**383.94**	**1587.69**	**345.92**	**0.0020**	**0.033**	**0.068**	**0.314**	0.54
H	Methyl Methacrylate	0.00	0.00	5.0	8.0	2.0	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0000**	**0.000**	**0.000**	**0.000**	0.00
I	Butyl Acrylates	0.04	0.21	7.0	12.0	2.0	0.0	0.0	10	37.62	47.62	0.4	1.5	1.9	3.8	7	6	0	37.6	10.0	0.3	0.2	0	3.0	0.4	**3.9**	1.0727	1.16	30.0	980.0	5.7	1.8	0.28	**0.24**	**0.00**	**4.40**	**0.77**	**5.69**	**23.52**	**5.13**	**0.0000**	**0.000**	**0.001**	**0.003**	0.01
J	Methyl Isobutyl Carbinol (MIBC)	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0000**	**0.000**	**0.000**	**0.000**	0.00
K	Hydrogen Sulphide (H_2S)	6.00	8.33	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	3.0	11.3	14.3	28.6	0	1	1	1.9	0.5	0.0	6.0	6.0	22.6	3.0	**37.5**	1.0727	1.16	30.0	980.0	107.4	69.9	0.0	6.0	6.0	77.7	17.7	**107.4**	**444.2**	**96.8**	**0.0008**	0.0139	0.0285	0.1306	0.15
	Sulphur Dioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					5.7		**5.7**	**23.6**	**5.1**	**14.88**	248.0	395.6	1815.6	
	Sulphur Trioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					0.3		**0.3**	**1.2**	**0.3**	**0.78**	13.1	20.8	95.6	
26	Supplementary N2 inerting												281.8												281.8	281.8	1.0727	1.16	30.0	980.0	281.8					281.8		**281.8**	**1165.4**	**253.9**					
	Total (VOC-nitrogen inert stream, incl. N2 inerting) - excludes SO2																									**6824.3**	1.0727	1.16	30.0	980.0	9095.4	2271.1	438.0	449.5	12.0	7062.3	1139.7	9101.4	37612.3	8194.9	0.031	0.517	0.825	3.787	12.8

General

Heat of combustion data: source: Perry Chemical Engineers Handbook 7th Ed., pg's 2-195 to 2-199, cmp no 67,6,123,83, 148, 228

Assume Heat of comb for MMA as per ethyl propionate 26.3 (methane =50.1 MJ/kg)

Ambient temperature is same as inlet temperature

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No :	**200003**	**Date**	**13/10/2021**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
Calculation No:	**200003CAL-002**	**Rev**	**2**

LWB Emission Estimate - Thermal Oxidiser TO-2

Worst Case Load

Waste stream flow rate 6.50 l/min

Composition 0% Hexene Liquid — Remainder water

% sulphur compounds in Benzene (liquid) 0.20% w/w — Based on historical BTX liquid analysis (Terminals Botany)- SGS report ENV11869- dated 20th October 2010

Combustor reduction eff (VOC)	99.99%	Initial flue gas temp	30
Scrubber reduction eff (S)	0.00%	Final flue gas temp	980
Combuster eff for (S)	99.99%		
Combustor/Scrubber reduction eff (S)	99.99%	% conversion of H2S to SO3	5%
Combustor diameter exit	1.02 m	Est	

Stream ID	Input stream	rate to TO	TO	Molecular formula					Requried for Comb with VOC			Requried for Comb Total			Combustion Air	Flue products with excess combustion air (only) at ambient temp									Averaae CP air	Flue orod density	Inlet Temp	Outlet Comb	Total flue flowrate	Quench air flowrate	Total flue products with excess combustion & quench air						Total flue vol rate at	Total flue vol rate at	HAP/VOC discharge	HAP/VOC discharge	Conc'n of HAP/VOC at stack exit temp	Conc'n of HAP/VOC at 0oC temp	exit velocity
		Equivalent 100% VOC vapour rate	Liquid	No of C	No of H	No of O	No of N	No of S	O_2	N_2	Air	O_2	N_2	Air	air input with 100% excess	CO_2	H_2O	SO_2	N_2	excess O_2	CO_2	H_2O	SO_2	N_2	excess O_2	Total	25C-980C	as air @ambient temp		Temp			Amb CO_2	Amb H_2O	Amb SO_2/SO_3	Amb N_2	Amb O_2	Amb Total	exit temp	0oC temp	rate from combust	rate from combust			
		Vol rate	mass rate						moles/moles or m³/m³							moles/moles or m³/m³ of combust VOC																												
		m3/hr	kg/hr									m³/hr	m³/hr	m³/hr		m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	kJ/kg°C	kg/m³	°C	°C	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	m³/hr	Am³/hr	Nm³/hr	kg/hr	g/min	mg/m³	mg/m³	m/sec
	Total (Waste Stream)																																										
A	Benzene	0.0	0.06988	6.0	6.0	0.0	0.0	0.0	7.5	28.21	35.71	0.2	0.6	0.8	1.6	6.0	3.0	0.0	28.2	7.5	0.1	0.1	0	1.2	0.2	**1.6**	1.0727	1.16	30.0	980.0	1.6	0.0	0.13	0.07	0.00	1	0	**1.6**	**7**	**1**	0.000	0.000	0.000	0.001	0.002
B	Hexene	70.7	242	6	14	0	0.0	0.0	9.5	35.74	45.24	671.6	2526.5	3198.1	6396.1	6	7	0	35.7	9.5	424.2	494.9	0	5052.9	671.6	**6643.5**	1.0727	1.16	30.0	980.0	9004.3	2360.7	424.16	**494.86**	**0.00**	######	######	**9004.28**	**37235.53**	**8112.77**	**0.024**	**0.403**	**0.649**	**2.980**	12.664
C	Acetone			3.0	6.0	1.0	0.0	0.0	4.5	16.93	21.43	0.0	0.0	0.0	0.0	3	3	0	16.9	4.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	0.000
D	Ethanol			2.0	6.0	1.0	0.0	0.0	3.5	13.17	16.67	0.0	0.0	0.0	0.0	2	3	0	13.2	3.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	0.000
E	Methanol			1.0	4.0	1.0	0.0	0.0	2	7.52	9.52	0.0	0.0	0.0	0.0	1	2	0	7.5	2.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	0.000
F	Styrene			8.0	8.0	0.0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	8	4	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	0.000
G	Vinyl Acetate			4.0	6.0	2.0	0.0	0.0	5.5	20.69	26.19	0.0	0.0	0.0	0.0	4	3	0	20.7	5.5	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	0.000
H	Methyl Methacrylate			5.0	8.0	2.0	0.0	0.0	7	26.33	33.33	0.0	0.0	0.0	0.0	5	4	0	26.3	7.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	0.000
I	Butyl Acrylates			7.0	12.0	2.0	0.0	0.0	10	37.62	47.62	0.0	0.0	0.0	0.0	7	6	0	37.6	10.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	0.000
J	Methyl Isobutyl Carbinol (MIBC)			0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.000**	**0.000**	**0.000**	0.000
K	Hydrogen Sulphide (H_2S) (0.2% w/w benzene)	0.00	0.00	0.0	2.0	0.0	0.0	1.0	0.5	1.9	2.4	0.00	0.00	0.00	0.00	0	1	1	1.9	0.5	0.0	0.0	0.00	0.0	0.0	**0.0**	1.0727	1.16	30.0	980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**	**0.0**	0.000000	0.0000	0.0000	0.0000	0.000
	Sulphur Dioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					0.0			**0.0**	**0.0**	**0.0**	**0.00**	0.0	0.0	0.0	
	Sulphur Trioxide (from combustion of H2S)																										1.0727	1.16	30.0	980.0					0.0			**0.0**	**0.0**	**0.0**	**0.00**	0.0	0.0	0.0	
	Total (VOC LWB stream)																									**6645.1**	1.0727	1.16	30.0	980.0	9005.9	2360.7	424.3	494.9	0.0	6919.2	1167.5	9005.9	37242.1	8114.2	0.024	0.403	0.649	2.981	12.7

General

Heat of combustion data: source: Perry Chemical Engineers Handbook 7th Ed., pg's 2-195 to 2-199, cmp no 67,6,123,83, 148, 228

Assume Heat of comb for MMA as per ethyl propionate 26.3 (methane =50.1 MJ/kg)

Ambient temperature is same as inlet temperature

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No :	**200003**	**Date**	**13/10/2021**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
Calculation No:	**200003CAL-002**	**Rev**	**2**

Liquid Waste Burning-Thermal load

91% Hexene, 6.5 L/min Flowrate (Normal Flow)- Thermal Load of Waste Stream at nominated Hexene conc. and nominal Benzene Conc. Note 1

Total Liquid Waste Disposal Rate	**6.50**	**l/min**
Initial temp	5	˚C
Final temp	980	˚C
Heat Capacity of liquid stream/waste	2	kJ/kg/K
Heat Capacity of stack gases	1.166	kJ/kg/K
Density of Air	1.2	kg/m3

Stream ID	Input stream	% V/V	Volumetric rate input stream l/min	Mass rate stream kg/min	MW	Liquid density @25˚C kg/m3	Mass rate kg/hr	Heat of Combustion of VOC net (LHV) MJ/kg	Energy (-ve = generated) (+ve = consumed) MJ/hr	Mol rate kmols/hr	formulae	Mol ratio comb O2/waste liquid	Combustion Air kmols/hr	Combustion Air m3/hr	Enthalpy of Evaporation MJ/kg	Sensible Heat + Super heat MJ/kg	Total Energy MJ/kg	Total Energy (-ve = generated) (+ve = consumed) MJ/hr
A	Benzene	0.0205%	0.00133	0.00116	78	874.00	0.070	40.21	-3	0.00	C6H6	7.50	0.03	0.73				-3
B	Hexene	91.4%	5.944	4.030	84	678.00	241.8	44.52	-10763	2.88	C6H12	9.00	123.95	2826.03				-10763
C	Acetone	0.0%	0.0	0.00	58	791.00	0.0	28.60	0	0.00	C3H6O	4.50	0.00	0.00				0
D	Ethanol	0.0%	0.0	0.00	46	806.00	0.0	26.85	0	0.00	C2H5OH	3.00	0.00	0.00				0
E	Methanol	0.0%	0.0	0.00	32	791.00	0.0	19.94	0	0.00	CH3OH	1.50	0.00	0.00				0
F	Styrene	0.0%	0.0	0.00	104	906.00	0.0	40.51	0	0.00	C8H8	10.00	0.00	0.00				0
G	Vinyl Acetate	0.0%	0.0	0.00	86	934.00	0.0	22.65	0	0.00	C4H6O2	4.50	0.00	0.00				0
H	Methyl Methacrylate	0.0%	0.0	0.00	100	943.00	0.0	26.40	0	0.00	C5H8O2	6.00	0.00	0.00				0
I	Butyl Acrylates	0.0%	0.0	0.00	128	894.00	0.0	32.24	0	0.00	C7H12O2	9.00	0.00	0.00				0
J	Methyl Isobutyl Carbinol (MIBC)	0.0%	0.0	0.00	102	802.00	0.0	38.70	0	0.00	C6H14O	9.00	0.00	0.00				0
	Water	8.5395%	0.555	0.55	18	997.00	33.2		0						2.26	1.42	3.68	**122**
	Total	100.0%	6.5	4.58			275.06		**-10766**									**-10644**

Note 1: Benzene concentration based on 9 kg benzene in 50,000 l of liquid waste in Waste Tank.

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No. :	**200003**	**Date**	**13/10/2021**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
		Rev	**2**
Calculation No:	**200003CAL-002**		

Vapour Density, Mole Fraction & Tank Expansion Factor

BENZENE — From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
83.918	-6517.7	-9.3453	7.1182E-06	2

Temperature	30	˚C
	303	K
Vapour Pressure	15747	Pa
	15.7	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Benzene Molecular Weight	78	Mole fraction	0.154
Nitrogen Molecular Weight	28	Mole fraction	0.846
			1.00
Therefore Average Molecular Weight	35.7		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.45	kg/m3	Total Flow
Density =	3.18	kg/m3	Benzene vapour

BENZENE — From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
83.918	-6517.7	-9.3453	7.1182E-06	2

Temperature	15	˚C
	288	K
Vapour Pressure	7750	Pa
	7.7	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Benzene Molecular Weight	78	Mole fraction	0.076
Nitrogen Molecular Weight	28	Mole fraction	0.924
			1.00
Therefore Average Molecular Weight	31.8		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.36	kg/m3	Total Flow
Density =	3.34	kg/m3	Benzene vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.08	
initial mol fract N2	0.92	
Volume Act	56.66814	
Volume Vol	693.3319	
	750	
Final temp	30	
Final mol fract act	0.15	
Final mol fract N2	0.85	
Volume Act	115.1429	
Volume Vol	634.8571	
	750	
Vapour pressure expansion	8.4%	
Thermal gas expansion	5.2%	
expansion factor	13.6%	

HEXENE — From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
85.3	-6171.7	-9.702	8.9604E-06	2

Temperature	30	˚C
	303	K
Vapour Pressure	30314	Pa
	30.3	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Hexene Molecular Weight	84	Mole fraction	0.296
Nitrogen Molecular Weight	28	Mole fraction	0.704
			1.00
Therefore Average Molecular Weight	44.6		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.81	kg/m3	Total Flow
Density =	3.42	kg/m3	Hexene vapour

HEXENE — From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
85.3	-6171.7	-9.702	8.9604E-06	2

Temperature	15	˚C
	288	K
Vapour Pressure	15862	Pa
	15.9	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Hexene Molecular Weight	84	Mole fraction	0.155
Nitrogen Molecular Weight	28	Mole fraction	0.845
			1.00
Therefore Average Molecular Weight	36.7		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.57	kg/m3	Total Flow
Density =	3.60	kg/m3	Hexene vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.15	
initial mol fract N2	0.85	
Volume Act	115.9806	
Volume Vol	634.0194	
	750	
Final temp	30	
Final mol fract act	0.30	
Final mol fract N2	0.70	
Volume Act	221.6568	
Volume Vol	528.3432	
	750	
Vapour pressure expansion	16.7%	
Thermal gas expansion	5.2%	
expansion factor	21.9%	

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
Project No. :	**200003**	**Date**	**13/10/2021**
Project :	**2nd Thermal Oxidiser and Liquid Waste Burning**	**Checked**	**AB**
		Rev	**2**
Calculation No:	**200003CAL-002**		

Vapour Density, Mole Fraction & Tank Expansion Factor

ACETONE From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
69.006	-5599.6	-7.0985	6.2237E-06	2

Temperature 30 ˚C = 303 K

Vapour Pressure 37719 Pa = 37.7 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Acetone Molecular Weight	58	Mole fraction	0.368
Nitrogen Molecular Weight	28	Mole fraction	0.632
			1

Therefore Average Molecular Weight 39.0

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.59 kg/m3 Total Flow
Density = 2.36 kg/m3 Acetone vapour

ACETONE From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
69.006	-5599.6	-7.0985	6.2237E-06	2

Temperature 15 ˚C = 288 K

Vapour Pressure 19548 Pa = 19.5 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Acetone Molecular Weight	58	Mole fraction	0.191
Nitrogen Molecular Weight	28	Mole fraction	0.809
			1

Therefore Average Molecular Weight 33.7

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.44 kg/m3 Total Flow
Density = 2.48 kg/m3 Acetone vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.19	
initial mol fract N2	0.81	
Volume Act	142.9372	
Volume Vol	607.0628	
	750	
Final temp	30	
Final mol fract act	0.37	
Final mol fract N2	0.63	
Volume Act	275.8063	
Volume Vol	474.1937	
	750	
Vapour pressure expansion	21.9%	
Thermal gas expansion	5.2%	
expansion factor	27.1%	

ETHANOL From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
74.475	-7164.3	-7.327	3.1340E-06	2

Temperature 30 ˚C = 303 K

Vapour Pressure 10443 Pa = 10.4 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Ethanol Molecular Weight	46	Mole fraction	0.102
Nitrogen Molecular Weight	28	Mole fraction	0.898
			1

Therefore Average Molecular Weight 29.8

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.21 kg/m3 Total Flow
Density = 1.87 kg/m3 Ethanol vapour

ETHANOL From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
74.475	-7164.3	-7.327	3.1340E-06	2

Temperature 15 ˚C = 288 K

Vapour Pressure 4300 Pa = 4.3 kPa

Tank Pressure 5 "WC = 1.25 kPag

System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Ethanol Molecular Weight	46	Mole fraction	0.042
Nitrogen Molecular Weight	28	Mole fraction	0.958
			1

Therefore Average Molecular Weight 28.8

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.23 kg/m3 Total Flow
Density = 1.97 kg/m3 Ethanol vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.04	
initial mol fract N2	0.96	
Volume Act	31.44251	
Volume Vol	718.5575	
	750	
Final temp	30	
Final mol fract act	0.10	
Final mol fract N2	0.90	
Volume Act	76.35719	
Volume Vol	673.6428	
	750	
Vapour pressure expansion	6.3%	
Thermal gas expansion	5.2%	
expansion factor	11.5%	

Client : Quantem (Terminals Pty Ltd)
Project No. : 200003
Project : 2nd Thermal Oxidiser and Liquid Waste Burning

Calculation No: 200003CAL-002

Calc by FS
Date 13/10/2021
Checked AB
Rev 2

Vapour Density, Mole Fraction & Tank Expansion Factor

METHANOL

C1	C2	C3	C4	C5
81.768	-6876	-8.7078	7.1926E-06	2

Temperature 30 °C
303 K
Vapour Pressure 21617 Pa
21.6 kPa

Tank Pressure 5 "WC
1.25 kPag
System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Methanol Molecular Weight	32	Mole fraction	0.211
Nitrogen Molecular Weight	28	Mole fraction	0.789
			1

Therefore Average Molecular Weight 28.8

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.17 kg/m3 Total Flow
Density = 1.30 kg/m3 Methanol vapour

METHANOL From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
81.768	-6876	-8.7078	7.1926E-06	2

Temperature 15 °C
288 K
Vapour Pressure 9678 Pa
9.7 kPa

Tank Pressure 5 "WC
1.25 kPag
System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Methanol Molecular Weight	32	Mole fraction	0.094
Nitrogen Molecular Weight	28	Mole fraction	0.906
			1

Therefore Average Molecular Weight 28.4

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.22 kg/m3 Total Flow
Density = 1.37 kg/m3 Methanol vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.09	
initial mol fract N2	0.91	
Volume Act	70.76916	
Volume Vol	679.2308	
	750	
Final temp	30	
Final mol fract act	0.21	
Final mol fract N2	0.79	
Volume Act	158.0642	
Volume Vol	591.9358	
	750	
Vapour pressure expansion	12.9%	
Thermal gas expansion	5.2%	
expansion factor	18.1%	

STYRENE

C1	C2	C3	C4	C5
105.93	-8685.9	-12.42	7.5583E-06	2

Temperature 30 °C
303 K
Vapour Pressure 1089 Pa
1.1 kPa

Tank Pressure 5 "WC
1.25 kPag
System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Styrene Molecular Weight	104.15	Mole fraction	0.011
Nitrogen Molecular Weight	28	Mole fraction	0.989
			1

Therefore Average Molecular Weight 28.8

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.17 kg/m3 Total Flow
Density = 4.24 kg/m3 Styrene vapour

STYRENE From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
105.93	-8685.9	-12.42	7.5583E-06	2

Temperature 15 °C
288 K
Vapour Pressure 430 Pa
0.4 kPa

Tank Pressure 5 "WC
1.25 kPag
System Total 102.6 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

Styrene Molecular Weight	104.15	Mole fraction	0.004
Nitrogen Molecular Weight	28	Mole fraction	0.996
			1

Therefore Average Molecular Weight 28.3

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.21 kg/m3 Total Flow
Density = 4.46 kg/m3 Styrene vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.00	
initial mol fract N2	1.00	
Volume Act	3.143507	
Volume Vol	746.8565	
	750	
Final temp	30	
Final mol fract act	0.01	
Final mol fract N2	0.99	
Volume Act	7.96287	
Volume Vol	742.0371	
	750	
Vapour pressure expansion	0.6%	
Thermal gas expansion	5.2%	
expansion factor	5.9%	

Client :	**Quantem (Terminals Pty Ltd)**	**Calc by**	**FS**
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Vapour Density, Mole Fraction & Tank Expansion Factor

VINYL ACETATE

C1	C2	C3	C4	C5
57.406	-5702.8	-5.0307	1.1042E-17	6

Temperature	30	˚C
	303	K
Vapour Pressure	18946	Pa
	18.9	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

Vinyl Acetate Molecular Weight	86.09	Mole fraction	0.185
Nitrogen Molecular Weight	28	Mole fraction	0.815
			1
Therefore Average Molecular Weight	38.7		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.58	kg/m3	Total Flow
Density =	3.51	kg/m3	Vinyl acetate vapour

VINYL ACETATE From Perry 7th Ed Table 2-6

C1	C2	C3	C4	C5
57.406	-5702.8	-5.0307	1.1042E-17	6

Temperature	15	˚C
	288	K
Vapour Pressure	9157	Pa
	9.2	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

Vinyl Acetate Molecular Weight	86.09	Mole fraction	0.089
Nitrogen Molecular Weight	28	Mole fraction	0.911
			1
Therefore Average Molecular Weight	33.2		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.42	kg/m3	Total Flow
Density =	3.69	kg/m3	Vinyl acetate vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.09	
initial mol fract N2	0.91	
Volume Act	66.95524	
Volume Vol	683.0448	
	750	
Final temp	30	
Final mol fract act	0.18	
Final mol fract N2	0.82	
Volume Act	138.5338	
Volume Vol	611.4662	
	750	
Vapour pressure expansion	10.5%	
Thermal gas expansion	5.2%	
expansion factor	15.7%	

METHYL METHACRYLATE

C1	C2	C3	C4	C5
107.36	-8085.3	-12.72	8.3307E-06	2

Temperature	30	˚C
	303	K
Vapour Pressure	6387	Pa
	6.4	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

MMA Molecular Weight	100.12	Mole fraction	0.062
Nitrogen Molecular Weight	28	Mole fraction	0.938
			1
Therefore Average Molecular Weight	32.5		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.32	kg/m3	Total Flow
Density =	4.08	kg/m3	Metylmetacrylate vapour

METHYL METHACRYLATE From BOC data (Same method as Perry 7th Ed Table 2-6)

C1	C2	C3	C4	C5
107.36	-8085.3	-12.72	8.3307E-06	2

Temperature	15	˚C
	288	K
Vapour Pressure	2819	Pa
	2.8	kPa
Tank Pressure	5	"WC
	1.25	kPag
System Total	102.6	kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

MMA Molecular Weight	100.12	Mole fraction	0.027
Nitrogen Molecular Weight	28	Mole fraction	0.973
			1
Therefore Average Molecular Weight	30.0		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.28	kg/m3	Total Flow
Density =	4.29	kg/m3	Metylmetacrylate vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.03	
initial mol fract N2	0.97	
Volume Act	20.61324	
Volume Vol	729.3868	
	750	
Final temp	30	
Final mol fract act	0.06	
Final mol fract N2	0.94	
Volume Act	46.70079	
Volume Vol	703.2992	
	750	
Vapour pressure expansion	3.6%	
Thermal gas expansion	5.2%	
expansion factor	8.8%	

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Vapour Density, Mole Fraction & Tank Expansion Factor

BUTYL ACRYLATE

A	B	C
8.141759	2199.925	273.16

Temperature	30	˚C	
	303	K	
Vapour Pressure	7.68	mmHg	
	1023	Pa	
	1.0	kPa	
Tank Pressure	5	"WC	
	1.25	kPag	
System Total	102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

BA Molecular Weight	128.17	Mole fraction	0.010
Nitrogen Molecular Weight	28	Mole fraction	0.990
			1
Therefore Average Molecular Weight	29.0		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.18	kg/m3	Total Flow
Density =	5.22	kg/m3	Butyl acrylate vapour

BUTYL ACRYLATE From Odor and VOC Control Handbook - H.J Rafson)

A	B	C
8.141759	2199.925	273.16

Temperature	15	˚C	
	288	K	
Vapour Pressure	3.22	mmHg	
	429	Pa	
	0.4	kPa	
Tank Pressure	5	"WC	
	1.25	kPag	
System Total	102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

BA Molecular Weight	128.17	Mole fraction	0.004
Nitrogen Molecular Weight	28	Mole fraction	0.996
			1
Therefore Average Molecular Weight	28.4		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.22	kg/m3	Total Flow
Density =	5.49	kg/m3	Butyl acrylate vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.00	
initial mol fract N2	1.00	
Volume Act	3.135541	
Volume Vol	746.8645	
	750	
Final temp	30	
Final mol fract act	0.01	
Final mol fract N2	0.99	
Volume Act	7.482607	
Volume Vol	742.5174	
	750	
Vapour pressure expansion	0.6%	
Thermal gas expansion	5.2%	
expansion factor	5.8%	

METHYL ISOBUTYL CARBINOL (MIBC)

A	B	C
6.63977	1521.88	196.767

Temperature	30	˚C	
	303	K	
Vapour Pressure	0.85	kPa	
Tank Pressure	5	"WC	
	1.25	kPag	
System Total	102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

MIBC Molecular Weight	102.174	Mole fraction	0.008
Nitrogen Molecular Weight	28	Mole fraction	0.992
			1
Therefore Average Molecular Weight	28.6		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.17	kg/m3	Total Flow
Density =	4.16	kg/m3	Butyl acrylate vapour

METHYL ISOBUTYL CARBINOL (MIBC) From Shell Chemicals Data Sheet

A	B	C
6.63977	1521.88	196.767

Temperature	15	˚C	
	288	K	
Vapour Pressure	0.28	kPa	
Tank Pressure	5	"WC	
	1.25	kPag	
System Total	102.6	kPa	

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement
No Oxygen - All Nitrogen and Solvent Vapour

MIBC Molecular Weight	102.174	Mole fraction	0.003
Nitrogen Molecular Weight	28	Mole fraction	0.997
			1
Therefore Average Molecular Weight	28.2		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density =	1.21	kg/m3	Total Flow
Density =	4.38	kg/m3	Butyl acrylate vapour

tank vol	1000	m3
tank empty	0.75	
vap vol	750	m3
initial temp	15	
initial mol fract act	0.00	
initial mol fract N2	1.00	
Volume Act	2.076018	
Volume Vol	747.924	
	750	
Final temp	30	
Final mol fract act	0.01	
Final mol fract N2	0.99	
Volume Act	6.203018	
Volume Vol	743.797	
	750	
Vapour pressure expansion	0.6%	
Thermal gas expansion	5.2%	
expansion factor	5.8%	

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Vapour Density, Mole Fraction & Tank Expansion Factor

Hydrogen Sulphide

Temperature 30 Deg C
303 Deg K

Tank Pressure 6 "WC
1.5 kPag
System Total 102.8 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

H2S Molecular Weight	34	Mole fraction	0.04
Nitrogen Molecular Weight	28	Mole fraction	0.96
			1.00
Therefore Average Molecular Weight	28.2		

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 1.15 Kg/m3 Of Total Flow
Density = 1.39 Kg/m3 Of H2S vapour

Sulphur dioxide

Temperature 30 Deg C
303 Deg K

Tank Pressure 6 "WC
1.5 kPag
System Total 102.8 kPa

Partial Pressure = Vapour Pressure at Saturation
Partial Pressure / Total Pressure = Mole Fraction = Volume Fraction

Tank Displacement

No Oxygen - All Nitrogen and Solvent Vapour

SO2 Molecular Weight 64 Mole fraction

PV =nRT, Density = MW x P/RT R = 8314 J/Kelvin.kmole

Density = 2.61 Kg/m3 Of SO2 vapour


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