AMMONIUM NITRATE PRODUCTION FACILITY

GREENHOUSE GAS ABATEMENT PROGRAM
(Incorporating Nitrous Oxide Emissions Improvement Plan)

VERSION 7

November 2010

PREFACE

This Ammonium Nitrate Production Facility Greenhouse Gas Abatement Program has been updated to include Ammonium Nitrate Production Expansion Project: Phase 2.

Specifically, the Program has been updated to include:

- Predicted greenhouse gas emissions from the proposed expanded ammonium nitrate production facility and associated CSBP commitments
- 2009-2010 greenhouse gas emissions data
- Current knowledge on nitrous oxide emission reduction technologies, and their commercial application
- An updated audit table

TABLE OF CONTENTS

APPENDICES

1. INTRODUCTION

1.1 Background

CSBP Limited (CSBP), part of the Wesfarmers Limited group, expanded its Ammonium Nitrate Production Facility (ANPF) in 2008. In 2010, CSBP is proposing to further expand the ANPF. The Ammonium Nitrate Production Expansion Project: Phase 2 (the proposal) comprises the addition of further components to the existing facility, with some existing components being re-engineered to enable increased throughput (debottlenecked). This will increase ammonium nitrate production capacity from 520,000 tpa to 780,000 tpa.

The proposal was referred by CSBP to the Environmental Protection Authority (EPA), under Section 38 of the *Environmental Protection Act 1986* (EP Act), in April 2010. The EPA subsequently set the level of assessment as Public Environmental Review (PER) with an eight-week public review period.

This document forms part of the PER for the proposal and has been prepared for assessment by the EPA under Part IV of the EP Act.

The chemical and fertiliser manufacturing operations at the CSBP Kwinana industrial complex currently include the following plants:

- ammonia plant;
- ANPF;
- sodium cyanide manufacturing facility;
- superphosphate plant;
- compound fertiliser granulating plant; and
- liquid fertiliser plant, which includes the manufacture of Flexi-N.

The ANPF at the CSBP Kwinana industrial complex currently consists of the following:

- 2 nitric acid plants (NAP1 and NAP2)
- 2 ammonium nitrate solution plants (AN1 and AN2)
- 1 prilling plant (PP2)
- packaging area
- combined bulk and bagged ammonium nitrate solids storage area
- despatch area.

In order to implement the Ammonium Nitrate Production Expansion Project: Phase 2, CSBP proposes to undertake the following changes to the existing facility:

1. Debottlenecking of existing nitric acid plants NAP1 and NAP2 (by 20%) and construction of an additional nitric acid plant, NAP3, which will then be debottlenecked (by 20%), for a total nitric acid production capacity of 720 000 tpa.
2. Debottlenecking of existing ammonium nitrate solution plants AN1 and AN2 (by 20%) and construction of an additional ammonium nitrate solution plant AN3,

which will then be debottlenecked (by 20%), for a total ammonium nitrate solution production capacity of 936 000 tpa.

3. Debottlenecking of the 2008 prilling plant PP2 (by 100%, or two-fold).
4. Construction of an additional 3500 tonne 63% nitric acid solution tank.
5. Construction of an additional 305 m^3 ammonium nitrate solution tank.
6. Construction of an auxiliary boiler.
7. Construction of additional bagged ammonium nitrate storage (within existing approval of 27 000 tonnes).
8. Increased ammonia imports (up to 25 shipments/yr) via Kwinana Bulk Jetty.
9. Upgrade of existing ammonium nitrate solid and solution despatch facilities.
10. Upgrade of existing and construction of new utilities and supporting infrastructure to support the expansion.

Table 1 provides a summary of the key characteristics of the existing and proposed expanded ANPF.

Process descriptions for ammonium nitrate production are provided as Appendix 1.

TABLE 1

KEY CHARACTERISTICS FOR THE PROPOSED EXPANSION OF THE CSBP ANPF COMPARED WITH EXISITING FACILITY

Characteristic	Existing Facility	Expanded Facility
Location	Kwinana Beach Road – Kwinana – KIA	
CSBP site area	138 ha	
Project life	20-30 years	
Plant operating hours	24 hour/day operation, 365 days per year except for maintenance shutdowns	
Plant commissioning	1996 – nitric acid ammonium nitrate plant 2007 – second nitric acid ammonium nitrate plant and 2008 prill plant	2014 – third nitric acid ammonium nitrate plant
Plant components	Two nitric acid plants Nitric acid storage tanks: 2000 tonnes total capacity Two ammonium nitrate solution plants Ammonium nitrate (90% solution) storage tank of 305 m^3 capacity Ammonium nitrate (70-90% solution) storage tank of 730 m^3 capacity 2008 prilling plant Ammonium nitrate bag packaging facility Ammonium nitrate solids storage facility (Dangerous Goods Licence permits storage up to 27 000 t)	Three nitric acid plants Nitric acid storage tanks of approximately 5500 tonne capacity Three ammonium nitrate solution plants Two ammonium nitrate (90% solution) storage tanks of approximately 610 m^3 total capacity Ammonium nitrate (70-90% solution) storage tank of 730 m^3 capacity 2008 prilling plant (debottlenecked) Ammonium nitrate bag packaging facility Ammonium nitrate solids storage facility (Dangerous Goods Licence permits storage up to 27 000 t) Auxiliary boiler
Production	Total nitric acid production — 400 000 tpa, as feedstock for: Total ammonium nitrate solution production — 520 000 tpa, as feedstock for: Total prilled ammonium nitrate — 420 000 tpa	Total nitric acid production — 720 000 tpa, as feedstock for: Total ammonium nitrate solution production — 936 000 tpa, as feedstock for: Total prilled ammonium nitrate — 780 000 tpa
Inputs	Ammonia, oxygen (air), and water	Ammonia, oxygen (air), and water
Outputs	Ammonium nitrate solution and prill, plus air/water emissions	Ammonium nitrate solution and prill, plus air/water emissions
Air emissions	Nitrogen oxides Ammonium nitrate particulate Ammonia	Nitrogen oxides Ammonium nitrate particulate Ammonia
Greenhouse gas emissions	925 688 tpa of net CO_2-e	1 110 000 tpa of net CO_2-e
Liquid effluent discharges (from CSBP Kwinana Industrial Complex)	Approx 2 ML/d effluent to the SDOOL	Approx. 2.4 ML/day effluent to the SDOOL
Noise	Within Environmental Protection (Noise) Regulations 1997 as proposed to be amended.	Within Environmental Protection (Noise) Regulations 1997 as proposed to be amended.
Net power generation	4 MW	6 MW
Shipping	15 ammonium nitrate shipments per year 6 ammonia imports per year	maximum 35 ammonium nitrate shipments per year maximum 25 ammonia imports per year

1.2 Purpose of this Greenhouse Gas Abatement Program

In 2006 CSBP prepared the Ammonium Nitrate Production Facility Greenhouse Gas Abatement Program to meet the requirements of Condition 6.1 of Ministerial Statement 689. In May 2007, the Program was updated to meet the requirements of Condition 7.2 of Ministerial Statement 689 and further updated in November 2008, December 2009 and April 2010, on advice from the Office of the Environmental Protection Authority (OEPA).

In November 2010, CSBP updated the Greenhouse Gas Abatement Program to include the proposed Ammonium Nitrate Production Expansion Project: Phase 2.

More specifically this Greenhouse Gas Abatement Program has been prepared to:

1. ensure that the plant is designed and operated in a manner which achieves reductions in “greenhouse gas” emissions as far as practicable
2. provide for ongoing "greenhouse gas" emissions reductions over time
3. ensure that through the use of available proven technology, the total net “greenhouse gas” emissions and/or “greenhouse gas” emissions per unit of product from the proposal are minimised
4. achieve continuous improvement in “greenhouse gas” intensity through the periodic review, and where feasible, the adoption of advances in technology and process management.

Environmental Objective

The EPA’s published environmental objective in relation to the assessment and management of greenhouse gases is:

- minimise greenhouse gas emissions in absolute terms and reduce emissions per unit of product to as low as reasonably practicable; and
- mitigate greenhouse gas emissions, mindful of Commonwealth and State greenhouse gas strategies and programs (EPA 2010).

Applicable Standards, Guidelines or Procedures

The EPA’s position with respect to greenhouse gas issues is detailed in *Guidance for the Assessment of Environmental Factors, Statement No. 12: Minimising Greenhouse Gas Emissions* (2002).

1.3 CSBP Ammonium Nitrate Production and Greenhouse Gas Emissions

The manufacture of ammonium nitrate at the CSBP Kwinana industrial complex contributes to the overall greenhouse inventory of the industrial complex.

Nitrous oxide (N_2O) is produced as a by-product of nitric acid production. N_2O is a greenhouse gas and has a global warming potential of 310, which means that each tonne of this gas has the equivalent greenhouse effect of 310 tonnes of CO_2 (based on the EPA's recommended 30 year time horizon).

The ANPF produced 925,688 tonnes net CO_2-e in 2009/10 following a full year of operation of the new expanded facility. Through heat recovery from the nitric acid and ammonium nitrate manufacturing processes, the ANPF generates and exports excess electricity to the remainder of the CSBP Kwinana industrial complex to create a net saving of power generation emissions. Greenhouse gas emissions saving from power generation was 44,728 tonnes CO_2-e in 2009/10.

Table 2 shows that N_2O emissions from the nitric acid plants for 2009/10 equate to approximately 937,262 tonnes of CO_2-e.

TABLE 2
AMMONIUM NITRATE PRODUCTION FACILITY GREENHOUSE GAS EMISSION DATA

ANPF[a]	**Production**[b] **(tpa)**	**Power Consumption (tCO_2-e)**			**N_2O**[c] **(tCO_2-e)**	**Total ANPF**[d] **(tCO_2-e)**	**GHG emission ratio (tCO_2-e/tonne product)**
		Generated	**Consumed**	**Nett**			
2006/07	627,696	-24,166	15,112	- 9,054	488,958	479,904	0.76
2007/08	751,347	-27,340	20,267	-7,073	567,393	560,320	0.75
2008/09	1,162,966[e]	-38,751	32,035	-6,716	788,817	782,101	0.67
2009/10	1,260,479	-44,728	33,154	-11,574	937,262	925,688	0.73

a. Ammonium Nitrate Production Facility (integrated nitric acid ammonium nitrate plants, prilling plant).

b. Production is the sum of tonnes nitric acid, tonnes ammonium nitrate solution and tonnes ammonium nitrate prill, ie 2009/10 (nitric acid – 398,223 tonnes, ammonium nitrate solution – 499,335 tonnes, ammonium nitrate prill – 362,921 tonnes)

c. Estimated N_2O emissions have decreased from previously reported estimates following identification of an error in N_2O emissions estimation methodology used for previous reporting.

d. CO_2-e calculations from 2005/06 to 2007/08 based on factors provided through Greenhouse Challenge Plus reporting and calculations from 2008/09 and 2009/10 from NGER reporting requirements.

e. Increase in production (tpa) as a result of commissioning of second nitric acid ammonium nitrate plant in 2008.

2. CALCULATION OF GREENHOUSE GAS EMISSIONS FROM THE EXPANDED ANPF

As the proposed expansion will occur in stages, the GHG emissions for various operating scenarios have been calculated. The scenarios are described below and the predicted emissions of each tabulated in Table 3. The estimations are based on data weighted using the 2009/10 production and design capability scenarios to determine emissions from the expanded facility. All scenarios assume maximum production rates of:

- ammonium nitrate, 936,000 tpa
- nitric acid, 720,000 tpa
- prill, 780,000 tpa
- total production, 2,436,000 tpa.

Scenario 1
This scenario represents expected emissions in the absence of implementation of CSBP commitments as detailed in Section 3. The scenario assumes that all plants to be fully debottlenecked and no N_2O abatement fitted to the three nitric acid plants.
This scenario leads to an increase in 2009/10 GHG emissions of approximately 660,000 tonnes CO_2e, or 71per cent.

Scenario 2
This scenario represents the maximum expected emissions from the ANPF following construction and full debottlenecking of the NAP3 with tertiary N_2O abatement technology, and with full debottlenecking of NAP1 and NAP2, to a maximum production rate without the installation of secondary abatement as detailed in CSBP commitments described in Section 3. It assumes no N_2O abatement on NAP1 and NAP2 and the inclusion of tertiary abatement on the proposed NAP3 (90% N_2O reduction).

This scenario leads to an increase in 2009/10 ANFP GHG emissions of approximately 184,000 tCO_2e, or 20 per cent.

Scenario 3
This scenario represents the expected emissions from the ANPF following implementation of commitments detailed in Section 3. The scenario assumes full debottlenecking of the nitric acid plants, secondary N_2O abatement in the two existing nitric acid plants following trialling in NAP 2 in 2011, if successful, (80 per cent N_2O reduction), and tertiary N_2O abatement in the proposed third nitric acid plant (90 per cent N_2O reduction).

This scenario leads to a decrease in 2009/10 ANPF GHG emissions of approximately 661 000 tonnes CO_2e, or 71 per cent and represents the expected maximum emissions from the proposal – subject to the successful trialling of secondary abatement technology in NAP2 in 2011.

TABLE 3
AMMONIUM NITRATE PRODUCTION FACILITY PREDICTED GREENHOUSE GAS EMISSIONS

ANPF	Production (tpa)	Power Consumption (tCO_2-e)			N_2O (tCO_2-e)	Direct CO_2[a] (tCO_2-e)	Total ANPF [d] (tCO_2-e)	GHG emission ratio (tCO_2-e/tonne product)
		Generated[b]	Consumed[c]	Nett				
2009/10	1,260,479	-44,728	33,154	-11,574	937,262	-	925,688	0.73
Scenario 1	2,436,000	-80,000	66,000	-14,000	1,585,000	15,000	1,586,000	0.65
Scenario 2	2,436,000	-80,000	66,000	-14,000	1,109,000	15,000	1,110,000	0.46
Scenario 3	2,436,000	-80,000	66,000	-14,000	264,000	15,000	264,000	0.11

a. Conservative estimate of direct CO_2 emissions due to new auxiliary boiler
b. Generated – nett power generated by nitric acid plants
c. Consumed – nett power consumed from 2008 prill plant and ammonium nitrate plants
d. Estimates are rounded to the nearest 1000

3. MEASURES TO MINIMISE TOTAL NET GHG EMISSIONS

Greenhouse gas emissions will be reduced in terms of CO_2-e per tonne of production compared to historic emissions because of the commitments CSBP has made:

- *CSBP designed and constructed NAP2 with a larger reactor boiler than was in NAP1.*

- *CSBP retrofitted a larger reactor boiler to NAP1 in November 2009 to reduce* CO_2*-e generation (from* N_2O*).*

- *CSBP designed and constructed the NAP2 to suit the catalyst technologies, and to implement the technology in NAP2 when it becomes commercially viable.*

- *CSBP designed and constructed the NAP1 to suit the catalyst technologies, and to implement the technology in NAP1 when it becomes commercially viable*

- *CSBP will design and construct the new third nitric acid plant NAP3 with a reactor boiler of similar size to that installed in NAP1 and NAP2.*

- *CSBP will design and construct the new third nitric acid plant to include tertiary* N_2O *abatement technology. Tertiary abatement technology will mitigate a minimum of 90 percent of the total* N_2O *produced from this nitric acid plant.*

- *CSBP commits to trialling secondary abatement technology in NAP2 in 2011 and, if the trial is successful, CSBP commits to installation of secondary abatement technology in NAP1 later in 2011. To be considered successful,* N_2O *reduction efficiencies must meet secondary abatement technology supplier specifications and have no adverse impact to current nitric acid plant performance. Specifically, ammonia conversion to nitric acid must remain within current design guidelines and production rates unaffected. Abatement technology installed will mitigate a minimum of 80 per cent of the total* N_2O *produced from these plants.*

- *Notwithstanding the above commitments, CSBP commits to ensuring abatement technologies are in place in the existing NAP1 and NAP2 when their combined production reaches 480 000 tonnes per annum nitric acid. That is, when the plants are fully debottlenecked.*

- *CSBP will submit an updated Greenhouse Gas Abatement Program report to the OEPA annually until the new technology is adopted or the EPA advises that the report is no longer required.*

  The Greenhouse Gas Abatement Program will be updated to:

  1. ensure that the plant is designed and operated in a manner which achieves reductions in “greenhouse gas” emissions as far as practicable
  2. provide for ongoing "greenhouse gas" emissions reductions over time

3. ensure that through the use of available proven technology, the total net "greenhouse gas" emissions and/or "greenhouse gas" emissions per unit of product from the project are minimised
4. achieve continuous improvement in "greenhouse gas" intensity through the periodic review, and where feasible, the adoption of advances in technology and process management.

- *Subject to a satisfactory contractual arrangement, CSBP will provide in the order of 70,000 tonnes* CO_2 *per annum to Alcoa World Alumina Australia for injection into residue disposal areas to create carbonates to bind* CO_2*.*
- *CSBP expects to be an obligatory participant in the national carbon pollution reduction scheme when it becomes operational, and will be required to conform with the legislated requirements to reduce national greenhouse gas emission rates.*

For detail of the current state of knowledge on low N_2O emission catalyst technologies, and their commercial application refer to Section 10 Review of Greenhouse Gas Reduction Practices and Available Technology.

Additionally, in 2004, CSBP implemented a revised method for managing purchased and self-generated electricity at Kwinana. This provides greater incentives for individual plants to maximize their efficiency of electricity use, and benefit from their actions, particularly in relation to off peak electricity use (which although not assessable in the generic CO_2 factors for the WA power grid, does, as CSBP understands, improve operating efficiency of base load power stations).

4. GREENHOUSE GAS OFFSET STRATEGIES

Alcoa World Alumina Australia is purchasing, through BOC, in the order of 70,000 tpa of CO_2, a by-product of CSBP's ammonia production, which is piped to the Alcoa World Alumina Australia Kwinana residue disposal area and injected into the residue. This process creates carbonates that not only bind CO_2 into a stable matrix, but also benefits in managing the residue disposal areas. CSBP is of the view that this activity permanently reduces CO_2 emissions that would otherwise have been released to atmosphere through the reforming of natural gas in the ammonia production process. This arrangement commenced in January 2007.

5. CALCULATION OF GREENHOUSE GAS EFFICIENCY OF THE ANPF

The average kg N_2O per tonne of nitric acid in Nitric Acid Plant 1 for the period December 2009 to June 2010 was 6.4 kg N_2O/tonne of nitric acid (period represents operation following installation of a larger reactor boiler). While the N_2O concentration in the tail gas averaged 968 ppm. The average kg N_2O per tonne of nitric acid in Nitric Acid Plant 2 for the period July 2009 to June 2010 was 7.1 kg N_2O/tonne of nitric acid. While the N_2O concentration in the tail gas averaged 1013 ppm. For plants of this type N_2O emissions are typically 5 – 9 kg N_2O/tonne of nitric acid, however, this is dependent on the plant operating pressure and the physical configuration of the reactor boiler and catalyst.

Calculation of these emissions is based on results from a continuous N_2O analyser CSBP installed in NAP1 (December 2005) and NAP2 (during construction).

6. IMPLEMENTATION OF THERMAL EFFICIENCY DESIGN AND OPERATING GOALS

The nitric acid plants are net producers of electricity because of the exothermic nature of many of the chemical reactions used in the production of nitric acid/ammonium nitrate.

Taking into account power consumption for each component, the ammonium nitrate plants, prilling plants and nitric acid plants combined resulted in a net power generation of approximately 53,248 MWhr in 2009/10. This is a credit in terms of plant greenhouse gas accounting of almost 44,728 tonnes of CO_2-e per annum, based on 2009/10 production rates. As a result, the ANPF exports energy to other areas of the CSBP industrial complex and offsets the greenhouse gas impact of CSBP's business units overall. Nett GHG emissions saving from power generation was 11,574 tonnes of CO_2-e in 2009/10.

7. ACTIONS FOR MONITORING, AUDITING AND ANNUAL REPORTING

7.1 Reporting

7.1.1 Greenhouse and Energy Reporting

CSBP, as part of Wesfarmers Limited, will report annually on greenhouse gas emissions, energy production and energy consumption under the *National Greenhouse and Energy Reporting (NGER) Act 2007*, with the first reporting period being 1 July 2008 to 30 June 2009. Data for the period 2009/10 was submitted to the Department of Climate Change and Energy Efficiency by 31 October 2010.

7.1.2 Greenhouse Challenge

CSBP was previously a signatory to the Commonwealth Government's *Greenhouse Challenge Program* from 1997 to its completion in 2009. The program ceased to exist in July 2009 when the first year of NGER data reporting was complete.

7.1.3 Energy Efficiency Opportunities

CSBP as part of the Wesfarmers group is participating in the Federal Government's Energy Efficiency program.

7.1.4 Sustainability Reporting

CSBP participates in the annual Wesfarmers Sustainability Report (formerly Social Responsibility Report), which gives an account of the company's performance across a range of issues relevant to our pursuit of a sustainable future including detail of greenhouse gas emissions, energy consumption and abatement initiatives. Copies of this report can be obtained from www.wesfarmers.com.au.

7.2 Monitoring

N_2O emissions from the nitric acid plants are monitored continuously. The continuous monitoring of N_2O has allowed more accurate quantification of N_2O emissions from the plants.

7.3 Auditing

As a participant in NGER, CSBP was internally verified by external auditing consultants in 2009 and 2010. Subsequent reporting periods are anticipated to be externally verified by government approved auditors in addition to internal verification.

In the past CSBP reported annual emissions to the Australian Greenhouse Office (AGO), and on occasion engaged an independent verifier who was certified by the AGO to audit the content of greenhouse reports, as well as the accounting systems used to generate internal greenhouse data.

8. TARGET SET FOR PROGRESSIVE REDUCTION OF TOTAL NET GREENHOUSE GAS EMISSIONS

In monitoring the greenhouse performance of each CSBP business unit, activities have been broken down into two major components, specifically chemical manufacture and distribution, and fertiliser manufacture and distribution. Separate Key Performance Indicator’s (KPI’s) have been utilised to assess ongoing performance of all of the company’s manufacturing arms. Within these, KPI’s have been developed to measure performance against greenhouse gas emissions (tonnes CO_2-e emitted per tonne of product generated).

The KPI’s for the ANPF are summarised in Table 4.

TABLE 4
GREENHOUSE GAS (GHG) SUMMARY FOR AMMONIUM NITRATE BUSINESS

ANPF	Production	Nett GHG Emissions	GHG KPI
	tpa	Tonnes $CO_{2\text{-}e}$	Tonnes $CO_{2\text{-}e}$ /tonne of product
2006/07	627,696	479,904	0.76
2007/08	751,347	560,320	0.75
2008/09[1]	1,162,966[e]	782,101	0.67
2009/10	1,260,479	925,688	0.73

1. The commissioning of the expanded ANPF occurred in 2007/08.

9. PROGRAM TO ACHIEVE REDUCTION IN GREENHOUSE GAS EMISSIONS

The proposed third nitric acid plant NAP3 will be similar in capacity and technology to that of NAP2 with the exception of the inclusion of N_2O abatement technology. The type of N_2O abatement technology to be utilised has yet to be determined however it is conservatively estimated that GHG emissions due to N_2O from NAP3, following debottlenecking, are expected to be in the order of 53,000 tCO_2-e per annum (0.71 kg N_2O/tonne HNO_3), approximately 90% lower than N_2O emissions from the existing nitric acid plants per tonne of nitric acid (7.1 kg N_2O /tonne HNO_3). The amount of N_2O emitted however depends on a number of factors, including the type and condition of N_2O abatement catalyst.

Debottlenecking all three nitric acid plants is proposed as part of the most recent proposal; however, debottlenecking activities are dependent on market conditions and represent the maximum operational capacity for the CSBP site and as such may occur in a staged fashion. As debottlenecking of these plants will increase output of nitric acid by up to 20% for each plant, output of N_2O will potentially increase.

To reduce N_2O emissions, CSBP commits to trialling secondary abatement technology in NAP2 in 2011. CSBP also commits to installing secondary abatement technology in NAP1 if trialling in NAP2 is successful. To be considered successful, N_2O reduction efficiencies must meet secondary abatement technology supplier specifications and have no adverse impact to current nitric acid plant performance; specifically, ammonia conversion to nitric acid must remain within current design guidelines and production rates unaffected.

Abatement technology, if successful, will mitigate a minimum of 80 per cent of the total N_2O produced from NAP1 and NAP2, reducing the N_2O emissions from NAP1 and NAP2 to less than 106 000 tonnes CO_2-e per annum per plant (based on an N_2O emission rate of 1.42 kg N_2O/tonne HNO_3 and a total production from the two plants of 480 000 tonnes HNO_3).

10. REVIEW OF GREENHOUSE GAS REDUCTION PRACTICES AND AVAILABLE TECHNOLOGY

The use of new catalyst materials, which could result in substantial reductions in N_2O emissions, will contribute significantly to greenhouse gas reductions in the ammonium nitrate production facility. Preliminary indications are that N_2O emissions could be reduced by more than 80% through the use of secondary abatement systems, and more than 90% for tertiary abatement systems.

Secondary abatement systems

Secondary abatement catalysts are located immediately below the primary ammonia oxidation catalyst and typically take the place of the existing inert support system for the primary catalyst, refer Figure 1. Making use of the heat of reaction of the ammonia oxidation process, the secondary catalyst abatement system requires no additional fuel and does not affect the efficiency of the primary ammonia conversion reaction, converting nitrous oxide to nitrogen and oxygen according to the following reaction: $2\ N_2O \rightarrow 2\ N_2 + O_2$

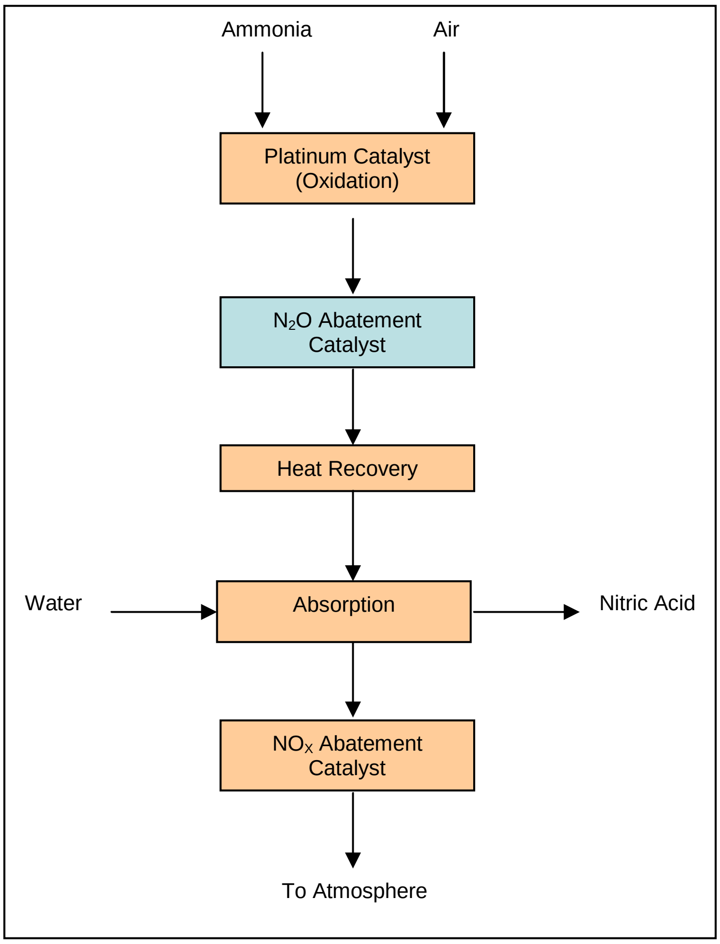

FIGURE 1 LOCATION OF SECONDARY N_2O ABATEMENT CATALYST IN NITRIC ACID PROCESS

CSBP is aware of four main technology providers of secondary abatement catalyst. CSBP remains in regular contact with each provider to ensure that it is aware of technological developments and the ongoing performance of the catalyst at a number of commercial installations.

Secondary abatement catalyst providers with whom CSBP is in regular contact are Johnson Matthey PLC (utilising technology provided by Yara International), BASF, Umicore AG & Co. KG and W. C. Heraeus GmbH. In March 2010, CSBP requested an updated list of reference sites for the use of secondary abatement catalyst from each of the technology providers. The reference sites for each secondary catalyst vendor are shown in Table 5. The expected nitrous oxide abatement efficiency for each technology is also shown.

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TABLE 5
NITROUS OXIDE SECONDARY ABATEMENT CATALYST SUPPLIER REFERENCE LIST

Technology Provider & catalyst description	Discrete Plant References for Secondary Abatement Catalyst	Expected Nitrous Oxide Abatement Efficiency (%)
Johnson Matthey (Amoxis) /Yara 58 –Y1	67	90
BASF (O3-8X)	30	90
Heraeus (HR-SC)	18	90
Umicore (MultiComb Greeline)	4	70 – 80

The Heraeus technology involves the placement of a thin layer of alumina raschig rings coated with a mixture of precious metals immediately below the existing precious metal catalyst system. The N_2O abatement layer replaces some of the existing inert support material beneath the precious metal catalyst and therefore requires no modification to the plant burner. Heraeus expects that the catalyst will need to be replaced every 3 – 10 primary catalyst change-outs (approximately every 15 – 50 months). The change-out frequency is based on a reduction in measured conversion efficiency.

CSBP currently uses precious metal catalyst supplied by Umicor. Umicor offer a non-precious metal-based honeycomb abatement system located beneath the primary precious metal catalyst.

The use of secondary abatement catalysts can provide a relatively straightforward way of reducing nitrous oxide emissions, with efficiencies of approximately between 70 and 90 percent, provided that the ammonia oxidation system is designed to incorporate the installation of the catalyst. The new ammonia oxidation reaction vessels currently used on NAP1 and NAP2 incorporate a design that allows for the installation of secondary abatement catalyst.

Based on reference data supplied by the catalyst technology vendors, 119 secondary nitrous oxide abatement systems are currently in use. Approximately 50 installations are thought to be Clean Development Mechanism (CDM) projects. The Kyoto CDM mechanism allows funding of abatement projects in developing nations in exchange for carbon offsets (Certified Emission Reduction (CER) units) flowing to the investing nation. A further 28 references relate to nitric acid plants operated by two of the technology providers, Yara and BASF.

Tertiary abatement systems

Installed in the tail gas stream, tertiary systems selectively destroy nitrous oxide. The use of tertiary abatement catalyst systems can achieve virtually complete destruction of nitrous oxides contained in the tail gas emissions of nitric acid production processes.

Tertiary systems can either form part of the original plant design, historically aimed at the destruction of highly visible NOx gases, or retrofitted to existing plants. Retrofitting requires very significant capital expenditure due to additional heating and cooling requirements for the tail gas (heating to achieve tertiary catalyst activation temperatures, and cooling to avoid exceedance of downstream rotating equipment design temperatures). Capital costs for retrofitted tertiary abatement systems are significantly higher than for secondary abatement systems.

Tertiary nitrous oxide abatement systems represent the most costly but potentially the most effective methods for reducing nitrous oxide emissions. Due to the high cost of retrofitting this system, CSBP is not currently proposing to pursue tertiary abatement options for its existing nitric acid plants NAP1 and NAP2 however is proposing to install tertiary abatement in the proposed third nitric acid plant.

CSBP keeps in close contact with all N_2O abatement catalyst suppliers to monitor developments in catalyst technology. N_2O catalyst abatement technology is not currently installed in CSBP's nitric acid plants, however, CSBP remains committed to its installation as committed in Section 3. The table in Appendix 3 compares CSBP's nitric acid plants to some examples from Europe of similar design. European plants are considered best available technology when it comes to nitrous oxide emissions.

11. CONTINUOUS IMPROVEMENT APPROACH

CSBP strives to continuously improve the efficiency of our operations. In our business two sources of greenhouse gases, CO_2 from the ammonia plant, and N_2O from the nitric plant constitute the largest part of our greenhouse emissions. For that reason our abatement and technology solutions focus on these plants - in the case of the ammonia plant, the focus is on internal energy efficiency and uses for the CO_2 emitted from the plant, whilst in the nitric acid plants the focus is on potential N_2O abatement through the installation of catalysts. The abatement of N_2O emissions from the nitric acid plants is expected to represent the single largest potential reduction in greenhouse gas emissions from the CSBP site.

12. REFERENCES

(EPA) Environmental Protection Authority (2002) *Guidance for the Assessment of Environmental Factors No. 12: Minimising Greenhouse Gas Emissions*.

(EPA) Environmental Protection Authority (2010) *Bluewaters Power Station Expansion - Phase III and Phase IV* (EPA Report 1349, March 2010)

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Government of Western Australia (2004) *Western Australian Greenhouse Strategy.* Perth, Western Australia. September 2004.

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13. GLOSSARY

AGO	Australian Greenhouse Office
CO_2	Carbon dioxide
CSBP	CSBP Limited
DEC	Department of Environment and Conservation
EMS	Environmental Management System
EPA	Environmental Protection Authority
FESA	Fire and Emergency Services Authority
HNO_3	nitric acid
KIA	Kwinana Industrial Area
N_2O	nitrous oxide
NH_3	ammonia
NH_4NO_3	ammonium nitrate
NO	nitric oxide
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
SCR	Selective catalytic reduction
USEPA	United States Environmental Protection Authority
WA	Western Australia

APPENDIX 1

Process Descriptions

The nitric acid ammonium nitrate plant process has been separated into the nitric acid production aspect and the ammonium nitrate solution production aspect to clearly explain the process undertaken to produce ammonium nitrate.

Nitric acid production

The nitric acid plant uses ammonia and air as raw materials to produce nitric acid ($NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$).

Liquid ammonia is vaporised in an ammonia evaporator and superheated under pressure. The pressure of the ammonia is reduced prior to mixing with processed clean air. The flow rate of the process air to the ammonia air mixer is measured and used as an input to determine the flow rate of ammonia into the mixer.

The ammonia/air mixture is fed into the ammonia reactor where the mixture is reacted catalytically over platinum/rhodium gauzes lying across the flow in the burner. The reaction product is a mixture of oxides of nitrogen.

After leaving the reactor, the reaction products are passed through the waste heat recovery boiler, the tail gas heater, the primary air heater, the economiser and the gas cooler condenser and separator. The mixture is cooled to approximately 60ºC and enters the absorption column where it is absorbed counter-currently in water, resulting in production of nitric acid solution with a concentration of approximately 63% w/w. The acid flows out from the bottom of the tower into storage tanks.

The reactions that produce nitric acid are strongly exothermic and much of this heat is used to produce steam to drive turbines and compressors within the plant and to generate electricity for use within the plant and elsewhere on the CSBP site (see Section **Error! Reference source not found.**).

At Kwinana, 99.9% of the nitric acid produced is converted into ammonium nitrate.

Ammonium nitrate production

The ammonium nitrate plant uses liquid nitric acid and gaseous ammonia as raw materials to produce ammonium nitrate ($HNO_3 + NH_3 \rightarrow NH_4NO_3$).

The nitric acid and ammonia react in the pipe reactor and flow into the reactor separator/demister to produce ammonium nitrate solution (NH_4NO_3). A significant portion of the water in the nitric acid solution is evaporated by the reaction heat and this water is separated out of the ammonium nitrate solution (approximately 96% w/w) as process steam for use within the plant. The ammonium nitrate solution flows under gravity into an ammonium nitrate pumping tank.

A portion of this solution is mixed with water to produce 70% to 90% ammonium nitrate solution for the production of *Flexi-N* liquid fertiliser, as required. The water used for the *Flexi-N* solution is primarily process condensate, which has a higher nitrogen content than other wastewaters in the process.

In a separate operation, ammonium nitrate solution is diluted to 90% and sold for use in the mining industry.

Ammonium nitrate prill

The concentrated ammonium nitrate solution is then formed into solid prill (small, round granules) by prilling (spraying) the molten solution into a large void tower.

The process of prill manufacture involves liquid ammonium nitrate and the following additives:

- nitric acid
- ammonia
- drying agent
- coating agent
- heat.

Ammonia is added to the mixture to adjust the pH of the ammonium nitrate solution. Ammonium nitrate solution, nitric acid and a drying agent are mixed in a melt tank to ensure homogeneity. Ammonia is added to the mixture to adjust the pH, and the combined solution is sent to the prilling tower.

At the top of the prilling tower, the ammonium nitrate solution is passed through small holes to create droplets of the solution. As the droplets fall, the cool air in the tower solidifies the solution into prill. The prill is then dried, cooled, screened, coated and weighed. Out of specification prill (too large or too small) are directed to the ammonium nitrate recycle system. Prill is then conveyed to the storage area for subsequent despatch.

APPENDIX 2

AUDIT TABLE

Note:

- Phases that apply in this table = **Design, Construction, Operation, Closure, Overall (several phases)**
- This audit table is a summary and timetable of conditions and commitments applying to the Ammonium Nitrate Production Facility project and relating to Greenhouse Gas Emission Abatement. Refer to Ministerial Statement 689 of 21/9/05 for full detail/precise wording of individual elements where referenced.
- Code prefixes: M = Minister's condition; P = Proponent's commitment.

Audit Code and Subject	**Action**	**Phase**	**Status**
689:M7.1 Nitrous Oxide (Greenhouse Gas Emissions) Improvement Plan - Plant design & const.	Design and construct the new nitric acid plant with a larger boiler than is currently in the existing nitric acid plant to achieve a reduction of carbon dioxide equivalent emissions (from nitrous oxide) by approximately 68,000 tonnes per annum when compared with the existing nitric acid plant (for equivalent capacity).	Overall Design and construction stages.	**Complete** The new nitric acid plant has an 85% larger gauze surface area due to the increase of the burner/gauze diameter from 2.2m (original NAP1) to 3.0m (NAP2). For the same production capacity, this lowers the velocity of the process gases through the gauzes, resulting in lower nitrous oxide production.
689:M7.2 Nitrous Oxide (Greenhouse Gas Emissions) Improvement Plan - Preparation & Submission	Prepare and submit a Nitrous Oxide Emissions Improvement Plan. Plan to take into consideration world-wide commercial-scale trials and applications of new "low nitrous oxide emission" catalysts for nitric acid plants and review the current state of trialling and application of low nitrous oxide emission catalysts, to the requirements of the Min for Env on advice of the EPA	Construction At least three months prior to commissioning of the new nitric acid plant.	**Complete** This document, the updated ANPF GHG Abatement Program, incorporates the Nitrous Oxide (GHG Emissions) Improvement Plan

Audit Code and Subject	**Action**	**Phase**	**Status**
689:M7.3 Nitrous Oxide (Greenhouse Gas Emissions) Improvement Plan - Updating	Update the Nitrous Oxide Emissions Improvement Plan.	Overall Every year until new technology is adopted for the plant or until the Min for Env advises that updating the Nitrous Oxide Emissions Improvement Plan required by condition 7.2 is no longer required.	**In process** This document, the 2010 updated ANPF GHG Abatement Program, incorporates the Nitrous Oxide (GHG Emissions) Improvement Plan and latest information on the current state of trialling and application of low nitrous oxide emission catalysts.
689:M7.4 Nitrous Oxide (Greenhouse Gas Emissions) Improvement Plan - Public Availability	Make the Nitrous Oxide Emissions Improvement Plan required by condition 7.2.publicly available.	Overall	**In process** This program will be made publicly available at www.csbp.com.au following distribution to the EPA.
689:P5 Greenhouse Gases - Existing nitric acid plant boiler	Retrofit a larger boiler to the existing nitric acid plant. To reduce greenhouse gas emissions by approximately 68,000 tpa of CO_2.	Operation Within 3 years following commissioning of the new nitric acid plant.	**Complete** A larger boiler was installed on nitric acid plant 1 in November 2009.
689:P6 Greenhouse Gases - Existing nitric acid plant N_2O reduction	Retrofit nitrous oxide reduction technologies in the existing nitric acid plant if the technology proves commercially successful in the new plant, and after any Australian greenhouse gas emission laws and related carbon trading schemes are known.	Operation Ongoing once commercially viable.	**Not required at this stage** Refer to Section 10 of this Program for details of the current state of knowledge on nitrous oxide emission reduction technologies, and their commercial application.

Audit Code and Subject	**Action**	**Phase**	**Status**
689:P7 Greenhouse Gases - CO_2 emissions reduction	Provide up to 80,000 tpa of CO_2 to Alcoa World Alumina Australia for injection into residue disposal areas to create carbonates to bind the CO_2 subject to the satisfactory contractual arrangement.	Overall	**Satisfactory to date** CSBP commenced suppling CO_2 to BOC for use in Alcoa World Alumina Australia's residue disposal areas in January 2007 at an average rate of 200 tonne/day (when running).
Commitment 4 Greenhouse Gases - New nitric acid plant N_2O reduction	Retrofit nitrous oxide reduction technologies in the new nitric acid plant after any Australian greenhouse gas emission laws and related carbon trading schemes are known.	Operation Ongoing once commercially viable.	**Not required at this stage**
Proponent Commitment 1	Design and construct the new nitric acid plant (NAP3) to include tertiary N_2O abatement technology.	Design and construction	**Not required at this stage**

Appendix 3

Table 1 COMPARISON OF CSBP NITRIC ACID PLANTS TO BEST AVAILABLE TECHNIQUES.

Process type	N_2O emission level.		Remark	Reference
	kg/tonne 100% HNO_3	ppmv		
CSBP NAP1and NAP2 medium pressure plant	6.4 - 7.1	968 - 1013	NAP1 data for period December 2009 to June 2010 inclusive following installation of larger reactor boiler. NAP2 data for period July 2009 to June 2010.	
With NSCR		300		[Maurer and Groves, 2004]
Variation within a campaign until gauze exchange	5.6-9	900-1500	With medium pressure burner. Correlating with N2O yield of 1.5-2.5%	
All plants	1.9-21.6	300-3500		[EFMA, 2000]
Norsk Hydro	2.5	400	Modern integrated plant	[IPCC, 2000]
Low pressure oxidation	4-5	650-810		
Medium pressure oxidation	6-7.5	970-1220		
EU designed dual pressure plants	8-10	1300-1620		
A few, outdated plants	10-19	1620-3080		
19 Yarra plants	33-9	490-1500		[Jenssen, 2004]
Atmospheric plants	5	810		
Medium pressure oxidation	7	1140		
High pressure oxidation	5-9	810-1500		
EU average	6	970		
Depending on the process conditions	3.1-12.3	500-2000		[ADEME, 2003]
EU representative level	6-8	970-1300		[IRMA,2003]
EU average	7	1140		[infoMil, 2001]
Dual M/H plant	0.12-0.25	20-40	Combined tail gas abatement system since 2003	[AMI,2006]
Dual L/M plant	3.4-4.9	550-800	0-3.8 bar	[Austrian UBA, 2001] [AMI, 2006]
Mono M/M olnat	4.9	800	Campaign average. Improved oxidation catalysed by Heraeus. 4.5 bar, 250°C in front of the expander	SKW Piesteritz
Mono M/M plant	6.2-7.4	1000-1200	230°C in front of the expander	Sasol Nitro, South Africa

Dual M/H plant	7.7	1250	Capacity:584000 tonnes/year, 5/10 bar	YARA, Sluiskil 6
Dual M/H plant	9	1500	Capacity:500000 tonnes/year, 5/11 bar 500°C in front of expander	DSM Geleen
Mono M/M plant	7.1	1150	Capacity:210000 tonnes/year, 5 bar 450°C in front of expander	DSM Geleen [Brink, 2000]
Dual M/H plant	7.7	1250	Capacity:730000 tonnes/year, 4/11 bar	YARRA, Sluiskil 6
Mono M/M plant	5.7	920	Capacity:255000 tonnes/year, 4 bar 00°C in front of expander	DSM Ijmuiden [Brink, 2000]
Dual M/H plant	9	1500	Capacity:245000 tonnes/year, 4/10bar	DSM Ijmuiden
Mono M/M plant	3.8	613	Capacity:80000 tonnes/year, 2.6-3.6 bar	Kemira Agro Pernis*
Mono H/H plant	0.2	27	Capacity:400000 tonnes/year, NSCR, 9 bar	Kemira Agro Rozenburg*
Dual M/H plant	5.3	860	Capacity:1100 tonnes/day, 3.5/12.8 bar, gauze age at time of measurement: 5 months.	Agropolychim, Devnia
Medium pressure plant	1.9	300	Heraeus secondary catalyst	GP Rouen AN6
Dual M/M (KD6)	5.5		Heraeus secondary catalyst	Lovochemie, Lovosice
			Heraeus secondary catalyst	Agropolychim
Dual M/H (Uhde2)	7.2	1350	Capacity 750 tonnes/day	Kemira GrowHow, Tertre
Dual M/H (Uhde3)	7.1	1150	Capacity 550 tonnes/day	
Dual H/H (Dupont)	0.2	33	Capacity 850 tonnes/day, NSCR	
Dual M/H (SZ2)	1.8	285	BASF secondary catalyst, 12cm (6.7 kg before reduction)	BASF, Antwerp
Dual M/H (SZ3)	1.7	272	BASF secondary catalyst, 12cm (6.7 kg before reduction)	
Dual M/H	6.7			
Dual M/H	0.01		NSCR	
M/H	2.0	325	YARA secondary catalyst, 50% filling (7 kg before reduction)	YARA, Ambes
	3.3	535	YARA secondary catalyst, 40% filling (7 kg before reduction)	
M/H	2.8	445	YARA secondary catalyst, 25% filling (5.2 kg before reduction)	YARA Montoir
	0.8	130	YARA secondary catalyst, 75% filling (5.2 kg before reduction)	

* Plant closed. Source: European Commission Integrated Pollution Prevention Control. Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers. August 2007.

The above table contains data on nitrous oxide emission intensity sourced from the EC Integrated Pollution Prevention Control reference document on Best Available Techniques (BAT) for the manufacture of large volume inorganic acids. The BAT document contains reference data for approximately 28 nitric acid installations and combined studies with reported nitrous oxide emission intensities of between 0.01 and 21.6 kg nitrous oxide per tonne nitric acid. Very low range nitrous oxide emissions data such as 0.12 – 0.25 kg nitrous oxide per tonne nitric acid [Ami, 2006], 0.2 kg nitrous oxide per tonne nitric acid [Kemira Agro Rozenburg] and 0.01 kg nitrous oxide per tonne nitric acid [BASF, Antwerp] are associated with the use of tertiary abatement catalysts.

Plants denoted as utilising secondary abatement catalyst such as [GP Rouen AN6], [Lovochemie, Lovosice], [Agropolychim], [BASF, Antwerp], [Yara, Ambès] and [Yara, Montoir] report nitrous oxide emission intensities in the range 0.8 to 5.5 kg nitrous oxide per tonne nitric acid.

A third group of plants, with no reported use of nitrous oxide abatement catalyst, report emissions in the range 2.5 to 9 kg nitrous oxide per tonne nitric acid.
References in Table 1 with nitrous oxide emission intensities of more than 10 kg nitrous oxide per tonne nitric acid are considered older, outdated plants [IPCC, 2000].

This table demonstrates a wide variety of nitrous oxide emissions from plant to plant, being dependant on a range of factors including abatement technologies, plant configuration and plant operating conditions. This table includes the operating plant pressure for some references (as operating pressure is known to influence nitrous oxide emission levels). Nitric acid plants can be designed to operate at either a single pressure, or dual pressure. Dual pressure plants, require a higher capital investment but allow for low ammonia oxidation pressures and high absorption pressures thereby optimising both ammonia conversion and absorption efficiencies. Pressure notations in Table 1 use two symbols L (low), M (medium) and H (high) to signify the operating pressure or pressures of the plants e.g. “LH” represents a dual pressure plant with low ammonia oxidation pressure and high absorption pressure. CSBP operates a single pressure plant that operates at a moderately high pressure. The notation for this type of plant is not used explicitly in Table 1, positioned between “MM” and “HH”.

This nitrous oxide emission intensity of NAP1 and NAP2 at 6.4 and 7.1 kg per tonne nitric acid respectively is in line with equivalent European plants operating at high pressures that do not incorporate nitrous oxide abatement systems e.g. 5 – 9 kg nitrous oxide per tonne nitric acid [Jenssen, 2004].

References for Appendix 4.

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