final report

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Solid Waste Boiler Combustion Trial - Reduction in Fossil Fuel Derived Energy in 5 years at Dinmore Food Processing Facility

This research was a joint collaboration between Meat & Livestock Australia and JBS Australia.

Abstract

This project is an important facet of a multi-stage plan by AMH to achieve a better than anticipated 10% reduction in fossil fuel derived energy in 5 years at its Dinmore facility.

The basis of the following trials was to prove firstly whether a super-heated steam dryer could adequately dry Australia Meat Holding's waste streams and secondly whether the efficiency of this process will fit in line with the overall project.

The trials were run over a period of five days, the first three days on week one were used for obtaining machine set points and operating temperatures and on week two the last two days were used to obtain energy figures that are represented in the mass balance.

The Super-Heated Steam Dryer dried all raw materials presented to a desired moisture content and we experienced none of the problems associated with conventional drying technology. Due to the physical nature of the sludge and the way it was presented to the dryer drum a higher than originally quoted energy figure was realised. This figure would be reduced with a more efficient feed system and a longer drum for product retention.

The dryer does exhaust a small amount of non-condensable gas, which has an odorous compound. This gas has been sampled and results will be forwarded to AMH.

The dryer is capable of processing the sludge and waste stream mixture at lower operating temperatures (350°c) although at higher temperatures it is expected that the energy efficiency will increase as the temperature rises. The super-heated steam heat to energy curve is higher than that of conventional air dryers.

Overall, the trial determined that the process was not sustainable due to the high moisture content of the dried materials. The cost of further drying the materials for produce more efficient burning was not viable. Further development in efficiencies of drying technologies and approaches are required in order for this process is to be considered viable.

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1 Background

Australia Meat Holdings Pty Ltd (AMH) is recognised as one of the nation's 250 largest energy users. To reduce their reliance on imported energy, AMH have established a corporate target of achieving a 10% reduction in fossil fuel demand at their Dinmore food processing facility within a 5 year period. One potential method of achieving this goal is to recover energy, in the form of electricity, steam and/or hot water from the solid waste streams currently generated at the site.

Energy could potentially be recovered or saved by in an overarching strategy by:
- Collecting and combusting the biogas generated by the existing anaerobic ponds;
- Dewatering the organic solid waste streams to reduce the energy used to transport the solids offsite for disposal; and/or
- Using thermal methods to recover energy from the dewatered organic solid wastes.

To further explore these possibilities, AMH entered into a "Partnership in Innovation" project grant with Meat and Livestock Australia (MLA) to conduct trials to assess the technical and financial risks associated with these opportunities for energy recovery. In particular, the study focused on developing an integrated process solution for utilisation of solid waste feed materials in order to confirm capital and operating costs for a full-scale commercial operation at the AMH Dinmore site.

The purpose of the project was to further develop the drying technology and efficiency over an extended period using the AMH Dinmore solid waste feed material in order to confirm capital and operating costs for a full-scale commercial operation. In addition, the project proposes to utilise the dried material as a fuel for combustion trials in the GE coal-fired boiler and examine the energy profile and environmental performance of the boiler under varied feed conditions utilising both coal and dried solid waste separately and in combination.

2 Project Objectives

The overall objective of this project was to. The specific aims were to:

- Determined the capital and operating cost economics of the Keith Engineering SHS dryer technology to process AMH Dinmore's solid waste at a commercial scale; and
- Assessed the technical viability of utilising the dried solids as an alternative source of fuel in AMH Dinmore's GE coal-fired boiler.

3 Methodology & Key Activities

The pilot study was completed in a number of phases, as follows:

1. Project team leaders will identify in a written report accepted by MLA: - Various consultants and expertise required to conduct the Project. Brief risk assessment on Project deliverables.
2. Keith Engineering undertakes preliminary modifications to the airless dryer and other necessary preparations to undertake trial at Dinmore.
3.1. Complete installation for solids drying trial to produce solid fuel for combustion trial by Australia Meat Holdings.
3.2. Complete installation of Airless dryer for solids drying trial by Keith Engineering.
4.1. Australia Meat Holdings conduct solids drying trial to produce boiler fuel for combustion trial. Report received and accepted by MLA.

4.2 Keith Engineering conduct solids drying trial to produce boiler fuel for combustion trial. Report received and accepted by MLA.
5. Conduct fuel combustion trial in the GE Boiler. Report received and accepted by MLA.
6.1 Australia Meat Holdings contribution to draft report on findings of the drying and combustion trials received and accepted by MLA.
6.2 Keith Engineering's contribution to draft report on findings of the drying and combustion trials received and accepted by MLA.
7.1. Australia Meat Holdings contribution to final report on the findings of the drying and combustion trials received and accepted by MLA.
7.2 Keith Engineering's contribution to final report on the findings of the drying and combustion trials received and accepted by MLA.

The process to evaluate the solid waste drying trial was as follows:

- Belt press cake was fed through the dryer at varying temps, samples taken at each temp change until maximum drying achieved. The temp reflecting the best drying was 350 Deg C. samples of the emissions were taken and sent for analysis [odour concentration]. Moisture reduced from 85 % in to 15 % out.
- Solid waste combined and put through Fan press [Stage 1], belt press sludge combined through mincer and total solids put through dryer. Temp set at 350 Deg C, moisture reduced from 76 % to 6 %.
- Samples from both trials were collected and sent for G.C.V. analysis.
- Trials conducted to ascertain energy consumption to achieve drying.

The following steps were utilised to evaluate the solid waste mix :

Step 1.

- Note bin weight.
- Add 500 kg Paunch grass.
- Add 200 kg Saveall 2 solids.
- Add 200 kg D.A.F. float [unflocculated].

Step 2.

- Collect bin from hide area and weigh.
- Note weight on bin.
- Take bin to Saveall area.

Step 3.

- Collect meal bin from D.C.B. area, bin has a slide gate in it.
- Take bin to Saveall area.

The specific waste streams measured as part of the waste to energy audit was as follows.

- Paunch grass.
- Primary D.A.F. float. [flocculated].
- Belt Press sludge.[flocculated]
- Saveall # 2 bottom scrapings.
- Saveall # 2 contrashear solids.

- Truck wash solids.
- Plastic waste, [3cu/m bins].
- Re-cycle cardboard.
- Waste cardboard.
- Hay, [Yearly total x 250 kg / bale] divided into weekly allotment

Loads were weighed daily, trailer numbers recorded and volumes calculated from data recorded. In the case of Plastic's, re-cycle cardboard and waste cardboard volumes were determined from bins accumulated.

4 Results and Observations

The results of detailed sampling schedules are as follows.

Table 1 : Solid waste volumes for week ending 7th February 2005

Waste			Volumes daily					Total
Origin	Tues	Wed	Thur	Fri	Sat	Sun	Mon	Week
Paunch Grass Tonnes	64.7	62	67.6	37	32	30	51.8	345
Saveall 2bottom Tonnes	13.40	15.10	20.2	30.9	16	14.6	5.2	115.4
Saveall 2contra Tonnes	7.44	10.7	5.9	2.3	1.4	2.9	3.7	34.3
D.A.F. Float Tonnes	27.51	25.8	31.1	10 poly dose low	22 Poly from B.P.	5 poly dosing B.P.	10 B.P. Poly	131.4
Belt press Tonnes	70.25	62.1	61.9	30.6	0	70.6	32.6	328
Truck wash Tonnes			32					32
Plastic's cu/M	12	12	12	12	4.5	7.5	6	66

Re-cycle cardboard Tonnes		1.44		1.91			1.87	5.22
Waste cardboard cu/M	3	4.5	3.5	4.5	4.5	4.5	5	29.5
Hay Bales								6.75 T week

Table 2: Belt Press set run time / flows / cake for week ending 7 February 2005.

	4a	4b	4a	4b	4a	4b	4a	4b	4a	4b	4a	4b	4a	4b	4a	4b
Day	T	T	W	W	Th	Th	F	F	S	S	Su	Su	M	M	Tot	Tot
Run time	12 hr	12 hr	12 hr	12 hr	10 hr	12 hr	4 hr	2 hr	0 hr	0 hr	8 hr	6 hr	12 hr	12 hr	58 hr	56 hr

	Tues	Wed	Thur	Fri	Sat	Sun	Mon	Total
Cake Tonnes	70.25	62.1	61.9	30.6	0	70.6	45	341

Note:

- **Belt press actual run times depend on tank levels / trailer emptying etc.**
- Total M.L.S.S. wasted to blue mixing tank for week ending 7-02-05: 4A: 4345 KL.
  4b: 4317 KL.

Table 3: Volumes for week ending 14 February 2005.

Waste	Volumes daily							Total
Origin	Tues	Wed	Thur	Fri	Sat	Sun	Mon	Week
Paunch Grass Tonnes	70	73	68	33	35	34	58	371
Saveall 2bottom Tonnes	22.2	17.6	17.4	24.7	14.1	13.7	12.7	122

Saveall 2contra Tonnes	3.4	2.3	4.5	1.1	1	3	3.7	15
D.A.F. Float Tonnes	20 Belt	12 Press	21 Poly	23 Used, as	14 normal	18 poly run out	18 poly on	126
Belt press Tonnes	62	52	27	15	28	62	53	295
Truck wash Tonnes					36			36
Plastic's cu/M	13	12	12	15	5	9	12	76
Re-cycle cardboard Tonnes	The	Data	For	The past	Three	months	av	5.8 wk
Waste cardboard cu/M	3	4	3	5	4.5	3.5	3	26
Hay Bales Tonne wk								6.75

Table 4: Belt Press run time / flows / cake for week ending 14 February 2005.

4a 4b 4a 4b 4a 4b 4a 4b 4a 4b 4a 4b 4a 4b 4a 4b

Day	T	T	W	W	Th	Th	F	F	S	S	Su	Su	M	M	Tot	Tot
Run time hrs	12	12	10	6	6	3	1	2	2	6	7	7	12	12	50	48

Tues Wed Thur Fri Sat Sun Mon Total

Cake Tonnes	62	52	27	15	28	62	53	295

Note

- Belt press actual run times depend on tank levels / trailer emptying etc.

In summary the results of the trial was as follows:

- Total M.L.S.S. wasted to blue mixing tank for week ending 14-02-05: 4a: 3728 KL.
    4b: 3700 KL.
- 4A / 4B M.L.S.S. remained between 6000 / 6500 mg/L.
- The belt press operated at 80cu/M Hr for the duration of the trial.
- 4A wasting rate was estimated at 29 L/sec.
- 4B wasting rate was estimated at 26 L/sec.
- At 80cu / Hr 4a runs for 15 min to reach the top level setpoint, it remains off for 6 min until the low level setpoint is attained, therefore total volume wastage / Hr run time is 74568 L.
- At 80cu / Hr 4b total is 77082 L.
- Refer to Figure 1 for photograph of the final dried product ready for burning.

Figure 1. Waste to energy dried samples

5 Outcomes

The results showed:

- The Super Heated Steam Dryer dried all raw materials presented to a desired moisture content and we experienced none of the problems associated with conventional drying technology.
- No back mixing of product is required and at no stage did the dryer experience a “sticky phase” with any of the materials presented for drying.
- Due to the physical nature of the sludge and the way it was presented to the dryer drum a higher than originally quoted energy figure was realised. This figure would be reduced with a more efficient feed system and a longer drum for product retention.
- The dryer does exhaust a small amount of non-condensable gas, which has an odorous compound. This gas has been sampled and results will be forwarded to AMH.
- The dryer is capable of processing the sludge and waste stream mixture at lower operating temperatures (350°c) although at higher temperatures it is expected that the energy efficiency will increase as the temperature rises. The super-heated steam heat to energy curve is higher than that of conventional air dryers.
- A condenser would be required to condense the surplus steam generated in the drying process.
- The sludge feed system on the pilot plant was labour intensive and a new system would be designed on a full-scale model to feed the sludge more consistently and in smaller particle sizes to aid in drying efficiency.
- The waste stream mixture that was presented to the dryer was easier to feed, dry and was more energy efficient. The waste stream mix was lighter and contained a lot more dust particles in its dry state.
- The waste stream mix would require multiple cyclones or a more efficient cyclone to reduce the carry over into the heat exchanger.

It is considered by the contractor that the figure for waste heat recovery can’t be accurately quoted as the theory and practice involved with waste heat recovery figures very rarely match up. Using the heat from the burner exhaust to preheat the air going to the burner will increase the overall efficiency of the dryer but to what extent can only be guessed at this stage. Using the waste steam from the dryer to further reduce energy costs could come in the form of using the hot water from the condenser to pre-heat the sludge in a jacketed screw conveyor. Again this figure I believe can only be an assumption.

The only indicative energy figure we have at this stage is 4.5MJ/KG for sludge and 3.6MJ/KG for the waste stream mix. We also know that we can reduce these figures by redesigning the feed system, using the waste heat from the burner loop to pre-heat the air entering the burner and using the waste steam to heat water in a jacketed conveyor to pre-heat the raw material. What results these modifications will have on our overall energy performance can only be theorised at this stage.

Overall, the trial determined that the process was not sustainable due to the high moisture content of the dried materials. The cost of further drying the materials for produce more efficient burning was not viable. Further development in efficiencies of drying technologies and approaches are required in order for this process is to be considered viable.

6 Opportunities arising / Recommendations

The corporate target of reducing fossil fuel usage at the Dinmore site by 10 % can be achieved with the implementation of a waste to energy program. Depending on the configuration adopted, 25 to 35% of the electrical needs and 15 to 25% of the steam/hot water needs of the site can meet through recovery of energy from solid waste and biogas generated on the site. This conclusion is premised on the ability to demonstrate that 50 % moisture can be achieved in the dewatered solid waste using mechanical dewatering technology.

The key conclusions for the specific areas of investigation for this report are as follows.

- Further detailed evaluation of the energy recovery options from solid waste should be deferred until the results of the SPC dewatering test work program are assessed. The success or otherwise of the mechanical dewatering circuit will be key in defining the economics and technical issues for energy recovery;
- If a suitable technology for mechanical dewatering to <50% moisture is not defined, it is recommended that anaerobic digestion be reconsidered;
- A site energy review is required to optimise the proposed layout, with particular emphasis on whether to maximise electricity or steam generation;
- Discussions with selected vendors (suppliers of FBC technologies) should be progressed to obtain an improved understanding of the commercial and technical issues associated with implementing waste to energy technologies on the Dinmore feed stocks;
- Vendors may recommend pilot testing. This should be considered on a case by case basis; and Pending agreement on the choice of FBC as the preferred technology and trailing the SPC dewatering unit, a detail design would be required to confirm waste composition and variation.

In concluion, if the energy figures supplied minus the assumed savings via the modifications don't add up to AMH's budgetary figures for the entire project, further experimentation should be carried out. Some previous trials in the form of coagulating the wet sludge have shown some promise and would present the sludge to the dryer in a form that would increase the energy efficiency.

Please note that reducing moisture content through heat transfer is the most uneconomical form of evaporation and if the moisture content of the product provided to the dryer was around the 55% to
60% mark from the above example huge savings would be made in gas usage and would offset the
capital expenditure for the extra equipment.

7 Acknowledgements

AMH and Meat & Livestock Australia would like to acknowledge the matching funds provided by the Australian Government to support the research and development detailed in this publication.

8 Appendix 1 – Detailed independent analyses of dried solid waste materials

project ID	00250
issue number	1
client	HiTech Pty Ltd
issue date	27th March 2007
testing date	8th March 2007
contact	Mr. Phill Redmond

newEQ
new environmental quality

New Environmental Quality
P.O. Box 119
Coopers Plains Qld. 4108
ABN: 56 115 736 046

Source emissions monitoring conducted on the Coal Fired Boiler at Australian Meat Holdings Pty Ltd

Table 1: Document Control

Report ID	Date	Comment	Author
250-1	27th March 2007	Initial release	LP

Yours Faithfully
New Environmental Quality Pty Ltd

NATA Signatory
Lyle Pott B.Sc
Technical Manager

NATA
WORLD RECOGNISED ACCREDITATION

Accreditation Number:
15438

EXECUTIVE SUMMARY

Table 2: Coal Fired Boiler Results Summary

Parameter		Baseline Test Result (g/Nm^3)	55% Paunch Trial Test Result (g/Nm^3)	Regulatory Limit (g/Nm^3)
Total Particulates	Actual :	0.24	0.27	-
	@ 12% CO_2 :	0.35	0.45	0.25
Nitrogen Oxides as NO_2 :		0.38	0.34	0.50

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INTRODUCTION

New Environmental Quality (newEQ) was commissioned by HiTech Pty Ltd to monitor stack emissions from a coal fired boiler at Australian Meat Holdings in Dinmore. Sampling and analysis was conducted by newEQ on 8th March 2007.

newEQ was responsible for the collection and analysis of all samples. The collected samples remained sealed and preserved in the appropriate manner. Upon return to the laboratory the samples were prepared and analysed by the correct methodologies.

TEST METHODS

Unless otherwise stated, the following test methods meet the requirements of the Qld EPA. All sampling and analysis was conducted by newEQ unless otherwise stated. The results presented in this report are related to one or more reference calibrations held by newEQ.

Table 3: Test Methods

Parameter	Test Method	Deviations
Sample plane criteria	AS 4323.1	Nil
Gas Velocity and Temperature	USEPA 2	Nil
Stack gas Density	USEPA 3a	Nil
Moisture	USEPA 4	Nil
Carbon monoxide	USEPA 10	Nil
Oxides of nitrogen	USEPA 7E	Nil
Total particulate matter	USEPA 5	Nil

Table 4: Analysis Notes

Analysis Note	Company	NATA Accreditation ID	Report Number
1	newEQ	15438	00245-1
2	SGS	2562 (4354)	50913

QUALITY ASSURANCE & QUALITY CONTROL (QA/QC)

newEQ operates within a quality system based upon the requirements of ISO17025. Our quality system defines specific procedures and methodologies to ensure any project undertaken by newEQ is conducted with the highest level of quality given the specific confines of each project. These procedures address such facets as:

- project management
- equipment calibration and maintenance
- adherence to specific sampling methodologies
- selection of sub-contracting laboratories
- storage and freight of collected samples
- final report preparation

DEFINITIONS

<	The analytes tested for was not detected; the value stated is the reportable limit of detection
°C	Degrees celsius
m	Metres
mb	Millibars
ml	Millilitres
Kg	Kilograms
Mole	SI unit that measures the amount of substance
g	Grams
mg	Milligrams (10^{-3} grams)
µg	Micrograms (10^{-6} grams)
ng	Nanograms (10^{-9} grams)
m^3	Gas volume in cubic metres at measured conditions
Nm^3	Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa)
sec	Second
min	Minute
mmH_2O	Millimetres of water
STP	Standard temperature and pressure (0°C and 101. 3 kPa)
FH	Front half of sample train (probe and filter holder) sample recovery
BH	Back half of sample train (filter holder and impingers) sample recovery

CALCULATION OF RESULTS

Table 5: PM Determination, Baseline

Source Data			
Client		AMH	
Sampling Location		Boiler stack	
Operating Condition		coal fired	
Reference Method		AS4323.2	
Test Parameters		PM	
Historical Data & Hardware Information			
Run Start Date		8-Mar-07	dd-mm-yy
Project ID		250	
Run ID		1	
Run Start Time		9:26	hh:mm
Run Stop Time		10:37	hh:mm
Meter Calibration Factor	(Y)	1.009	
Pitot Tube Coefficient	(C_p)	0.840	
Actual Nozzle Diameter	(D_{nz})	6.000	mm
Stack Test Data			
Initial Meter Volume	$(V_m)_i$	40.352	m^3
Final Meter Volume	$(V_m)_f$	40.875	m^3
Total Sampling Time	(°)	1:11	hh:min
Average Meter Temperature	$(t_m)_{avg}$	38.9	°C
Average Stack Temperature	$(t_s)_{avg}$	226.9	°C
Barometric Pressure	(P_b)	1006	mb
Stack Static Pressure	(P_{static})	15.00	mm H_2O
Absolute Stack Pressure	(P_s)	1007	mb
Sample Volumes			
Total Meter Volume	(V_m)	0.526	m^3
Standard Meter Volume	$(V_m)_{std}$	0.459	dscm
Standard Meter Volume - refernced	at 7%O2	0.310	dscm
Standard Meter Volume - refernced	at 10%O2	0.396	dscm
Standard Meter Volume - refernced	at 12%CO2	0.309	dscm
Moisture Content Data			
Impingers 1-3 Water Volume Gain	(V_n)	22.0	ml
Impinger 4 Silica Gel Weight Gain	(W_n)	5.0	g
Total Water Volume Collected	(V_{lc})	27	ml
Calculated Stack Moisture	$(B_{ws(calc)})$	6.82	%
Gas Analysis Data			
Carbon Dioxide Percentage	$(\%CO_2)$	8.08	%
Oxygen Percentage	$(\%O_2)$	11.5	%
Carbon Monoxide Percentage	(%CO)	0.00	%
Nitrogen Percentage	$(\%N_2)$	80.4	%
Dry Gas Molecular Weight	(M_d)	1.33	kg/Nm3
Dry Gas Molecular Weight	(M_d)	28.95	g/g-mole
Wet Stack Gas Molecular Weight	(M_s)	28.95	g/g-mole
Volumetric Flow Rate Data			
Average Stack Gas Velocity	(v_s)	8.98	m/sec
Stack Diameter	Ds	1.28	m
Stack Cross-Sectional Area	(A_s)	1.29	m^2
Actual Stack Flow Rate	(Q_{aw})	693	Am^3/min
Wet Standard Stack Flow Rate	(Q_{sw})	377	Nm^3/min-wet
Dry Standard Stack Flow Rate	(Q_{sd})	351	Nm^3/min-dry
Percent of Isokinetic Rate	(I)	99	%
Particulate Concentration			
Total Mass of Particulates	(m_n)	0.11	g
Stack PM Concentration	(c_s)	0.24	g/Nm^3
		236	mg/Nm^3
Particulate Emission Rate	(E)	83	g/min
Particulate Emission Rate	(E)	1.4	g/sec
Particulate Uncertainty Calculation			
Uncertainty expressed at 95%CI	(U)	5.36	%
Uncertainty expressed at 95%CI	(U)	12.7	mg/Nm^3

Table 6: PM Determination, 55% Paunch Trial

Source Data			
Client		AMH	
Sampling Location		Boiler stack	
Operating Condition		55/45 paunch/coal	
Reference Method		AS4323.2	
Test Parameters		PM	
Historical Data & Hardware Information			
Run Start Date		8-Mar-07	dd-mm-yy
Project ID		250	
Run ID		2	
Run Start Time		14:50	hh:mm
Run Stop Time		16:03	hh:mm
Meter Calibration Factor	(Y)	1.009	
Pitot Tube Coefficient	(C_p)	0.840	
Actual Nozzle Diameter	(D_{na})	6.000	mm
Stack Test Data			
Initial Meter Volume	$(V_m)_i$	40.891	m^3
Final Meter Volume	$(V_m)_f$	41.332	m^3
Total Sampling Time	(°)	1:13	hh:min
Average Meter Temperature	$(t_m)_{avg}$	41.1	°C
Average Stack Temperature	$(t_s)_{avg}$	208.2	°C
Barometric Pressure	(P_b)	1006	mb
Stack Static Pressure	(P_{static})	15.00	mm H_2O
Absolute Stack Pressure	(P_s)	1007	mb
Sample Volumes			
Total Meter Volume	(V_m)	0.445	m^3
Standard Meter Volume	$(V_m)_{std}$	0.384	dscm
Standard Meter Volume - refernced	at 7%O2	0.202	dscm
Standard Meter Volume - refernced	at 10%O2	0.257	dscm
Standard Meter Volume - refernced	at 12%CO2	0.231	dscm
Moisture Content Data			
Impingers 1-3 Water Volume Gain	(V_n)	20.0	ml
Impinger 4 Silica Gel Weight Gain	(W_n)	3.0	g
Total Water Volume Collected	(V_{lc})	23	ml
Calculated Stack Moisture	$(B_{ws(calc)})$	6.93	%
Gas Analysis Data			
Carbon Dioxide Percentage	$(\%CO_2)$	7.21	%
Oxygen Percentage	$(\%O_2)$	13.6	%
Carbon Monoxide Percentage	(%CO)	0.00	%
Nitrogen Percentage	$(\%N_2)$	79.2	%
Dry Gas Molecular Weight	(M_d)	1.33	kg/Nm3
Dry Gas Molecular Weight	(M_d)	28.94	g/g-mole
Wet Stack Gas Molecular Weight	(M_s)	28.94	g/g-mole
Volumetric Flow Rate Data			
Average Stack Gas Velocity	(v_s)	6.95	m/sec
Stack Diameter	Ds	1.28	m
Stack Cross-Sectional Area	(A_s)	1.29	m^2
Actual Stack Flow Rate	(Q_{aw})	537	Am^3/min
Wet Standard Stack Flow Rate	(Q_{sw})	303	Nm^3/min-wet
Dry Standard Stack Flow Rate	(Q_{sd})	282	Nm^3/min-dry
Percent of Isokinetic Rate	(I)	103	%
Particulate Concentration			
Total Mass of Particulates	(m_n)	0.10	g
Stack PM Concentration	(c_s)	0.27	g/Nm^3
		268	mg/Nm^3
Particulate Emission Rate	(E)	75	g/min
Particulate Emission Rate	(E)	1.3	g/sec
Particulate Uncertainty Calculation			
Uncertainty expressed at 95%CI	(U)	6.43	%
Uncertainty expressed at 95%CI	(U)	17.2	mg/Nm^3

APPENDIX 1:

CALIBRATION AND UNCERTAINTY CERTIFICATE.

report to HiTech Pty Ltd — newEQ Project ID: 00250

New Environmental Quality
Calibration and Uncertainty Certificate

Calibrations are performed according to ISO/ EEC 17025 Appendix A: Calibration intervals for commonly used chemical testing equipment, equipment specific manuals and external laboratory procedures. Uncertainties are obtained from external calibrations from the corresponding laboratories and quoted verbatim. All certificates can be provided upon request.

Item	Manufacturer	Type	newEQ ID	Last Calibration	Uncertainty	Internal/ External	Certificate Number
Reference gas meter	American Meter	Dry gas meter	SN069	30.08.05	± 0.3%	External: Gas Technology Services Pty Ltd NATA: 14344	30M-05-0093-TRP-001-01
Console	Actraris	Gallus 2000 G4	SN003	Each use	± 0.3%	Internal	N/A
Console	Actraris	Gallus 2000 G4	SN028	Each use	± 0.3%	Internal	N/A
Console	Actraris	Gallus 2000 G4	SN127	Each use	± 0.3%	Internal	N/A
Portable gas analyser	Testo	350	SN027	Each use	O_2: ± 1% rel CO_2: : ± 1% rel CO: : ± 2% rel NO: ± 2% rel SO_2: : ± 2% rel	Internal	N/A
Portable gas analyser	Testo	350	SN034	Each use	O_2: ± 1% rel CO_2: : ± 1% rel CO: : ± 2% rel NO: ± 2% rel SO_2: : ± 2% rel	Internal	N/A
Inclined manometer	Airflow	MK5 P	SN119	09.03.06	± 0.1cm H_2O	External: Gas Technology Services Pty Ltd NATA: 799	30M-06-0035-TRP-001-01
Thermometer	Brannan	No806	SN135	03.05.06	± 0.2ºC	External: WIKA NATA: 410	496/ 06
Balance	Ohaus	E12140	SN002	29.10.04	Max ± 0.00032g (at 199.99990g loading)	External: Australian Calibrating Services Pty Ltd NATA: 1239	Q.AC/ 636-A-3
Oxygen, carbon dioxide, carbon monoxide and nitrogen calibration	Linde	N/A	N/A	02.11.05	O_2: ± 1% rel CO_2: : ± 1% rel	External: Linde NATA:12803	QCSPC000413

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newEQ Project ID: 00250
issue number: 1

Item	Manufacturer	Type	newEQ ID	Last Calibration	Uncertainty	Internal/ External	Certificate Number
gases					CO: : ± 2% rel		
Nitrogen oxide and sulphur dioxide calibration gases	Linde	N/A	N/A	16.11.05	NO: ± 2% rel SO_2: : ± 2% rel	External: Linde NATA: 12803	QCSPC000463
Digital calipers	Guogen	N/A	SN033	19.09.06	± 0.18µm	Internal	N/A
Digital calipers	Guogen	N/A	SN121	25.07.06	± 0.18µm	Internal	N/A
Digital calipers	Guogen	N/A	SN143	16.10.06	± 0.18µm	Internal	N/A
Gauge block	Mitutoyo	N/A	SN148	26.06.06	± 0.18µm	External: A.C.M. Laboratory NATA: 723	723 1244/06
Gauge block	Mitutoyo	N/A	SN149	26.06.06	± 0.18µm	External: A.C.M. Laboratory NATA: 723	723 1244/06
Gauge block	Mitutoyo	N/A	SN150	26.06.06	± 0.18µm	External: A.C.M. Laboratory NATA: 723	723 1244/06
Gauge block	Mitutoyo	N/A	SN151	26.06.06	± 0.18µm	External: A.C.M. Laboratory NATA: 723	723 1244/06
Thermocouple Simulator	PIE	521	N/A	21.06.06	± 0.3°C	External: VMS International NATA: 116	NC 06.32279
Mass flow controllers	Sierra Instruments Inc	C100L-LE-NR-2-OV1-SV1-PV2-V1-S1-CO	N/A	28.10.06	± 1%	Sierra Instruments Inc	R79722[a]
Pump	TCR Tecora	Bravo-R-Basic	128	07.07.05	Not quoted	External: TCR Tecora	P-527498RB
Pump	TCR Tecora	Bravo-R-Basic	129	07.07.05	Not quoted	External: TCR Tecora	P-527499RB

[a] Sales order number – no certificate number provided.

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