Pinjarra Alumina Refinery Efficiency Upgrade

Alcoa of Australia Limited

Air Quality Management Plan

June 2018

FOREWARD

This document has been prepared in accordance with Ministerial Statement conditions granted for the Pinjarra Efficiency Upgrade Project, and is intended to reflect Alcoa of Australia Limited's public commitment to transparency in its environmental management program. This document has been updated to reflect the operational phase of the Pinjarra Efficiency Upgrade Project and supersedes earlier versions. Public comments on its contents may be forwarded by mail to:

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TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The purpose of this Air Quality Management Plan is to provide the framework for an effective programme of control and monitoring of emissions to air so as to ensure that air quality criteria are met to the satisfaction of all stakeholders, with particular reference to the additional pollution control equipment installed as part of the Pinjarra Efficiency Upgrade project.

The Plan meets the requirements of Condition 6 of Ministerial Statement No. 000646 of the Minister for the Environment of the Government of Western Australia to provide a detailed plan for the monitoring of emissions from point sources and areas sources, and for assessing impacts on ambient air quality in the surrounding region.

The Plan has been updated to reflect current air quality management arrangements for the operational phase of the Pinjarra Efficiency Upgrade. Monitoring and verification requirements during the construction and commissioning phases of the Pinjarra Efficiency Upgrade have been completed with evidence provided to the Department of Environment and Conservation (DEC), now known as the Department of Water and Environment Regulation (DWER). Information regarding the completion status of the requirements during the construction and commissioning phases have also been provided to the Office of Environmental Protection Agency (OEPA) in relevant annual Ministerial Statement audit compliance reports.

1 INTRODUCTION

1.1 BACKGROUND

The Pinjarra Refinery is located within the Shire of Murray in the Peel region south of Perth, Western Australia and approximately 6 km east of the Pinjarra town site within industrial-zoned land owned by Alcoa of Australia Limited (Alcoa). The refinery is sited at the foot of the Darling Scarp and incorporates the refinery footprint, the residue storage areas (RSAs), and surrounding cattle grazing areas encompassing a total area of approximately 6,772 ha of freehold property. Bauxite is supplied to the refinery from the Alcoa Bauxite Mines, situated in state forest to the east of the refinery.

Prior to the Efficiency Upgrade, the refinery had a production capacity of approximately 3.5 million tonnes per annum of alumina. As with the majority of other alumina refineries throughout the world, the Bayer process is used. Commencing in late 2004, the efficiency of the refinery was upgraded to increase alumina production capacity to 4.2 million tonnes per annum. This upgrade is known as the Pinjarra Efficiency Upgrade (the Efficiency Upgrade, or PEU) project. The production increase was achieved primarily by improving the efficiency of the refinery by increasing the alumina yield from the Bayer liquor circuit through improvements in the precipitation process.

Alcoa submitted a non-substantial change application in October 2012, under Section 45C of the EP Act, to the Office of the Environmental Protection Authority (EPA) for changes to Schedule 1 of Ministerial Statement 646. An amendment to the non-substantial change application was made to the EPA in March 2014, with approval of the application granted on 21 September 2015. The approval allows Alcoa to incrementally increase the alumina production capacity of the PEU to 5.0 million tonnes per annum.

1.2 EMISSIONS TO AIR

Emissions from the refinery may occur from localised points (“point sources”) and from open areas of liquids or solids (“area sources”).

The main point sources of gaseous emissions to air are combustion processes, in particular the power station, calciners and the oxalate kiln. These sources all produce CO, CO_2, NO_X, and some Volatile Organic Compounds (VOCs), as well as water vapour. The calciners and kiln also have the potential to emit dust.

VOCs are produced in the Bayer process itself, in which bauxite is reacted with caustic soda to liberate the alumina. In this process, a proportion of the organic compounds in the bauxite react to form compounds which may be emitted to air from various points in the refinery as VOCs. VOCs may also be produced from reagents added to the process as flocculants and dewatering aids.

Area sources include the Residue Storage Areas (RSAs) and associated process liquor and water storages, which are potential sources of VOCs and dust, the bauxite stockpiles and transport systems which are potential sources of bauxite dust, and the alumina transport system which is a potential source of alumina dust.

Emissions of gases and dusts have the potential to affect the air quality in the surrounding region. Effective control and monitoring at emission sources are essential to ensure that perceptible odour and dust events are minimised, and that no substances are present at levels that could be of concern to human or environmental health.

1.3 PURPOSE AND SCOPE OF PLAN

The purpose of this Air Quality Management Plan is to provide the framework for an effective programme of control and monitoring of emissions to air so as to ensure that air quality criteria are met to the satisfaction of all stakeholders, with particular reference to the additional pollution control equipment installed as part of the PEU project.

The Plan has been updated to reflect current air quality management arrangements for the operational phase of the PEU. Monitoring and verification requirements during the construction and commissioning phases of the PEU have been completed with evidence provided to the DER (now DWER, Department of Water and Environmental Regulation). Information of the completion status of the requirements relevant to the construction and commissioning phases of the PEU have also been provided to OEPA in relevant annual Ministerial Statement audit compliance reports.

2 POINT SOURCE EMISSIONS

There are four major point source groups within the upgraded Pinjarra Refinery for which additional pollution control equipment was installed as part of the Pinjarra Efficiency Upgrade project, these being as follows:

- Oxalate Kiln Stack;
- Digestion RTO Stack;
- Calciner Stacks (1 – 7); and
- Boilers Stacks (2 – 7);

The details of the control and monitoring of each of these are provided in the following sections.

2.1 OXALATE KILN STACK

2.1.1 Description

Sodium oxalate is a by-product of the bauxite refining process that is removed from the production stream and converted to sodium carbonate in a rotary kiln. The combustion process results in the production of CO and a range of VOCs as products of incomplete combustion, and fine particulates that report to the exhaust gases stream.

The Efficiency Upgrade included an increase in the capacity of the oxalate kiln, and the installation of improved emissions reduction equipment, specifically a more efficient wet scrubber and a Regenerative Thermal Oxidiser (RTO). In the upgraded scrubber, the original venturi scrubber was replaced by two combination high pressure venturi scrubbers to clean and cool the gas stream before it goes to the RTO. This increased the scrubbing efficiency substantially, reducing the dust concentration in the stack emissions from approximately 80 mg/m^3 to less than 10 mg/m^3.

The RTO heats the scrubbed exhaust gases to 850^{o}C, at which temperature over 90% of the VOC and CO are converted to CO_2 and water. The temperature is as specified by the manufacturer, HPS-Enerflex, who designed the RTO specifically for this purpose on the basis of the specified gas compositions and flows and the required destruction efficiency. The RTO consists of beds filled with inert ceramic material to provide the heat transfer required. The beds are swapped between hot and cold duty on a 2 to 5 minute cycle to maximise destruction efficiency and heat recovery. The existing kiln stack Number 2 was retained, but the exhaust gas is hotter and has lower moisture content than before the upgrade, and the kiln stack discharge nozzle was also modified to improve dispersion. This has eliminated the visible plume from the RTO and improved the dispersion characteristics of the exhaust gas.

Since the efficiency of the RTO is intrinsically linked to the temperature at which it operates, continuous temperature monitors are installed. Continuous CO monitors are also installed at the inlet and outlet of the RTO to enable direct measurement of overall destruction efficiency. CO has a higher ignition temperature than the VOCs, so the VOCs react at lower temperatures than CO in the RTO. This means that the CO destruction efficiency provides an indication of the minimum VOC destruction that is occurring (i.e. the actual VOC destruction efficiency can be expected to be always greater than the measured CO destruction efficiency).

The design of the RTO specifies continuous operation capability. To ensure efficient and reliable operation, the design allows for up to fifteen days per year for inspection, planned maintenance and overhaul. RTO maintenance is planned to coincide with kiln shutdowns, to maximise the overall effectiveness of the system in relation to both oxalate destruction and emissions minimisation. Other minor or breakdown maintenance is scheduled as part of the Equipment Management Strategy as required to maintain efficient operation.

2.1.2 Nature of Emissions

The oxalate kiln stack is a relatively minor source of Dust, VOCs and CO, and a negligible source of NO_X and SO_2. Nevertheless, it had a significant intermittent localised impact in the workplace in relation to odour (caused by VOCs), CO and dust. The installation of a high efficiency scrubber and RTO during the Efficiency Upgrade has reduced the VOCs and CO concentration by at least 90% compared to pre-Efficiency Upgrade conditions, and a particulate emissions concentration of not greater than 20 mg/m^3. The dust emitted from the oxalate kiln also contains metal oxides as a result of oxidation of trace metals in the liquor and oxalate burnt in the kiln. The high efficiency scrubber has reduced these emissions substantially as a result of reducing dust emissions overall. Mercury is emitted from the kiln as a gaseous metal, so it is uncertain to what extent the improved scrubbing has reduced mercury stack emissions.

2.1.3 Monitoring Program

The key parameters that are monitored for effective operation of the RTO are operating temperature and CO destruction efficiency. The temperature of the RTO is the main parameter that determines the effectiveness of operation and CO destruction is an indicator of the actual destruction achieved for VOCs as well as CO itself. Both temperature and CO are monitored continuously (except during instrument down time). For the scrubber, the key parameter that is monitored is particulates.

Ongoing monitoring is undertaken as follows:

- Continuous monitoring of RTO bed temperatures;
- Continuous monitoring of CO concentrations;
- Quarterly monitoring of particulates by stack sampling as required under the site’s Environmental licence;
- Monthly monitoring of CO, NOx and SO_2 by stack sampling;
- Stack sampling for other species, in particular VOCs, on an as required basis.

Table 1: Monitoring of key parameters of the Oxalate Kiln RTO

Emission Source	Monitoring location	Parameter	Frequency	Method
Oxalate Kiln	RTO burner bed	Temperature	Continuous	Temperature sensor
	Inlet to RTO and RTO outlet stack	CO	Continuous	CO monitor
	RTO outlet stack	Particulates	Quarterly	USEPA method 5 or 17
	RTO outlet stack	CO	Monthly	USEPA Method 10 or approved modification of USEPA Method 10
	RTO outlet stack	NOx	Monthly	USEPA Method 7E or approved modification of USEPA Method 7E
	RTO outlet stack	SO_2	Monthly	USEPA Method 6C or approved modification of USEPA Method 6C

2.1.4 Failure Response and Contingency Plan

Key Control Parameters:

- The key control parameter to ensure the effective operation of the RTO is RTO temperature. The RTO is operated at the design temperature of 850degC (with a minimum of 800degC) specified by the manufacturer to meet the design of >90% VOC destruction. The CO stack monitor provides a direct indication of destruction performance on a continuous basis. In the event of the RTO temperature dropping below 800degC, priority is given to the restoration of the correct operating temperature. If the temperature remains below 800degC, feed will be taken off the kiln within a specified period of time to allow for trouble shooting until the RTO temperature is restored.
- The key control parameters for the wet scrubber are water flow and pressure drop. If there is a failure of the scrubber system, feed will be taken off the kiln within a specified period of time to allow for trouble shooting until the scrubber functionality is restored.

Maintenance and Equipment Failure:

- The RTO will be shut down according to the Equipment Management Strategy for inspection, planned maintenance and where applicable overhaul. Inspection, planned maintenance and overhauls will be managed within the Alcoa Equipment Management System to ensure the continued reliability and effectiveness of the equipment.
- Planned shutdowns of the RTO will be scheduled to coincide with Kiln shutdowns so that there is no effect on emissions. Unplanned shutdowns, e.g. as a result of equipment failure, will be managed to minimise emissions (see Table 2 for details). In the event of an unplanned shutdown of the RTO, or if the RTO bed temperature is less than 800degC, oxalate feed will be taken off the kiln within a specified period of time to allow for trouble shooting until normal RTO operation is restored.

2.1.5 Management Plan Summary

The key actions required for management of the emissions from the Oxalate Kiln Stack are summarised in Table 2.

Table 2: Oxalate Kiln Stack emissions management summary

Aspect	Action
Operation	RTO temperature continuously recorded, with allowance for instrument down time; the kiln is operated at a target temperature of 850degC with a minimum of 800degC.
Operation	The CO concentration continuously monitored at points before and after the RTO; procedures are in place to manage emissions and ensure timely repair in the event of failure of the continuous monitor.
Operations	Operating procedures ensure that the equipment is operated to meet the emission control intent and to minimise emissions in the event of planned or unplanned shutdown of the equipment.
Maintenance	The RTO will be shut down according to the Equipment Management Strategy for inspection, planned maintenance and where applicable overhaul to ensure effective operation.
Maintenance	Equipment Management Strategy is implemented in the Alcoa Equipment Management System to manage equipment reliability and planned shutdowns, and to minimise unplanned shutdowns.
Monitoring	Oxalate Kiln stack exit gases are monitored according to the monitoring program.
Reporting	Particulate emission monitoring results reported to the DWER according to licence requirements.
Contingency	In the event of an unplanned shutdown of the RTO, or if the bed temperature is less than 800degC, feed will be taken off the kiln within a period of time to allow for trouble shooting until normal RTO operation is restored.
Contingency	In the event of a scrubber system failure, feed will be taken off the kiln within a period of time to allow for trouble shooting until the scrubber functionality is restored.

2.2 DIGESTION RTO STACK

2.2.1 Description

In Digestion, bauxite is treated with caustic liquor under pressure to extract the alumina. In that process, a proportion of the organic material contained in the bauxite also reacts with the caustic liquor. One of the consequences of this is the formation of a range of VOC species. A proportion of these VOCs are susceptible to release with steam emissions at various points within the plant liquor circuit, along with VOCs produced from chemicals added to the liquor for such purposes as improving mud settling and filtration. The original Pinjarra Refinery was designed with multiple exit points for these steam emissions and their associated VOCs. Each of these individual emission points was a relatively minor source of emissions to air, however collectively they accounted for approximately one third of the total point source VOC emissions for the refinery.

As part of the Efficiency Upgrade, a number of key emission points in the refinery were collected together and fed to an RTO located in the Digestion area (“Digestion RTO”) for VOC destruction. The sources that were combined together are:

- 25A – Slurry storage tank vents;
- 25V – Digestion vacuum pump exhaust;
- 30E – Liquor to mills evaporator vacuum pump exhaust;
- 35J – Causticiser heating vacuum pump exhaust;
- 40 – Heat interchange vacuum pump exhaust; and
- 42 – Evaporation vacuum pump exhaust.

Together these sources account for approximately 15% of the VOC emissions from point sources in the refinery. The RTO is of a similar design to the RTO installed on the Oxalate Kiln, except that it has been designed to operate at a higher temperature (1000˚C) because of the higher proportion of the more stable VOCs expected to be present. It was supplied by the same manufacturer (HPS-Enerflex).

As with the Oxalate RTO, the key operating parameter for ensuring VOC destruction is the RTO temperature, which is monitored continuously. The sources directed to the Digestion RTO do not contain significant CO, so CO monitors are not installed as they would not give a useful indication of overall destruction efficiency.

The design of the RTO specifies continuous operation capability. To ensure efficient and reliable operation, inspection, planned maintenance and overhaul are scheduled as required as part of the Equipment Management Strategy to maintain efficient operation. Unlike the oxalate kiln, it is not possible to shut down the processes feeding the Digestion RTO during periods of RTO maintenance or breakdown. Therefore every effort is made to ensure that down-times are minimised and on-line performance is maximised.

2.2.2 Nature of Emissions

The emissions from the steam sources are primarily water vapour (steam) along with varying quantities of VOCs. The Digestion RTO has been designed to be capable of reducing VOC emissions to air by at least 90% when operating at design conditions. The RTO is a relatively minor source of the combustion products CO, NOx and SO_2 at the refinery.

2.2.3 Monitoring Program

The key parameter to be monitored for effective operation of the Digestion RTO is the operating temperature of the RTO beds, which determines the effectiveness of VOC destruction. Temperature is monitored continuously.

Ongoing monitoring is as follows:

- Continuous monitoring of RTO bed temperatures;
- Monthly monitoring of CO, NOx and SO_2 by stack sampling;
- Stack sampling for other species, in particular VOCs, on an as required basis.

Table 3: Monitoring of key parameters of the Digestion RTO

Emission Source	Monitoring location	Parameter	Frequency	Method
Digestion RTO	RTO burner bed	Temperature	Continuous	Temperature sensor
	RTO stack	CO	Monthly	USEPA Method 10 or approved modification of USEPA Method 10
	RTO stack	NOx	Monthly	USEPA Method 7E or approved modification of USEPA Method 7E
	RTO stack	SO_2	Monthly	USEPA Method 6C or approved modification of USEPA Method 6C

2.2.4 Failure Response and Contingency Plan

Key Control Parameters

The key control parameter that ensures effective operation of the Digestion RTO is the RTO temperature. The RTO is operated at the target temperature of 1000degC specified by the manufacturer to meet the design of >90% reduction in VOCs emitted to air. In the event of the RTO temperature dropping below 950degC, priority is given to restoration of the correct operating temperature.

Maintenance and Equipment Failure

It is not possible to shut down any of the production processes that feed the RTO, so all steps will be taken to ensure that down time is minimised. The RTO will be shut down according to the Equipment

Management Strategy for inspection, planned maintenance and where applicable overhaul to ensure effective operation. An Equipment Management Plan is in place and managed within the Alcoa Equipment Management System to ensure the ongoing reliability and effectiveness of the equipment.

2.2.5 Management Plan Summary

The key actions required for management of the emissions from the Digestion RTO are summarised in Table 4.

Table 4: Digestion RTO emissions management summary

Aspect	Action
Operation	The temperature of the RTO continuously recorded, with allowance for instrument down time; the RTO is operated at the target temperature of 1000degC.
Operation	Operating procedures ensure that the equipment is operated to meet the emission control intent and to minimise emissions in the event of planned or unplanned shutdown of the equipment.
Maintenance	The RTO will be shut down according to the Equipment Management Strategy for inspection, planned maintenance and where applicable overhaul to ensure effective operation.
Maintenance	Equipment Management Plan in Alcoa’s Equipment Management System to manage equipment reliability and planned shutdowns, and to minimise unplanned shutdowns.
Monitoring	Digestion RTO stack exit gases monitored according to the Monitoring Program.
Contingency	In the event of an unplanned RTO shutdown, or if the bed temperature is less than 950degC, corrective actions will be initiated to minimise the time required before normal RTO operation is restored.

2.3 CALCINERS

2.3.1 Description

The final stage of the alumina refining process is Calcination, in which aluminium hydroxide (“hydrate”) is converted to alumina by heating to around 950degC with the evolution of three molecules of water per molecule of alumina. At Pinjarra, this is achieved in a set of stationary fluid bed kilns, or calciners. Prior to the Efficiency Upgrade there were six calciners at Pinjarra. Calciner 7 was added as part of the Efficiency Upgrade. The calciners use natural gas as the fuel source.

2.3.2 Nature of Emissions

The predominant emissions from the calciners are steam produced from the calcination process itself, at a rate of approximately half a tonne of steam per tonne of alumina produced, and products of combustion, predominantly CO_2 and water from the combustion of natural gas. The other main combustion products are CO and NO_x. The emissions also contain trace quantities of SO_2 and VOCs including formaldehyde from combustion of fuel and chemicals present in the calciner feed material, and trace quantities of elemental mercury.

In addition to the gaseous emissions, the calcination of hydrate creates fine particulates which can be emitted as dust. The dust emissions are mitigated and controlled to low levels by the use of Electrostatic Precipitators (ESPs) on the calciner stacks. Each calciner stack is fitted with Continuous Emission Monitoring (CEM) in the form of continuous Dust Concentration Monitors (DCMs), which assist in managing dust emissions from the calciners. Dust emissions are regulated according to the site’s DWER Environmental Licence, on the basis of dust readings from the DCMs as well as isokinetic sampling according to USEPA methods to a schedule specified in the Licence. The Efficiency Upgrade included the installation of a three zone ESP system to the new calciner (Calciner 7), and upgrades to the ESPs on calciners 4, 5 and 6.

2.3.3 Monitoring Program

The key indicator for the performance of the calciner emissions control equipment (the ESPs) is the dust concentration in the stack gases. This is monitored continuously by the DCMs for control and regulatory purposes, and periodically by isokinetic sampling for verification and regulatory purposes. Additional isokinetic measurements were incorporated for the new and upgraded equipment installed in the Efficiency Upgrade, and the DCMs are used for continuous assessment of ESP performance during operation, with allowance for instrument down time.

Ongoing monitoring is carried out for each calciner stack as follows:

- Continuous monitoring of particulates by DCM as required by the site’s DWER Environmental Licence;
- Quarterly stack sampling for Particulates (half yearly sampling is required by the site’s DWER Environmental Licence;

- Monthly monitoring of CO, NO_x and SO_2 by stack sampling (quarterly sampling of CO and NO_x is required by the site's DWER Environmental Licence);
- Stack sampling for other species, in particular VOCs, on an as required basis.

Table 5: Monitoring of key parameters of Calciner stacks

Emission Source	Monitoring location	Parameter	Frequency	Method
Calciners	Calciner ESP stack	Particulates	Continuous	Dust Concentration meters
	Calciner ESP stack	Particulates	Quarterly	USEPA method 5 or 17
	Calciner ESP stack	CO	Monthly	USEPA Method 10 or approved modification of USEPA Method 10
	Calciner ESP stack	NOx	Monthly	USEPA Method 7E or approved modification of USEPA Method 7E
	Calciner ESP stack	SO_2	Monthly	USEPA Method 6C or approved modification of USEPA Method 6C

2.3.4 Failure Response and Contingency Plan

Key Control Parameters:

The key control parameters relating to stack particulate emissions are ESP temperature, ESP voltages, and particulate concentration as measured by the DCMs. Alcoa has operating procedures which set the required operating ranges and specify responses in the event of any deviations from those operating ranges.

Maintenance and Equipment Failure

Inspection, planned maintenance and overhauls of the ESPs and DCMs are managed within Alcoa's Equipment Management System to ensure the continuing reliability and effectiveness of the equipment. The DCMs are correlated on an annual basis against stack sampling by USEPA Method 5 or 17 according to established procedures. In the event of DCM failure, procedures are in place to ensure that emissions remain in control and that the DCM is repaired and brought back into operation as soon as practicable.

2.3.5 Management Plan Summary

The key actions required for management of the emissions from the Calciner stacks are summarised in Table 6.

Table 6: Calciners emissions management summary

Aspect	Action
Operation	The calciners are operated within the regulatory targets or limits specified in the site's DWER environmental licence.
Maintenance	The ESPs will be shut down according to the Equipment Management Strategy for inspection, planned maintenance and where applicable overhaul to ensure effective operation.
Maintenance	Equipment Management Strategy in Alcoa's Equipment Management System to manage equipment reliability and planned shutdowns, and to minimise unplanned shutdowns.
Maintenance	The DCMs are maintained in each calciner, with allowance for instrument down time; procedures are in place to manage emissions and ensure timely repair in the event of failure of the continuous monitor.
Monitoring	Calciner stack exit gases and particulates are monitored according to the Monitoring Program.
Reporting	Particulate emission monitoring results reported to the DWER according to licence requirements.
Contingency	Dust emission events (defined as sustained emissions above Environmental licence target or limit levels) will be identified and acted upon as quickly as possible, in accordance with established procedures.

2.4 BOILERS

2.4.1 Description

The Pinjarra powerhouse generates steam using six gas fired boilers (numbered 2 to 7), which are supplemented by two Heat Recovery Steam Generators (HRSGs) from the adjacent Alinta cogeneration plant. Boilers 2, 6 and 7 were manufactured by International Combustion Australia Limited (ICAL), and boilers 3, 4 and 5 were manufactured by John Thompson Australia (JTA).

The heat input into the boilers is via front wall mounted burners. The burners are integral to the boilers operation, and are the only source of heat input into the units for steam generation. Each of boilers 2, 6 and 7 has six identical burners per boiler. Individual burners can be shut down, with a corresponding reduction in steam output. The burners can also operate at varying firing rates up to a maximum rating.

The boilers operate using natural gas as the primary fuel, and distillate (diesel) as the emergency backup fuel during curtailment of gas supply.

As part of the Efficiency Upgrade project, the burners on boiler 2 and boiler 6 were replaced with Low-NOx burners that generate less oxides of nitrogen (NOx). The burners on boiler 7 were retrofitted with the same low NOx type in 2000. Boilers 3, 4 & 5 were not retrofitted with low NOx burners, but are generally running at lower loads due to the operation of the HRSGs.

2.4.2 Nature of Emissions

The main emissions from the gas-fired boilers are water and CO2, the intended products of combustion of the natural gas. Small quantities of CO and traces of VOCs are formed as products of incomplete combustion. In addition, oxides of nitrogen (NOx) are formed by reaction of oxygen and nitrogen in the air within the hottest part of the burner flame. NOx is the main contaminant in the flue gases. It is reduced by the use of improved burner designs ("low-NOx burners") which reduce the oxidation of atmospheric nitrogen by reducing the flame temperatures reached in the combustion process. This is achieved by improving the air-fuel mixing process, resulting in lower flame temperatures and improved combustion efficiency. The installation of low-NOx burners in Boilers 2, 6 and 7 have reduced NOx emissions from those Boilers significantly.

2.4.3 Monitoring Program

The performance of the burners is determined by analysis of the flue gas for NOx and CO. Multi-gas analysers are permanently installed on each of boilers. These measure methane (CH4), CO2, CO, and O2. These parameters are inputs into the Burner Management System, and are used mainly to monitor combustion safety. The CO and NOx concentrations are monitored by stack sampling as required by the site's DWER Environmental Licence.

Ongoing monitoring is carried out for each boiler stack as follows:

- Monthly monitoring of CO, NO_x and SO_2 by stack sampling (quarterly sampling of CO and NO_x is required by the site's DWER Environmental Licence).

Table 7: Monitoring of key parameters of Powerhouse boilers

Emission Source	Monitoring location	Parameter	Frequency	Method
Boilers	Boiler stack	CO	Monthly	USEPA Method 10 or approved modification of USEPA Method 10
	Boiler stack	NOx	Monthly	USEPA Method 7E or approved modification of USEPA Method 7E
	Boiler stack	SO_2	Monthly	USEPA Method 6C or approved modification of USEPA Method 6C

2.4.4 Failure Response and Contingency Plan

The low NO_X burners are an integral part of the boilers. The boilers cannot be operated without the installed NO_X control equipment. Individual burners can be removed from service in the event of a malfunction. This can reduce boiler output, but does not affect NO_X emission levels from the individual boilers.

2.4.5 Management Plan Summary

The key actions required for management of the emissions from the boiler stacks are summarised in Table 8.

Table 8: Boilers emissions management summary

Aspect	Action
Operation	The low NOx burners are an integral part of the boiler, which therefore cannot be operated without the installed NOx control equipment.
Maintenance	The burners are maintained according to the schedule and procedures specified in the Equipment Management Strategy to ensure long term effective operation.
Monitoring	Boiler exit gases are monitored according to the schedule in the Monitoring Program.
Reporting	Boiler exit gases emission monitoring results reported to the DWER according to licence requirements.
Contingency	The low NOx burners are an integral part of the boiler, which therefore cannot be operated without the installed NOx control equipment. Individual burners can be removed from service in the event of a malfunction. This can reduce boiler output, but does not affect NOx emission levels from the individual boilers.

3 AREA SOURCE EMISSIONS

3.1 EMISSION SOURCES

The most significant area source emissions that require management at the refinery are dust emissions from the Residue Storage Areas (RSAs) as well as from the Bauxite stockpiles and transport systems. The following sections cover the dust management and monitoring at these areas.

Note that the RSAs and associated process liquor storage lakes are area sources of VOC emissions and the impacts were assessed in the 2014 revisions of Refinery's Air Quality Model as well as the Health Risk Screening Assessment.

3.1.1 Residue Storage Areas dust management

The material remaining after the alumina has been extracted from the bauxite ore is commonly termed "Residue". Residue is stored in RSAs adjacent to the Refinery. Residue consists of a coarse sand fraction and a fine silt fraction. The residue sand fraction is used for construction of dyke walls, drainage layers, rehabilitated surfaces and roads within the RSA. The fine silt fraction is pumped to a thickener vessel where they are settled using flocculent, producing a high-density slurry which is pumped to a number of drying beds where it is placed in layers and allowed to dry through natural evaporation. To assist the natural drying process, the surface of the residue bed is mechanically turned over using bulldozers and amphirols.

Dust generated from the RSA mostly consists of fine clay particles and some sodium carbonate crystals precipitated on the surface of residue as entrained moisture evaporates. The distance over which these particles are transported depends on a variety of factors including meteorological conditions and the size, shape and mass of the particles. Besides the drying beds, the surrounding infrastructure such as roads, embankments, and drains can also be a source of airborne dust and are managed accordingly. The months from October to April are considered to be the time of the year when the risk of airborne dust generation is potentially the greatest, however Alcoa implements a detailed dust management program throughout the year irrespective of the season. In summer, the predominant winds are moderate to strong east-southeasterly winds and moderate southwesterly winds. Strong and gusty east-southeasterly winds often start around midnight, peaking between 2am and 5am, and abating mid-morning. The speed of these winds together with the higher ambient temperatures over summer, and therefore faster mud drying rates, require careful control mechanisms to be in place to prevent dust being released.

Long term, midterm and day to day controls are in place to manage residue dust at Pinjarra, and an overview of each follows.

Long Term Controls (annual):

On an annual basis, dust control measures for the coming year are planned. These measures aim to ensure that:

- activities with a higher risk of dust generation, such as sand stockpiling and sand construction activities, are performed during times of the year when wind speeds are forecast to be low, wherever possible;
- dust control mechanisms are in place for any newly constructed or exposed embankments before times of the year when higher wind speeds are forecast to be high;
- new or exposed internal embankments likely to remain in place undisturbed for an extended period are planted with native vegetation or grasses during winter to allow them to establish an effective long-term dust control cover; and
- embankments or areas that are not required in the shorter term are covered with crushed rock aggregate or woodchips (mulch).

Mid Term Controls (weekly):

- Dust management activities are tracked at weekly review meetings, which include the personnel involved in dust control. Inspections and surveys are carried out to check the effectiveness of dust controls and identify areas needing attention.
- A specialist consulting company supplies seven day and seasonal weather forecasts, which are reviewed weekly and allow Alcoa to maintain preparedness for conditions conducive for dust generation by, for example, operating sprinklers well ahead of forecast winds.

In addition, the following specific midterm dust control methods are employed by Alcoa to minimise dust generation:

- regularly turning over the mud in the drying area thereby leaving wet mud on the surface; and
- spraying exposed banks and roads with dust suppressants;

Day to Day Controls:

The main day to day control mechanism to manage dust emissions from the drying beds is the use of the sprinkler system. As part of Alcoa's commitment to continuous improvement, the sprinkler design standard was amended to reduce sprinkler spacing to 60 m x 60 m. All RSAs constructed since 2000 have the new design standard for dust suppression systems. All existing sprinkler systems were also upgraded to incorporate the 60m x 60m spacing. The specialist consulting company also supplies a local three day weather forecast on a daily basis, which include a Dust Risk Rating that takes into account rain, wind speed and wind direction. The sprinkler system is operated in response to daily weather forecasts and residue area conditions as well as readings from real time dust monitors located along the western boundary of the RSAs.

3.1.2 Bauxite Stockpile and Transport Systems dust management

The Bauxite Stockpiles area is located on the south east section of the Pinjarra Refinery. This is the furthest point within the refinery from the Pinjarra town site. The bauxite stockpiles area consists of bauxite stockpile bays, roads (sealed and unsealed) and infrastructure including conveyors, interchanges, stackers and reclaimers.

Fugitive dust is generated through a diverse range of activities in the bauxite stockpile area through dispersal of particles from exposed surfaces by wind erosion as well as abrasion of surface materials by application of mechanical force.

Controls have been implemented to minimise dust generation at the bauxite stockpile. These include:

- Treatment of unsealed roads and open areas requiring vehicle access with chemical dust suppressant or binding agents;
- Covering of open areas that don’t require vehicle access with blue metal or mulch;
- Operation of Water trucks based on a dust risk forecast issued by a specialist consulting company (which is also used at the RSAs) that takes into account rain, wind speed and wind direction;
- Regular housekeeping to prevent build-up of dust under conveyors;
- Use of water spray systems on stackers and around conveyor transfer points;
- Operating procedures to ensure stackers are operated to reduce dust risk;
- There is also an ongoing trial of the use of a dust suppressant on the bauxite stockpiles.

3.2 AMBIENT DUST MONITORING

Alcoa’s program for monitoring of dust emissions from area sources exceeds the site’s DWER Environment Licence requirements. Ambient dust monitors are distributed around the refinery boundary, close to possible dust sources. The monitoring specifically targets dust emissions from the Residue Storage Areas (RSAs) and the bauxite stockpiles.

High Volume Air Samplers (HVAS) are used to measure dust levels at various locations in accordance with the site’s DWER Environmental Licence. The HVAS samplers are used to determine Total Suspended Solids (TSP) concentrations in accordance with applicable Australian standards over a 24 hour period.

Tapered Element Oscillating Microbalance (TEOM) samplers as well as Beta Attenuation Monitors (BAM) are used for continuous monitoring of dust levels along the western boundary of the RSAs and in the vicinity of the stockpiles. This data is used for dust management purposes at the RSAs and the Bauxite stockpiles. Where necessary, the data is also used for the assessment and modelling of dust distribution and dispersion.

The dust monitoring network is supported by a local weather station. A summary of the locations and nature of the dust monitoring network at Pinjarra is given in Table 9 below and presented in Figure 1 below.

Table 9: Alcoa Pinjarra Dust Monitoring Network

Monitoring Site Name	Licence Requirement	Monitor Type	Size Fraction Measured	Averaging Period	Sampling Methods
Pinjarra Racecourse	Yes	HVAS	TSP	24-hour	3580.9.3:2015
	No	Real time	TSP	6-minute	AS/NZS 3580.9.8-2008
Fairbridge Airstrip	Yes	HVAS	TSP	24-hour	3580.9.3:2015
RSA10 W	No	Real time	TSP	6- minute	AS/NZS 3580.9.11-2016
RSA north	No	Real time	TSP	6-minute	AS/NZS 3580.9.8-2008
RSA south	No	Real time	TSP	6-minute	AS/NZS 3580.9.11-2016
Oakley South	Yes	HVAS	TSP	24-hour	3580.9.3:2015
Hillgrove	No	Real time	TSP	24-hour	AS/NZS 3580.9.11-2016

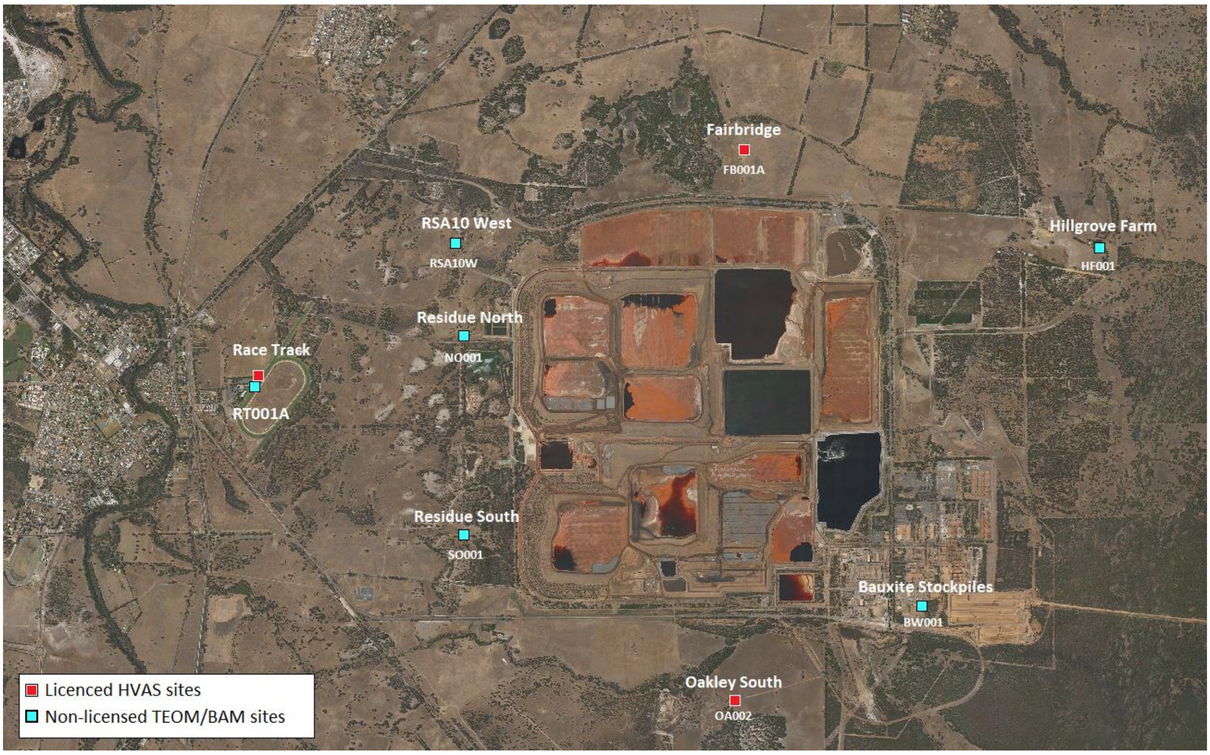

Figure 1: Alcoa Pinjarra Dust Monitoring Network

This network has been used as the basis of investigations into the sources, distribution and compositions of dusts, as well as for validation of dust dispersion modelling. Chemical analysis of dusts is carried out as required to determine major and trace metal compositions, to support studies of specific dust events or more general studies including dust source attribution, and dust generation and dispersion modelling when required. All chemical analysis is carried out by standard techniques in independent, NATA accredited laboratories, for all routine analyses and for all investigations as far as is practicable, although this may be varied if necessary for specific reasons if a procedure not covered by such standards is required for a particular investigation.

3.3 CUMULATIVE PARTICULATE EMISSIONS

An assessment of cumulative particulate emissions, taking into account background levels from other refinery sources, the "Pinjarra Refinery Cumulative Particulate Monitoring" report (Air Assessments, March 2007), concluded that the area sources, in particular the RSAs, accounted for the majority of the dust generated by the refining operation, and the refinery point sources generally were a small component of the overall contribution to particulate levels. Consequently, the successful management and improvement of dust suppression were identified as the key focus area for improvement in relation to dust levels overall.

4 AMBIENT AIR QUALITY

4.1 SAMPLING LOCATIONS, METHODS AND QA/QC PROCEDURES

4.1.1 Gaseous Pollutants

The goal of ambient monitoring for gaseous compounds is primarily to assist in the calibration and validation of dispersion modelling used to predict the refinery's contributions to the ground level concentrations of pollutants in the vicinity of the refinery. This approach is preferred over the alternative of extensive monitoring of a range of pollutants because the contribution of the refinery to the levels of VOCs, for example, is generally small in relation to existing background levels and as such is generally not distinguishable from background and the contributions of other sources by direct observation. It is therefore more informative to concentrate on continuing to develop the modelling approach, which can then be used to assess the likely impact of different future scenarios of refinery configuration, expansion, and pollution control options.

The species that are most useful for model validation are NO_X and CO. This is because:

i. NO_X is the most prevalent gaseous species apart from water vapour and CO_2 in the refinery point source emissions, and along with CO is present in all combustion source emissions
ii. NO_X and CO are amenable to continuous monitoring by well-established technology, and
iii. It has been demonstrated that NO_X and CO measurements can be used to provide a refinery signal that can be distinguished from background and from other point sources by analysis of data from suitably deployed monitors.

Nevertheless, care must be taken to ensure that the effects of other sources, in particular trains, motor vehicles and other mobile equipments, and other industrial sources, are taken into account when analysing the monitoring results.

Despite these complications, considerable success has been achieved in using NO_X and CO data for model validation. Previous ambient NOx and CO monitoring programs included:

- An ambient NO_x and CO monitoring program conducted in 2003/2004 which provided the data for an air quality model validation study conducted in 2005 (Air Assessments, 2006).
- An ambient NO_x monitoring campaign in 2006 which provided data for an air quality model revaluation (Air Assessments, 2008a).

Further ambient air gaseous monitoring may be conducted based on a campaign basis if the need arises.

4.1.2 Dust Monitoring

The monitoring locations, methods and procedures currently in place for dust monitoring at Pinjarra Refinery are as described in Section 3.1 above. In addition to the routine monitoring network, additional dust monitors with size selective inlets (for PM_{10} and $PM_{2.5}$) were used as a basis for a detailed study of the distribution of dust and the associated metal oxides carried out for Alcoa's Western Australian

Operations (WAO) during 2005-6 (Air Assessments, 2008b). The key findings of the study included the following:

1. The nature of residue dust is typical of windblown dusts of crustal (mineral earth, or "soil-like") origin, in relation to both particle size distribution and chemical composition. As such, near the source it is characterised by $PM_{2.5}/PM_{10}$ and PM_{10}/TSP ratios which are consistent with wind erosion of a soil-like surface. In addition, the trace metals tend to be concentrated in the finer fraction as is expected from erosion of the surface of a soil-like material.
2. The contribution of a residue component to the ambient dust at the monitoring sites is dominated by the effect of a small number of high dust events. Residue is a much smaller contributor to ambient dust most of the time (on an annual average, 85% of the dust at the Race Track monitor comes from other sources).
3. The annual average concentrations of trace metals in ambient in the Pinjarra region studied are comparable to those found in other semi-rural areas in Australia.
4. Six metals were identified as priority elements for the purposes of Health Risk Assessment. These are nickel, cadmium, arsenic, selenium, mercury and manganese. This study indicates that:
   a. Arsenic, cadmium, selenium and nickel from residue dust is not a significant source in the ambient dusts in the Pinjarra region;
   b. Manganese and Mercury from residue dust are considered to possibly have some contribution to the ambient concentrations.

4.2 EFFECTS AT RECEPTOR LOCATIONS

The results of the studies of gaseous pollutants and dusts described in the previous sections were used to refine the estimates of atmospheric emissions and health risk factors at receptors in the region of the refinery. This was done through the development of an Air Quality Model for the refinery (Air Assessments, 2008c) and subsequently a Health Risk Screening Assessment (Environ, 2008) after the commissioning of the PEU in early 2008. Potential health effects arising from the predicted short-term (acute) and long-term (chronic) exposure to non-carcinogenic compounds, and potential carcinogenic risks were considered in the Health Risk Screening Assessment by comparing the predicted exposure concentrations at the discrete receptor locations with health protective guidelines for ambient air developed by reputable authorities such as the National Environment Protection Council (NEPC), World Health Organisation (WHO) and the U.S Environmental Protection Agency (US EPA). The results indicated that:

- the potential for emissions from the Upgraded Refinery to cause acute or chronic non-carcinogenic health effects is low;
- the potential for emissions from the Upgraded Refinery to contribute significantly to an increase in the incremental carcinogenic risk in the exposed population is low; and
- the Acute and Chronic health indexes, and incremental carcinogenic risk are predicted to be lower at all of the receptor locations for the Upgraded Refinery emissions scenario compared to the pre-upgrade scenario.

The results of the 2008 modelling and assessment were subjected to peer reviews (CH Environmental, 2008 and Professor Philip Weinstein, 2008) prior to submission to the EPA. The outcomes were also presented to stakeholder groups including the PEU Stakeholder Reference Group and the Pinjarra Community Consultative Network.

In 2014, the Air Quality Model for the Refinery was updated (Air Assessments, 2014) to reflect the proposed incremental increase in alumina production capacity to5 million tonnes per annum (Mtpa). The model update included changes to the RSAs since the previous modelling in 2008. The results from the updated model were used to revise the 2008 Pinjarra Refinery Health Risk Screening Assessment using the latest health protective guidelines.

The results of the revised 2014 Health Risk Screening Assessment (Environ, 2015) indicated that, in relation to the proposed incremental increase in the alumina production capacity of the Pinjarra Refinery up to 5 Mtpa, the potential for emissions to cause acute or chronic non-carcinogenic health effects as well as the potential for emissions to contribute to the incidence of cancer in the exposed population remains low. The results of the 2014 air modelling and health risk screening assessment were subjected to peer reviews (Pacific Environment Limited, 2015 and Professor Philip Weinstein, 2015), with the outcomes of the peer reviews submitted to the EPA.

5 QUALITY CONTROL

Quality control is an essential component of both source and ambient monitoring programs to ensure that the results produced are representative of actual concentrations.

The key actions Alcoa undertakes to ensure quality control in all of its air monitoring programs at the Pinjarra refinery are summarised in Table 10.

Table 10: General quality control commitments

Implementation Phase	Action
Sampling	All sampling for regulatory compliance will be conducted by parties holding NATA accreditation for that activity, where available.
	Sampling will be performed in accordance with the relevant Australian/NZ Standards or USEPA methods. Where NATA certifiable process are possible, monitoring and sampling will be undertaken by NATA certified facilities carrying out the appropriate NATA certified processes against the appropriate Australian Standard and analysis process. When variations to these methods are employed, the variation will be recorded and explained.
	Sampling will be conducted by suitably qualified external consultants.
	Each time a stack test is performed, standard methods will be used to determine the temperature, moisture and volumetric flow rate wherever this is possible.
	Sufficient volumes of gas will be collected to achieve suitable limits of detection for each key parameter.
	Where possible, stack samples will be collected under steady state operating conditions.
	Field blanks and duplicates will be included in sampling runs.
	Samples will be preserved in accordance with relevant standards and analysed as soon as possible after collection.
	Records of the chain of custody will be maintained for all samples.
Analysis	All analysis for regulatory compliance will be conducted by parties holding NATA accreditation for that activity, where available. Where a NATA accredited laboratory is not available, analysis will be performed at a laboratory with sound quality control procedures. Analysis will be performed in accordance with the relevant USEPA or AS methods where possible. When variations to these methods are employed, the variation will be recorded and justified.
Reporting	All reports will include the date and time of sample collection, and any unusual operating conditions at the time of collection.
	All results will be presented with limits of detection for each parameter recorded.
	Results will be presented with information on potential errors in sampling, preservation and analysis.

6 REVIEW AND REPORTING

This Plan may be altered from time to time for reasons such as changes to production requirements or stakeholder expectations. Care will be taken to ensure that any changes are consistent with the original intent of the Plan, and that there is stakeholder consultation whenever alterations are made, at a level appropriate to the nature and significance of the alteration.

Status of management controls, monitoring and investigations (where applicable) undertaken under this Plan will be reported to the Office of Environment Protection Agency annually as part of the compliance reporting process for Ministerial Statement 646.

7 DEVELOPMENT OF THE PLAN

Development of the initial Air Quality Management Plan (2007) was carried out in consultation with the Stakeholder Reference Group (SRG) for the Pinjarra Efficiency Upgrade. This group had twelve members representing the following interests:

- Local community and Pinjarra residents;
- Farming community and Pinjarra refinery neighbours;
- Pinjarra refinery workforce;
- Local Government;
- Pinjarra businesses;
- Local education and training departments;
- Indigenous community;
- Local Landcare groups;
- Pinjarra refinery Community Consultative Network;
- Department of Environment;
- Department of Industry and Resources; and
- Pinjarra Efficiency Upgrade project team.

This version represents an update of the Plan to reflect current air quality management arrangements. This version of the Plan will be presented to the Pinjarra Refinery Community Consultative Network.

8 INDEPENDENT EXPERT REVIEW

Independent expert peer review was conducted on the initial Air Quality Management Plan (2007). This version represents an update of the Plan to reflect current operational air quality management arrangements.

9 REFERENCES

The references are given as footnotes in the text. They are provided here as a list in order of reference for convenience.

- Ministerial Statement 646, Government of Western Australia Minister for the Environment, 3 March 2004
- Western Australia Department of Environment and Conservation Licence Number 5271/1983/14
- Air Assessments (2007): Pinjarra Refinery Cumulative Particulate Monitoring, March 2007
- Air Assessments (2006): Air Quality Model Validation – Pinjarra Refinery, October 2006
- Air Assessments (2008a): Ambient NO_X Monitoring (2006) and Resultant Revised Air Quality Model Validation for the Pinjarra Refinery, March 2008.
- Air Assessments (2008b): Evaluation of Dust Emissions Pinjarra and Kwinana Refineries, May 2008
- Air Assessments (2008c): Pinjarra Refinery Efficiency Upgrade Air Quality Modelling for the 2008 HRA, July 2008
- ENVIRON Australia Pty Ltd (2008): Health Risk Screening Assessment of the Upgraded Pinjarra Refinery, July 2008
- CH Environmental (2008): Review: Air Quality Modeling for the 2008 HRA – Final Report, July 08
- Professor Philip Weinstein (2008): Review of the report: "Health Risk Screening Assessment of the Upgraded Pinjarra Refinery" prepared by ENVIRON for Alcoa in July 2008, July 2008
- Air Assessments Ltd (2014): Pinjarra Alumina Refinery, Air Quality Modelling for 2014 Health Risk Assessment, December 2014
- ENVIRON Australia Pty Ltd (2014): Revision of Pinjarra Refinery Health Risk Screening Assessment, December 2014
- Pacific Environment Limited (2015): Peer Review – Pinjarra Refinery Modelling, July 2015
- Professor Philip Weinstein (2015): Expert Peer Review of the Revised Pinjarra Refinery Health Risk Screening Assessment (ENVIRON, December 2014), August 2015

10 GLOSSARY

Abbreviations

AQMP	Air quality management plan
CEMS	Continuous emissions monitoring system
CO	Carbon monoxide
DCM	Dust concentration monitor
DWER	Department of Water and Environmental Regulation
DoH	Department of Health
EMS	Environmental management system
ESP	Electrostatic precipitator
NATA	National Association of Testing Authorities
NO_x	Oxides of nitrogen
PEU	Pinjarra Efficiency Upgrade
RTO	Regenerative thermal oxidiser
SO_2	Sulphur dioxide
SRG	Stakeholder reference group
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compounds

Units

mg/m^3	milligram per cubic metre (expressed dry at 0 degrees Celsius and 1 atmosphere)
%	percent